

Final Report

An Integrated Pest and Disease Management Extension program for the Olive Industry

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OL17001

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An Integrated Pest and Disease Management Extension program for the Olive Industry OL17001

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Summary

The key objective of OL17001 An Integrated Pest and Disease Management Extension Program for the Olive Industry was to develop and provide the Australian olive industry with appropriate Integrated Pest and Disease Management (IPDM) extension outputs focused on sustainable (including organic) management of the three major olive pests/diseases: Black Scale, Olive Lace Bug and Anthracnose. In practice, however, and consistent with the philosophy of IPDM, we addressed all potential pests, diseases and disorders, as well as beneficial organisms. The project team worked closely with the Australian Olive Association (AOA) in implementation of extension interventions and the provision of extension outputs to industry.

We initially conducted a detailed literature review and knowledge gap analysis, followed by a baseline survey of Australian olive growers to elucidate pest and disease issues and the current management strategies used by conventional and organic/biodynamic growers, as well as how growers accessed/wished to access information on pests and diseases. The survey had 130 completions, representing >70% of Australian olive production. While the survey confirmed the importance of the three key plant protection problems addressed in this project, it raised some other questions about correct pest and disease identification, and about the level of implementation of IPDM practices. Between mid-2018 and early 2019, the project team conducted ten one-day IPDM workshops/field days across all olive-growing states addressing IPDM principles and practices; monitoring for pests, diseases and beneficial species; identifying key pests and diseases; and strategies for their conventional and organic management. Workshops/field days comprised formal presentations, grove walks and grower discussions. There was a total participation of 275 growers at workshops/field days with very positive feedback on technical content and knowledge transfer. A two-day Master Class was conducted for olive consultants and pest scouts in September 2019, but with limited attendance.

Based on outcomes from the survey and field days/workshops, a series of outputs were identified and developed for the industry, namely: **On-line tutorials** (9) providing information on IPDM, Monitoring, Biosecurity, as well as the key pests and diseases; **Flyers** (9), 1-2 page summaries of information on key pests and their management, for use by advisors, consultants and pesticide suppliers as well as growers; a revision of the 2007 **Field Guide to Olive Pests, Diseases and Disorders**: providing updated information, supporting identification of possible pests, diseases and disorders, as well as beneficial natural enemies; and a **Best Practice IPDM Manual**: a supplementary extension tool, providing “how to” explanatory information on IPDM strategies, enabling more informed decision making. Industry access to these outputs, particularly the Field Guide and IPDM Manual, has been high since they were made available on the AOA’s website, OliveBiz in September 2020.

In an end-of-project survey, 79% of respondents stated that they had participated in at least one other IPDM project activity; and of these, 89% responded that their knowledge of olive pests and diseases and IPDM had been improved as a result. Furthermore, 60% indicated that they had changed or were anticipating changes to their IPDM practices. Other major project achievements include increased grower confidence in pest and disease identification, a greater percentage (now >90%) of growers monitoring their crops for pests and diseases, and substantially increased adoption of on-farm biosecurity. It is recommended that the AOA, on behalf of the olive industry, maintains the extension outputs from this project, and reviews and updates them as required.

Keywords

Integrated Pest and Disease Management; olive; black scale; olive lace bug; anthracnose; extension, apple weevil; cercospora leaf mould; peacock spot; exotic olive pests and diseases

Introduction

The Australian olive industry is characterized by a small number of very large producers and a large number of small producers. A recent industry shakeup has led to a turnover of properties (especially small and medium size growers), as well as abandoned groves. There has consistently been strong interest by the industry in sustainable production and Integrated Pest and Disease Management (IPDM), with a significant minority interest in organic and biodynamic production. While most large olive growers have well-developed IPDM and monitoring programs, a number of medium size and smaller “boutique” and “organic” growers were having difficulty effectively managing their pest and disease problems. Although Australia is currently free of many important olive pests and diseases, these pose serious threats to the industry in the event of an incursion. Furthermore, other cosmopolitan as well as endemic plant protection problems can pose significant problems for the economic production and quality of olive products (Hall et al., 2012; Sergeeva et al., 2011; Spooner-Hart et al., 2007).

This is the second project to address extension of IPDM in Australian olives. A national RIRDC project UWS-17A Sustainable Pest and Disease Management in Australian Olive Production was undertaken 2001-2004 by Spooner-Hart (2005). In addition to conducting field days, and identifying key olive pests and diseases, this project led to the development of the Field Guide to Olive Pests, Diseases and Disorders in Australia (Spooner-Hart et al. 2007). Since then, two Strategic Agrichemical Review Processes (SARPS) have been conducted: 2008 by RIRDC (Dal Santo, 2009), and 2014 by HIA (<https://olivebiz.com.au/minor-use-permits-bring-major-benefits-industry/>), in which the key pests were confirmed as black scale (*Saissetia oleae*), olive lace bug (*Froghattia olivina*), and anthracnose (*Colletotrichum* spp.). In 2017, the industry via its Olive Strategic Investment Advisory Panel (SIAP) advised that the IPDM information currently available required updating, particularly in light of new international pests and diseases, and that the formal and informal information needed to be consolidated and made more widely accessible.

The current project, OL17001 An Integrated Pest and Disease Management Extension Program for the Olive Industry, aimed to address these identified shortfalls, by developing and delivering a comprehensive set of educational outputs focused on sustainable (including organic) management of these three major olive pests. In practice, the project focused more widely than just these three species, consistent with an IPDM approach. It has addressed strategies from two Industry Outcomes in the Olive Strategic Investment Plan 2017-2021, namely: Develop and refine pest and disease control (IPDM) strategies (Outcome 1. Improved on-farm productivity, sustainability and product quality), and Communicate and extend outcomes of industry R&D (Outcome 3. Greater skills, capacity and knowledge in the industry).

We approached the project by assembling a national team of highly experienced research/extension scientists in horticultural (including olive) IPDM, to ensure a network of collaborative knowledge-sharing and a platform for further communication on olive IPDM, beyond the life of the project. An initial industry baseline survey, together with ten interactive regionally-based field days, provided additional data for the team to identify the most appropriate mechanisms and materials required for extending IPDM in Australian olives. The olive industry’s peak organization, Australian Olive Association (AOA), has played an important role in leadership, especially with development of the olive industry Australian Standard and Code of Practice, as well as the establishment of the industry levy. It has also organized annual Conferences, at which technical, management and marketing issues are discussed and communicated. However, it had not played a major role in industry extension. The AOA, through its new CEO, Greg Seymour, saw its role to increasingly play a part in disseminating (two-way) information to growers and other industry stakeholders. A key component of OL17001 was strong collaboration with

the AOA that will also ensure the extension materials produced as outputs of the project will be disseminated and maintained, well beyond the formal life of the project.

Methodology

The Project Team

A national project team was initially set up, involving a network of highly recognised IPDM researchers in olives and perennial horticultural crops, all of whom had extensive experience in industry extension and with particular expertise in olive IPDM; and links with state departments of primary industries. The team comprised Robert Spooner-Hart (entomologist; Western Sydney University [WSU], project leader), Dr Len Tesoriero (plant pathologist, NSW DPI/consultant), Barbara Hall (plant pathologist, SARDI), Stewart Learmonth (entomologist, DPIRD WA), and Prof Andrew (GAC) Beattie (entomologist WSU). Spooner-Hart and Tesoriero participated in all field days, the other collaborators participated in field days in their respective states. In addition, because Barbara Hall and Stewart Learmonth were contemplating retirement, their respective replacements (Dr Cathryn Todd and Alison Matthews) were included in the field days and reviewing extension outputs, to ensure a succession plan for the olive industry. Spooner-Hart, Tesoriero and Hall participated in the Masterclass, as did Prof Beattie and Dr Paul Milham (WSU). As previously stated, the AOA was an integral project collaborator, together with its network of state and regional associations and its platform and infrastructure for effective and efficient information dissemination.

Literature Review and Knowledge Gap Analysis

We collated and analysed existing national and international information on the three project target species: Black Scale, Olive Lace Bug and Anthracnose: their biology, management and research in progress, and also undertook a knowledge gap analysis to identify future research directions. Details of the literature review and knowledge gap analysis are provided in the Outputs section.

Baseline Industry Survey

An on-line national IPDM baseline survey was conducted in June 2018. A copy of the survey is provided in *Appendix 2*. In summary, the survey contained 30 questions in five sections:

- Orchard/grove attributes
- Pests & Diseases
- Integrated Pest & Disease Management
- Biosecurity
- Future Extension

The survey questions and feedback, particularly the current industry situation with regard to IPDM knowledge and practice, informed our development of workshop/field day activities and other extension outputs.

Workshops/Field Days

We conducted ten one-day workshops/field days in all olive-growing states: 2 in NSW (Marulan 10 Aug 2018, Lovedale-Hunter Valley 12 Aug 2018), 1 in Qld (Perseverance –Toowoomba Qld 3 Nov 2018), 3 in

Vic (Pomonal/Grampians 16 Nov 2018, Bright/Mt Buffalo 1 Feb 2019, Mornington Peninsular/Red Hill 3 Feb 2019), 1 in SA (Roseworthy 24 Nov 2018), 1 in TAS (Launceston 1 Dec 2018), and 2 in WA (New Norcia 15 Feb 2019, Margaret River 17 Feb 2019). The workshops were conducted in collaboration with local DPI staff as well as the AOA, with additional presentations on topics related to IPDM, including Olive Care® and tree health and maintenance, including pruning and canopy management. This approach enabled the building of local networks to provide for sustainability of the IPDM work beyond the life of the project. Furthermore, the other topics relating to grove management complemented the IPDM components of the field days.

In summary, the IPDM component was comprised of four sections:

- Principles and Practices of IPDM including feedback from the national survey (after the first field day, we held this session prior to lunch)
- Key arthropod pests and their management
- Key diseases and disorders and their management
- Field walk and discussion. Included IPDM and grove management, demonstration of drone technology and possible uses for monitoring crop health and pests and diseases

A colour copy of the IPDM presentations was provided at registration, and the AOA provided a 10X hand lens to each participant. A participant feedback form was completed at the end of the field days.

Following the formal closing of the workshop, an informal dinner or barbecue was provided to enable additional grower-grower and grower-speaker networking. A detailed field day program is presented in *Appendix 3*.

Master Class

A free two-day Master Class was conducted on 25-26 September 2019 at the Hawkesbury campus of WSU, Richmond NSW. A wide advertising campaign was conducted throughout the industry, via the AOA and featured in the August and September issues of *Grove Innovation* (see examples in *Appendix 6*); additionally, it was advertised through the Hort Innovation and Western Sydney University communications channels as well as via direct contact with key organisations providing consultancy services and agrichemical suppliers to the Australian olive industry.

In addition to Spooner-Hart, Tesoriero and Hall, WSU presenters included Prof Andrew Beattie (biological control of scales, spray oils in IPDM); Dr Paul Milham (soil chemistry, leaf nutrient analysis); and Dr Tom Jeffries (soil health and microbiology). Following feedback from the field days, in addition to direct information on the biology and sustainable management of pests and diseases of olives, the program included information related to soil health and its impacts on plant health that had been presented to a recent Soils Master Class. It also featured the latest findings on black scale biology and its natural enemies in Australia, from a recently completed WSU PhD study. There was a detailed presentation and discussion on the potential for use of horticultural spray oils for management of olive pests, in particular black scale. The program also scheduled a hands-on laboratory session in the second half of Day 1, in which the participants were provided access to live specimens of all the key olive pests and diseases, with discussions by the presenters on symptoms of damage, diagnosis, life stages, different strains of *Colletotrichum* spp., and identification of bacterial ooze from active olive knot (*Pseudomonas savastanoi* pv. *savastanoi*). All presentation materials were provided to participants. A detailed report on the Master Class is provided as *Appendix 4*.

IPDM Extension Outputs

Tutorials

We developed nine **on-line tutorials** in PowerPoint/PDF format for industry. Tutorials comprise 12-20 slides, and completion time is expected to be 10-15 minutes each. Each tutorial includes a brief knowledge self-assessment, as well as questions to prompt changes for improved practices as a result of completing it. Details of the tutorials and their topics are provided in the Outputs section.

Flyers

We developed nine **1-2 page summary flyers** in PDF format of information on key pests and their management, particularly for use by advisors, consultants and pesticide suppliers, as well as growers. Originally, six flyers were planned; however, following discussions with growers and the AOA, a further three flyers were developed. Details of the flyers and their topics are provided in the Outputs section.

Field guide

A revision was undertaken of the 2007 **Field Guide to Olive Pests, Diseases and Disorders** (RIRDC/AgriFutures, Spooner-Hart et al.), in electronic format, providing updated Australian information as well as inclusion of new exotic pests and diseases. It supports the identification of possible pests, diseases and disorders, as well as beneficial natural enemies in olive groves. Details of the Field Guide is provided in the Outputs section.

Best practice manual

A **Best Practice IPDM Manual**: a supplementary extension tool, providing “how to” explanatory information on IPDM strategies, enabling more informed decision making. It includes more detailed information on biosecurity, cultural strategies, biological control strategies, appropriate selection and use of pesticides as well as an IPDM seasonal checklist and plan. Details of the Best Practice Manual is provided in the Outputs section.

Status of extension materials

The projects outputs materials were presented and demonstrated to industry by Robert Spooner-Hart and Len Tesoriero at a **Webinar** conducted on 1 September 2020. The follow-up survey for the project was discussed. Participants were also able ask questions on any pest and disease topic during the webinar and after the presentation.

All of the above outputs are now available to industry via the AOA’s website at <https://olivebiz.com.au/ipdm-project-outputs/>. Master copies of the materials provided to the AOA, to enable them to be revised and updated well beyond the life of the project.

End-of-Project Survey

Finally, we conducted an end-of-project survey in September 2020. In summary, the survey contained 23 questions in four sections (see *Appendix 6*):

- Orchard/grove attributes
- Pests & diseases
- Integrated Pest & Disease Management (including participation in olive IPDM project activities)
- Biosecurity

A number of these questions were common with the initial 2018 baseline survey, to enable consistency with regard to farm attributes, and particularly to enable comparisons between grower-expressed knowledge on pests and diseases and IPDM prior to and after the project interventions. There were also several questions directly related to participation in and grower outcomes from the project’s activities.

Most importantly, this survey aimed to determine the project's impact and how effectively it met its objectives of more informed and more engaged growers with respect to IPDM.

Other Activities and Industry Communications

Update reports on the project were presented by the project leader at the National Olive Industry Conference & Trade Exhibition AOA national conference in Wagga Wagga in October 2018, and in Albury in October 2019. In addition, he conducted IPDM grove walks as part of the conference programs.

Outputs

Literature Review and Knowledge Gap (*Appendix 1*)

The collated and analysed existing national and international information on the three project target species: Black Scale, Olive Lace Bug and Anthracnose: their biology, management and research in progress, and knowledge gap analysis to identify future research directions is provided as *Appendix 1*.

With respect to black scale, there were no high priority knowledge gaps identified. However, there was a paucity of information on olive lace bug, primarily because it is a native species, and work is required to elucidate its biology and ecology as well as sustainable management strategies. With respect to anthracnose, the review identified the need for systematic surveying for species of *Colletotrichum* associated with olive anthracnose around Australia, in light of recent taxonomic revisions of this genus, as well as the need to investigate alternative fungicide groups (particularly organically acceptable) for anthracnose management.

Baseline Industry Survey

A detailed report on the results and findings of the baseline industry survey is presented as *Appendix 2*. There were 130 survey responses, with a good distribution of respondents, especially across the key olive-growing states and with a range of production systems. The survey was highly successful, in its capture of a substantial number of growers, representing more than 75% of the olive production in Australia. These results should therefore have been representative of the industry as a whole. The three major plant protection problems identified in the survey were black scale, olive lace bug and anthracnose. This was heartening, as these three were the major focus of the project. However, responses indicated that different states and even different regions may have different plant protection problems. For example, weevils were a problem in WA, some parts of SA, Vic and NSW; whereas olive lace bug was not a major problem in SA, southern Vic or Tas. Growers experienced greater difficulty in identifying diseases than they did insect pests. As a result, the project team substantially broadened the range of pests and particularly diseases included in our field day presentations and all other project outputs.

Approximately two-thirds of respondents indicated that pesticides were important or very important for pest and disease management. Growers obtained their information on pesticide use from a wide range of sources, but the most common was the AOA website. This validated our decision to provide access to the current project outputs via the AOA website OliveBiz. Almost two-thirds of growers also indicated they knew either nothing or only a little about IPDM. The survey further indicated there was a lack of knowledge and implementation of on-farm biosecurity. The project team therefore decided to include a web-based tutorial on biosecurity, and the industry's OliveCare® program also increased its coverage of this topic, including in the IPDM workshops/field days.

Workshops/Field Days

A report on the ten workshops/field days is provided as *Appendix 3*.

Attendance was very good, with a total of 275 growers attending: with numbers from 12 to 41, depending on the location. The number of attendees were: Marulan NSW 41; Lovedale NSW 28; Perseverance Qld 12; Pomonal /Grampians Vic 20; Buffalo/Bright Vic 36, Red Hill/Mornington Peninsular Vic 37; Roseworthy SA 37; Launceston Tas 25; New Norcia WA 14; and Margaret River WA 25.

Written feedback from attendees was extremely positive. Although there were some venue differences (especially relating to comfort of the venue (e.g. hall/shed and weather, and also with the grove used for the field walk), all activities scored an overall mean of 4.5 or above (out of 5), with the IPDM Principles & Practice and Olive Pests and Diseases sessions scoring highest at 4.8/5. The format that allowed informal discussions, during breaks and the after-field day social gathering, was highly appreciated. Apart from their interactions with the “experts”, many commented on the benefits they derived by talking to other growers.

Master Class

A report on the Master Class is provided as *Appendix 4*. Despite a wide advertising campaign throughout the industry, via the AOA, Hort Innovation and Western Sydney University communications channels as well as via direct contact with key organisations providing consultancy services and agrichemical chemical suppliers to the Australian olive industry, there were only three attendees, although two of them represented the largest olive producer. The attendees provided extremely positive feedback to most of the sessions, with most sessions scoring 4 or 5/5. Participants also indicated that they would be looking to implementing changes to their IPDM program, particularly with regard to black scale monitoring and exploring options for use of oil sprays.

IPDM Extension Outputs

A range of industry IPDM extension outputs, including on-line tutorials, flyers, a revised Field Guide to Olive Pests, Diseases and Disorders, and an Olive Best Practice IPDM Manual were developed and are now available to industry via the AOA’s website at <https://olivebiz.com.au/ipdm-project-outputs/>

Tutorials

We developed nine on-line tutorials in PowerPoint/PDF format for industry, on the following topics:

1. Principles and practices of Integrated Pest and Disease Management
2. Monitoring for pests and diseases in olive groves
3. Biosecurity, including pests and diseases not present in Australia
4. Black scale: biology, damage and management
5. Olive lace bug: biology, damage and management
6. Apple weevil: biology, damage and management
7. Anthracnose: life cycle, conditions conducive, symptomatology and damage, and management
8. Peacock spot: life cycle, conditions conducive, symptomatology and damage, and management
9. Cercospora leaf mould

The tutorials are available on the AOA’s OliveBiz website at <https://olivebiz.com.au/ipdm-online-tutorials/> **Flyers**

There were 9 1-2 page flyers developed. In addition to growers, we believe they will be of use for advisors, consultants and pesticide suppliers. Topics of the flyers are:

1. Black scale
2. Olive lace bug

3. Weevils
4. Anthracnose
5. Peacock spot
6. Cercospora leaf mould
7. Olive wood rots and dieback
8. Exotic pests and diseases
9. Current chemical options for key pests and diseases

They are available on the AOA's OliveBiz website at <https://olivebiz.com.au/ipdm-flyers/>

They are also provided as *Appendix 5*.

Revised Field Guide

A revised Field Guide to Olive Pests, Diseases and Disorders was produced by Robert Spooner-Hart, Len Tesoriero, Barbara Hall and Stewart Learmonth as an output of the project. It provides updated Australian information as well as inclusion of new exotic pests and diseases (such as *Xylella* and *Verticillium* wilt [defoliating strain]). It is primarily to assist in identification of possible pests, diseases and disorders, as well as important beneficial natural enemies. It is in clickable search form. It is available on the AOA's OliveBiz website at <https://olivebiz.com.au/ipdm-revised-field-guide/>

Best Practice IPDM Manual

The Best Practice IPDM Manual: a supplementary extension tool, providing “how to” explanatory information on IPDM strategies, enabling more informed decision making. It includes more detailed information on biosecurity, cultural strategies, biological control strategies, appropriate selection and use of pesticides as well as an IPDM seasonal checklist and plan. It is available on the AOA's OliveBiz website at <https://olivebiz.com.au/best-practice-ipdm-manual/>

End-of-project Survey

A report on this survey is presented as *Appendix 6*. There were 47 survey responses, compared with 130 responses in the original baseline survey. This reduced number is likely, at least in part, due to “survey fatigue” associated with the substantial increase in on-line communications as a result of COVID-19 restrictions on travel and personal engagement. Nevertheless, there was a good distribution of respondents, especially across the key olive-growing states and with a range of production systems, meaning it should be highly representative of the industry as a whole.

Grower responses to questions related to the project's activities, the project's impact, and how effectively it met its objectives are discussed in the Outcomes section of this report.

Other Project Industry Communications

Field days provide the missing link. Australian and New Zealand Olive Grower and Processor, September 2018 pp. 6-8.

Interest in IPDM proves strong at NSW field days. R&D Insights, Grove Innovation News, November 2018.

IPDM Field day program: it's a wrap. R&D Insights, Grove Innovation News March 2019.

WSU-AOA IPDM Field day resources online and accessible 24/7. Grove Innovation News March 2019.
Examples of industry communications about the project and its activities are provided in *Appendix 7*.

Outcomes

Project Outcomes in the Context of the Original Brief (RFP)

This project was tasked to focus on management of the three most economically significant pests, Black scale, Olive Lace Bug and Anthracnose. While the industry knows how to deal with these pests and diseases, growers lose focus on important detail, don't have a simple "how to guide" to assist and encourage them, and each feels they are "working on their own". Thus, the task was to "coordinate the provision of integrated pest and disease management extension services to the Australian olive industry, with the aim of reducing reliance on the use of IPM disruptive chemical control options".

It delivered on strategies from two Industry Outcomes in the Olive Strategic Investment Plan 2017-2021, in particular "Developing extension packages and delivery models appropriate to the industry, including pest and disease management fact sheets".

The project team through its comprehensive engagement plan of two industry surveys, a series of ten field days, a Master Class and production and dissemination of an array of extension outputs, including on-line tutorials, information flyers, a revised Pest and Disease Field Guide and a Best Practice Handbook, exceeded the original project plan. This aspect of the project is discussed further in the Monitoring and Evaluation section of this report.

Industry Engagement with Project Outputs

The on-line outputs were launched at a Webinar on 1 September 2020, and access to them was logged by the AOA until 19 October 2020 (i.e., a period of seven weeks). The number of page views ("hits") are presented in Table 1. Considerable engagement occurred over the relatively short period of time. Interestingly, the number of views of the IPDM Outputs Home Page exceeded the number of attendees at all Field Days. Of the specific outputs, the Field Guide and Best Practice Manual were the most frequently accessed; although the tutorials and flyers were also popular, with more than 100 views each.

Table 1. Engagement with on-line project outputs 01/09/20 - 19/10/20

NUMBER OF PAGE VIEWS	URL	OUTPUT
314	/ipdm-project-outputs/	IPDM Output Home Page
148	/ipdm-revised-field-guide/	Field Guide
116	/best-practice-ipdm-manual/	Best Practice Manual
110	/ipdm-online-tutorials/	Tutorials Home Page
104	/ipdm-flyers/	Flyers Home Page
126	/webinar-ipdm-project-resources/	Webinar on Outputs
48	/ipdm-project-resources-now-available/)	Grove Innovation Article (15/9/20) on IPDM Outputs
Metrics period = 01/09/20 - 19/10/20; logged by AOA		

Numbers attending, and feedback from extension activities

We were able to engage with a large number of olive growers around Australia during the field days, with a total of 275 attendees. Feedback from attendees was extremely positive, with the IPDM Principles & Practice and Olive Pests and Diseases sessions very highly (4.8/5). More than 85% of attendees stated that they had learned new information from the field day with respect to pests and diseases and IPDM, and almost half indicated they would be changing their pest management practices as a result. Most frequently stated changes related to monitoring practices, tree health and canopy management, better selection of chemical and non-chemical choices and developing a farm biosecurity plan.

Of the growers that participated in the end-of-project survey, approximately 65% had attended a field day. This suggests that many growers had a continuous engagement with project activities over an approximately 2-year period following field day engagement.

With regard to the **Master Class**, despite there being only three attendees, the feedback was also very positive with all indicating that they had learned a deal of new information and would be looking to implement changes in their IPDM programs.

End-of-project survey feedback

There were 47 survey responses, compared with 130 responses in the original baseline survey. This reduced number is likely to be, at least in part, due to “survey fatigue” associated with the substantial increase in on-line communications as a result of COVID-19 restrictions on travel and personal engagements. Nevertheless, there was a good distribution of respondents, especially across the key olive-growing states. The CEO of AOA indicated it should be highly representative of the industry as a whole (pers. comm., 21 Oct 2020). The results of the end-of-project survey are compared in the following sections with those of the baseline survey, to enable estimates of the project’s impact and how effectively it met its key objectives of more informed and more engaged growers with respect to IPDM. Key survey data are compared in Table 2.

**Table 2. Comparative summary of key data from Baseline and End of Project Surveys
(percentage rounded to whole numbers)**

		BASELINE SURVEY % GROWERS (N= 130)	END OF PROJECT SURVEY % GROWERS (N= 47)
LOCATION	NSW	25	21
	VIC	35	32
	SA	17	23
	WA	13	15
	TAS	6	6
	QLD	2	2
PRODUCT STATUS	Oil	62	51
	Oil and table	32	38
	Table only	6	9
ORGANIC PRODUCTION STATUS	Registered organic/in conversion	9	22
	Not organic, but interested	20	46
MAJOR ARTHROPOD PESTS (and states where problem)	1	Black scale/ants (all states)	Black scale/ants (all states)
	2	Olive lace bug NSW, Vic, WA, Qld	Olive lace bug
	3	Weevils WA, SA	Weevils WA, SA, Vic
	4	Others: Grasshoppers, Rutherglen bug, Fruit fly	Others: Grasshoppers, Rutherglen bug, Fruit fly
MAJOR DISEASES	1	Anthrachnose (all states, exc. Tas)	Anthrachnose (all states, exc. Tas)
	2	Peacock spot	Cercospora leaf mould
	3	Dieback	Peacock spot
	4	Phytophthora/ Verticillium	Dieback
PESTICIDE USE AS IMPORTANT STRATEGY		66	70
GOOD KNOWLEDGE OF IPDM		30	52
CONFIDENT IN IDENTIFY KEY INSECT PESTS		80	93
CONFIDENT IN IDENTIFY KEY DISEASES/DISORDERS		62	88
CONFIDENT IN IDENTIFY BENEFICIAL SPECIES		40	54
MONITOR GROVE FOR PESTS AND DISEASES		80	93
HAVE VEHICLE WASHDOWN FACILITY		51	71
HAVE FARM BIOSECURITY PLAN		18	34
HAVE READ OLIVE BIOSECURITY PLAN		12	45

Status of pests and diseases between the two surveys

With regard to arthropod pests, the three major species identified in the end-of-project (2020) survey were the same as those in the baseline (2018) survey, namely (in order): black scale (with associated ant activity), olive lace bug and apple weevil (Table 2). The most widely distributed pest (reported in all states) was black scale, with olive lace bug a major pest in NSW, Qld, WA and some parts of Victoria. Apple weevil was a problem in WA, and less but increasing in SA and Vic.

Interestingly, however, there was a change in status of the three most important diseases/disorders reported. Whilst anthracnose was still the major disease, cercospora leaf mould (*Pseudocercospora cladosporioides*) was the second most important (previously this had been peacock spot, caused by *Fusicladium oleaginum*) (Table 2). This is unsurprising to the project team, because we discovered widespread distribution of cercospora leaf mould during the field day activities, although its economic damage was difficult to determine. As a result, we developed a tutorial and a flyer on this disease. Dieback was the next most common disease/disorder. However, this condition is associated with a number of pests and diseases including black scale, olive lace bug, anthracnose, peacock spot and cercospora leaf mould, soil-borne pathogens, as well as adverse environmental conditions, so it is difficult to diagnose the most likely cause(s). As a result, we developed an additional flyer on Wood Rots and Dieback (see *Appendix 5*). Peacock spot was relegated to the third most important disease in the end-of project survey. It is suspected that most leaf spot/leaf drop prior to our project activities (and thus recorded in the baseline survey) was attributed to peacock spot; clearly, this has been a major achievement of the project in rectifying this issue. However, it may have also led to an over-inflated concern about cercospora leaf mould, and hence, its apparent rise in status. Hopefully, our project outputs that clearly describe the different symptoms of these pathogens (tutorials and flyers have been developed for both of these diseases), together with the strong recommendation in a number of our outputs to obtain definitive disease diagnoses from qualified laboratories in the event of uncertainty, will alleviate this issue.

Pesticide use

While nearly 70% (cf. 66% in baseline survey) of respondents indicated that pesticides were important or very important for pest and disease management, these included organic chemical options (Table 2). As a result, the selection and appropriate use of chemical options remains an important extension issue for the industry and should continually be reviewed by the industry in collaboration with Hort Innovation.

Participation in project activities

Seventy-nine percent (37/47) of the respondents participated in at least one other IPDM project activity. Of those that did, the most common activity was participating in the first survey, in field days/workshops, attending the webinar and accessing the project outputs on the AOA's website OliveBiz (particularly the Field Guide and IPDM Manual) (Table 3). Amongst the growers that participated in project activities, 89% responded that their knowledge been improved as a result. Common responses as to which knowledge were improved pest, disease and beneficial identification, better understanding of biology and life cycles, information on alternatives to chemicals, planning of spray timing, and access to project output materials.

When growers were asked whether their IPDM practices have changed, or were anticipated to change as a result of their participation in the project, 60% responded that they would change and 23% were unsure. The most common responses for change were increased emphasis on monitoring and record keeping, better tree health and canopy management, and investigating options (including organic ones) to chemicals before undertaking pest and disease control options.

Table 3. Project activity participation (%) of growers that completed end-of-project survey

Activity	Percentage participation
The previous (2018) project survey	64.9%
Attended a field day	64.9%
Attended the Master Class	8.1%
Attended the Webinar	35.1%
Accessed video(s) of Field Day presentations via OliveBiz	18.9%
Accessed new on-line tutorials	13.5%
Accessed new on-line flyers	21.6%
Accessed the revised Field Guide	32.4%
Accessed the IPDM Manual	32.4%
Direct contact with the project researchers	18.9%

Growers' IPDM knowledge and practices

With regard to the growers' end-of-project knowledge of IPDM, approximately 52% indicated they knew it well or quite a lot, compared to 30% in the baseline survey (Table 2). Ninety-three percent (cf. 80% in baseline study) stated they were confident in identifying important pests, compared with 88% (62%) confident in identifying diseases and disorders, and with 54% (40%) being confident in identifying beneficial species. Furthermore, 80% (70%) were confident they can now effectively monitor their grove. These are substantial improvements from the baseline data, and is an excellent outcome for the project in just over two years. Ninety-three percent (cf. 80%) of respondents indicated they monitored for pests and diseases in their grove, with visual observations the most common practice, with one third of growers also utilising meteorological data to predict outbreaks, especially of fungal diseases. One grower is using drone or other imaging technology

With regard to implementing IPDM practices (including monitoring), the most common problems were (in order) black scale and associated ant activity, foliar diseases, olive lace bug, fruit diseases and rots and root and stem diseases (Table 2). This is similar to the baseline survey, but with an apparent increase in foliar disease monitoring.

Biosecurity practices

With regard to biosecurity, over 71% of respondents in the end-of-project survey (cf. 50%) had vehicle wash down facilities on their grove, 34% (18%) had a farm biosecurity preparedness plan and 45% (12%) had read the current (2016) version of Biosecurity Plan for Olive Industry (Table 2). Sixty-two percent agreed they assessed visitors before, or on, arrival for the risk that they might bring a pest or disease onto their property (this question was not asked in the baseline survey). The surprisingly substantial increase in implementing biosecurity activities can, in part, be attributed to the project's activities including producing a tutorial on the topic, including a section in the IPDM manual, and including exotic pests and diseases in a tutorial, a flyer, and as a major section in the Field Guide. It was undoubtedly also influenced by communications from the OliveCare® Administrator, Peter MacFarlane (including at the project workshops/field days), and increasing industry concern over the serious exotic olive disease *Xylella fastidiosa* (including contributions to project activities by the Program Manager, National Xylella Preparedness Program, Craig Elliot).

Additional grower feedback from the end-of-project survey

In addition to positive comments on the project, there were a number of useful additional comments. One related to the need for continual updating of the project outputs, another requested a Master

Class, and another suggested even more emphasis on tree health.

Future Legacy of the Project Outputs and the Olive IPDM Succession Plan

The project team deliberately organized a succession plan for the olive industry with regard to IPDM. First, it engaged the replacements for soon-to-retire long-standing olive researchers/extension personnel Barbara Hall (SARDI) and Stewart Learmonth (DPIRDWA) in various project activities, including field days and editing extension outputs. The project leader (RSH) has also developed a succession plan at Western Sydney University for an entomologist/extension person with experience in sustainable horticulture to continue this work when he retires.

Monitoring and evaluation

Achieving Project Outcomes

The end of project outcomes as outlined in the project's M&E plan were that growers would

- have a better understanding of life cycles and biology of the three key pests/diseases (Black Scale, Olive Lace Bug and Anthracnose),
- be better able to identify the key pests/diseases and natural enemies,
- be better able to implement effective pest and disease monitoring,
- improve their surveillance of pests and diseases,
- implement best practice for quarantine/sanitation, and
- use chemical, organic and non-chemical pest and disease interventions ensuring minimal impacts on olive product quality and safety.

Furthermore, it was intended that mechanisms and platforms would be in place to ensure ongoing IPDM extension and communication beyond the life of the project.

Nevertheless, although rather ambitious, these objectives have been achieved (particularly with respect to grower learning and changes in IPDM practices), as evidenced by comparison between the baseline and end-of-project surveys, feedback provided by growers at the workshops/field days and the Master Class, and the feedback provided by the CEO of the AOA. The intention to ensure extension and communication beyond the project was realized with the engagement of junior state DPI researchers in SA and WA in project activities and the development of a succession plan at WSU. Additionally, arrangements have been put in place whereby the AOA will maintain the web-based project outputs on behalf of the industry, providing on-going access and revision as required.

Formal summative Industry Feedback on the project was received from Greg Seymour, CEO of the Australian Olive Association (*Appendix 8*). In part, the feedback states that the project ticked all the boxes for improved management in the industry:

“Improved management begins with recognition of the need to improve, followed by access of quality information, and finally an environment that builds confidence of the manager, and fosters the implementation of improved management techniques. ...The attendance numbers and engagement levels of producers is testimony to the strategic applicability of the project. The final survey responses reporting high levels of adoption of IPDM management recommendations provide the evidence for a well-executed project.

The industry is grateful that such high-quality outputs from the project have been posted on the industry's OliveBiz website and have been provided in a form that can be updated from time to time when new information becomes available.

I have noted in industry events such as workshops, field days and conferences over the past couple of years that the IPDM message is resonating strongly with producers. The ‘lessons’ learned by producers at the IPDM/AOA field days are top of mind, judging by the comments and questions incorporating aspects of IPDM management e.g., if I do x, how will that impact my IPDM program?

Finally, the relaxed, personal, and interactive nature of the field events led by you and Dr Len Tesoriero made the experiences memorable and enjoyable for growers and has provided the benchmark for all our subsequent extension activities”.

Conversely, the project team's close working relationship with the AOA, especially with regard to communications about the project, collaboration in workshops/field days and hosting the industry surveys and its electronic outputs, undoubtedly contributed to the project's success in engaging with olive growers.

Engagement of Intended Beneficiaries

There was a high level of grower engagement in the project, as evidenced by high attendance at workshops/field days, and good participation in the surveys, the webinar and accession of the project's on-line outputs. In fact, of all project activities (other than accession of the Home Page of the project's outputs) the workshops/field days had the greatest number of participants. More details of engagement are presented in the Outcomes section of this report.

We attribute the high field day attendance and the positive feedback to a number of factors:

- This was the first time for quite a while that researchers visited regions to engage directly with growers
- We organized as many field days as possible on weekends, because many of the olive growers we wished to engage with are part-time
- We developed and conducted a full day of activities, to make travel and attendance worthwhile
- We conducted the field days on farms of key growers, wherever possible, and provided a combination of formal presentations, discussions and field walks in the host growers' groves
- We allowed time for interactions between growers during and after the formal sessions
- We collaborated with the AOA, including with field day advertising and registration

The project team kept industry well informed about the project and its activities via the AOA's communication channels of OliveBiz, OliveCare®, Grove Innovation and Olive Grower and Processor (see *Appendix 7*), as well as giving presentations at the national conferences and via project milestone reports.

Project Outputs and the Olive IPDM

The end-of-project outputs in the project plan were:

- Literature review, and gap analysis
- Baseline and end-of-project IPDM grower surveys
- Web-based learning modules (tutorials) and flyers
- IPDM Manual and revised Field Guide
- Extension activities: 9 Workshops/Field days and 2-3 Master Classes

These outputs were generally achieved, and in some cases, exceeded. For example, there was a broader range of pests and diseases addressed than in the original RFP brief for the three key ones; this emphasis occurred in all outputs, including field days, tutorials and flyers and the Field Guide and Manual. As a result, the number of tutorials produced was increased from six to nine and the number of flyers increased from five to nine.

Also, ten field days were conducted rather than the initially envisaged nine, because of their popularity; they were initially oversubscribed in Victoria (we were aiming at a maximum of 35 participants to enable effective discussion and other social interactions, although this was occasionally exceeded). Conversely,

only one Master Class was conducted although two and possibly three were originally envisaged. This decision was reluctantly taken because of the extremely poor attendance at the initial Master Class, and it followed discussions with both the AOA and Hort Innovation. Two further field days scheduled to “replace” the Master Class and to showcase the project outputs to industry were abandoned due to COVID-19 restrictions, but were replaced with a Webinar specifically designed for this purpose.

Maximising Research/Industry Benefits

The strong collaborative links formed with the AOA from the outset of this project provided more efficient, effective, industry engagement. Furthermore, as a consequence of its engagement in this project the AOA is now playing a more active role in industry extension, including in future IPDM.

Recommendations

1. We recommend that the on-line materials (tutorials, flyers, Field Guide and Best Practice Handbook), be maintained by the AOA and made available to all levy-paying olive growers. The AOA should also be tasked with reviewing and updating the information in these outputs, as required.
2. The AOA should conduct IPDM field days and related extension activities from time to time, to foster field experience and grower-to-grower learning.
3. Where possible, state DPI researchers/extension staff (particularly those involved in the current activities) should be part of future extension activities. This would encourage the building of strong associations and networking, particularly for biosecurity activities and future industry-focused research.
4. Opportunities should be explored for conducting future IPDM Master Classes, particularly for participation by consultants and chemical resellers.
5. Overseas and Australian data should be collated on olive cultivar susceptibility to a range of key pests and diseases, in particular anthracnose and other fruit diseases, to assist growers in selecting suitable varieties for planting in known disease-prone areas. This may require obtaining objective field data in Australia on cultivar susceptibility to verify current anecdotal information.
6. It is recommended that the alternative strategies for olive lace bug management be investigated, particularly for organic growers. These investigations should include elucidating its biology, ecology and natural enemies, as well as organically-acceptable insecticides and other non-chemical management strategies. Similarly, alternative strategies for management of foliar and fruit pathogens should be investigated or adopted from overseas studies, particularly for organic growers, where currently copper is essentially the only option.

Refereed scientific publications

Spooner-Hart, R., Tesoriero, L., Hall, B., Learmonth, S., 2020. Field Guide to Olive Pests, Diseases and Disorders (second edition). Horticulture Innovation Australia Limited, Sydney.

References

- Dal Santo, P., AgAware Consulting, 2009. Strategic Agrichemical Review Process, RIRDC, Canberra.
- Hall, B., Tesoriero, L., Spooner-Hart, R., 2012. Diseases and disorders of olives in Australia. *Acta Horticulturae* 949: 323–327.
- Hort Innovation, 2017. Olive Strategic Investment Plan 2017-2021.
<https://www.horticulture.com.au/globalassets/hort-innovation/levy-fund-financial-and-management-documents/sip-pdfs-new/hortinnovation-sip-olive-2017-2021-revised.pdf>.
- Sergeeva, V., Hall, B., Tesoriero, L., Spooner-Hart, R., 2011. Olive diseases and disorders in Australia and New Zealand. In: Schena, L., Agosteo, G.E., Cacciola, S.O. (Eds.), *Olive Diseases and Disorders*. Transworld Research Network, Kerala, India. ISBN 978 81 7895 539 1. pp. 357–377.
- Spooner-Hart, R., 2005. Sustainable Pest and Disease Management in Australian Olive Production. Rural Industries Research and Development Corporation, Canberra. Publication No. 05/080 Rural Industries Research & Development Corporation Canberra ISBN 1 74151 143 7.
- Spooner-Hart, R., Tesoriero, L., Hall, B., 2007. Field Guide to Olive Pests, Diseases and disorders in Australia. Rural Industries Research and Development Corporation, Canberra, Australia. 68 pp.

Intellectual property, commercialisation and confidentiality

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

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Dr Cathryn Todd (SARDI)

We also particularly thank the olive growers that hosted the project field days

Appendices

Appendix 1. Literature Review

Appendix 2. Report on base-line survey

Appendix 3. Report on workshops/field days

Appendix 4. Report on Master Class

Appendix 5. IPDM flyers

Appendix 6. End-of-project survey

Appendix 7. Other project communications

Appendix 8. AOA formal feedback on project

Appendix 1. Literature Review

LITERATURE REVIEW AND KNOWLEDGE GAP ANALYSIS

Introduction and background

The olive industry in Australia comprises approximately 900 growers. Only about 21 of these are considered as operating on a large scale (more than 80 hectares), and a further 64 growers operate between 20 to 79 hectares. While the majority of production is from a single grower, the vast majority of growers are considered boutique (Hort Innovation 2016). There has been an industry shake-up, associated with competition and economics of production. One of the characteristics of this shake-up is that there has been a rapid turnover of properties (especially small and medium growers), so that there are a number of new entrants into the industry. The shake-up has also led to abandoned groves, which pose a pest and disease risk. Second, many olive growers are part-time or hobby farmers, resulting in a number of them visiting their groves infrequently. However, most growers are well read and are familiar with modern communication technology. There has consistently been an industry interest in IPDM and sustainable production with a significant minority interest in organic and biodynamic production. Although Australia is currently free of many important olive pests and diseases, it nevertheless has other cosmopolitan as well as endemic plant protection problems (see Biosecurity).

With the rapid expansion of the olive industry in Australia in the 1990s, the first work to comprehensively address pests and diseases in Australian olives was undertaken by Spooner-Hart and colleagues (Spooner-Hart 2005). This project conducted the first national survey on pests and diseases; monitored pests, diseases and beneficial species in key olive growing districts; and conducted workshops/field days nationally on pest and disease recognition, monitoring and sustainable management. The five most important arthropod pests were in order: black scale and associated ants, olive lace bug, grasshoppers, weevils, and scales green other than black scale. However, there were 20 pests identified and “other pests” i.e. not on the list ranked high. Of the diseases, the most important were in order: peacock spot *Fusicladium oleagineum*, phytophthora root rot (*Phytophthora* spp.), anthracnose (*Colletotrichum* spp.), rhizoctonia root rot (*Rhizoctonia* spp.), and verticillium wilt (*Verticillium dahliae*). It is noticeable that there is a heavy preponderance of root diseases, which was probably representative of the early stages of development (establishment) of many groves at the time. Since then, two Strategic Agrichemical Review Processes (SARPs) have been conducted for the olive industry: 2008 via RIRDC (Dal Santo 2009), and 2014 via HIA, in which key pests and diseases were identified, the chemical options for their management evaluated and recommendations for new options recommended. These reviews have indicated that while the two most important olive insect pests remain black scale and olive lace bug, there has been a shift in relative importance of pathogens, with diseases of “established” groves, including anthracnose (caused by *Colletotrichum* spp.), grey mould/cercosporosis (*Pseudocercospora cladosporioides*) and olive knot (caused by *Pseudomonas savastanoi* pv. *savastanoi*) becoming more prominent.

Based on the feedback from the survey and subsequent field days, a “ute handbook” Field Guide to Olive Pests, Diseases and Disorders in Australia (Spooner-Hart et al. 2007) was developed. This is still widely used, including as an electronic version. However, the Field Guide was primarily designed for diagnosis, and while it included a section on IPDM principles, and a “how to monitor groves” section, it didn’t provide details of chemical options (that were rapidly changing) and only limited information on non-chemical options for pest and disease management.

The current project, **An Integrated Pest and Disease Management Extension program for the Olive Industry**, aims to develop, coordinate and provide industry with appropriate integrated pest management extension services focussed on sustainable (including organic) management of the three major olive pests/diseases, namely Black Scale, Olive Lace Bug, and Anthracnose. While a number of large growers have well-developed IPDM and monitoring programs, a number of medium size growers and smaller “boutique” and “organic” growers are having difficulty effectively managing their pest and disease problems, despite a deal of information being available, and improvements in technology for monitoring and diagnosis. This has been exacerbated by turnover of properties so that

there are a number of new entrants into the industry. Our project therefore aims to deliver an industry engagement strategy to provide appropriate, high quality outputs for sustainable management of these three key plant protection problems, which we believe will be well adopted by the Australian olive industry.

Black Scale

Saissetia oleae has a world-wide distribution and has attained the status of a pest mainly within temperate zones of the northern and southern hemispheres (California, Chile, Mediterranean regions, and southern Australia). It is widely distributed in Australian olive production areas (Spooner-Hart et al. 2002) and also occurs in citrus orchards in coastal and inland regions of New South Wales, Victoria and South Australia, and in coastal regions of southeast Queensland and southwest Western Australia (Hely et al. 1982; Smith et al. 1997). Lin et al. (2017) recently reported the first record of two other *Saissetia* species, *S. miranda* and *S. neglecta*, in northern Australia.

Black scale has a wide range of hosts, including all commercial varieties of olive and citrus, (Quayle 1938; Simmonds 1951; Hely et al. 1982; Smith et al. 1997). Smith & Compere (1928) noted that black scale was the most important pest in both the olive and citrus industries in California. In the Mediterranean region, where 95% of the nearly 800 million olive trees of the world are grown, black scale is one of three of the most important olive pests, the others being olive fruit fly *Bactrocera oleae* and olive moth *Prays oleae* (Tena 2007). According to Haniotakis (2005), the scale is considered a major secondary pest, occurring throughout the region and causing damage of major economic importance only locally or occasionally. It was previously categorised as a major secondary pest, but its status as an olive pest in the Mediterranean region was reduced because of the advances in pest management including biological control based on a range of parasitoids. Biological control has also proved effective in northern and coastal olive groves of California (<http://www.ipm.ucdavis.edu/PMG/r583300511.html>, accessed 18 March 2018).

Black scale is oviparous and generally parthenogenetic (Argyriou 1963; Blumberg et al. 1975; Bartlett 1978; Briales & Campos 1986; Waterhouse & Sands 2001). Reports indicate considerable variation in fecundity. Quayle (1911) reported a range of 200-3,000 eggs per female, and Smith et al. (1997) in Australia about 2,000. In eastern Spain, Tena et al. (2007) recorded a maximum of 2,675 for a female scale on olive trees in spring, in contrast to a maximum of 774 eggs in autumn.

After hatching, crawlers move from the egg chamber beneath the mother's body and then wander over the surface of the host plant, searching for a suitable location to settle. Although it can take up to 36 h, crawlers usually settle within 2–3 h. Generally, they prefer to colonise the nearest suitable location to the mother scale. As a result, they tend to form groups with a high, aggregated distribution on host plants (Briales & Campos 1988). Crawlers prefer settling along leaf midribs, mostly towards the petiole on the lower surfaces of leaves, in the lower parts of tree canopies (Argyriou 1963; Orphanidis & Kalmoukos 1970), and on young shoots (Smith et al. 1997). The dispersal of the crawlers may happen actively or passively (Pellizzari 1997). Active movement of the crawler was explained above. The most important means of passive dispersal is by wind, which can transfer crawlers over large distances (Argyriou 1963; Mendel et al. 1984a). Other means of passive dispersal include rain, farm implements, and the transport of young on host plant, material enabling the crawler to be introduced to other locations.

There are different opinions about the number of developmental stages of *Saissetia oleae*. Two instar stages were recognised in the studies of Quayle (1911) in California and in the studies of Bodenheimer (1951) in Israel. However, three instar stages were recorded by Argyriou (1963) in Greece and Bartlett (1978) in California. Males are rare (Hely et al. 1982) and are also unnecessary for reproduction (Bartlett 1978). They have only been reported in California (Quayle 1911) and Australia (Simmonds 1951).

The number of annual generations of black scale on olive trees in the Mediterranean varies from one to four (Quayle 1938, Bodenheimer 1951, Argyriou 1963, Blumberg et al. 1975, Briales & Campos

1986, Tena et al. 2007), as well as in southern California (Quayle 1938). There are usually one or two annual generations in the southern Australia, and up to four in the northern Australia (Simmonds 1951; Smith et al. 1997; Waterhouse and Sands 2001; Spooner-Hart 2002; Broughton & Learmonth 2012). Smith et al. (1997) reported hatching occurred in spring (December–January) in Southern Australia. The second scale generation produced a fewer number of eggs. The life cycle takes 4–8 months in temperate southern regions, but is shorter in the temperate and subtropical regions of Queensland (Smith et al. 1997).

The development of black scale populations is affected by biotic and abiotic factors (Panis 1977; Mendel et al. 1984a). These factors relate to climate (mainly temperature, humidity, wind and rain), horticultural practices (irrigation, fertilisers, pruning and plant density), as well as natural enemies natural enemies. Climate mainly influences the first instar, and mortality may reach 99% at the active crawler stage. High mortality is a consequence of extreme temperatures, solar radiation, wind and heavy rain (Argyriou 1963; Mendel et al. 1984a).

Excessive plant density, lack of pruning, excessive irrigation and applications of nitrogen fertilisers may all contribute the development and survival of the scale. Irrigation and nitrogen fertilisers can improve the physiological condition of the host plant and particularly favour the growth of the second scale generation, leading to greater scale problems (Pellizzari 1997).

Honeydew is produced and excreted by black scale, and by other soft scales (Chomnunti et al. 2014). Larval and adult stages of black scale, particularly the young adults, produce copious quantities of honeydew on which sooty mould fungi grow (Quayle 1911; Hely et al. 1982). Honeydew accumulation can lead to asphyxiation of the scales if it is not washed off by rain or overhead irrigation, or removed by ants tending the scales (Andrews 1930; Smith 1942; Gullan 1997; Dao 2012).

Natural enemies of black scale

Natural enemies of black scale include primary parasitoids, predators, entomopathogens and some species of ants (Quayle 1911; Compere 1925; Smith & Compere 1928; Bartlett 1978; Kennett 1986; Smith et al. 1997; Malipatil et al. 2000; Waterhouse & Sands 2001; Tena & Garcia 2006; Broughton & Learmonth 2012).

Scutellista caerulea, a major constraint on black scale populations, is native to Africa (Bartlett 1978). It is a facultative, arrhenotokous ectoparasitoid and gregarious egg predator. In addition to black scale include a range of soft scales (Smith & Compere 1928; Waterhouse & Sands 2001; Badary & Abd-Rabou 2011). The female adult is small, 1.3–1.8 mm, bluish black, robust with brownish legs and antennae (Malipatil et al. 2001). The male adult is 1.2–1.5 mm (Malipatil et al. 2001), humpbacked, metallic blue, and fly-like with light brown antennae and tarsi (Smith & Compare 1928).

A number of biotypes of *S. caerulea* have been introduced into Australia, several successfully and a number apparently unsuccessfully. A black-scale biotype was introduced into Western Australia from California in 1903 (Wilson 1960; Waterhouse & Sands 2001) and a white wax scale biotype from South Africa was successfully introduced into NSW during 1969–1970 (Sands et al. 1986; Waterhouse & Sands 2001).

Larvae of *Scutellista caerulea* complete their development by preying on host eggs (Quayle 1911; 1938; Mendel et al. 1984b; Waterhouse & Sands 2001). The female wasp lays her eggs under the body margins of immature or mature female scales (Quayle 1938; Mendel et al. 1984b). Eggs hatch after 4–9 days, depending on ambient temperatures. Larvae complete their development by preying on host eggs (Quayle 1911, 1938; Mendel et al. 1984b; Waterhouse & Sands 2001). As a gregarious parasitoid, Quayle (1911) and Smith & Compare (1928) reported that up to four larvae may grow under a single host. The adult *S. caerulea* is frequently seen walking about over scale-infested twigs. Adult life span is shorter at lower temperatures, lasting an average of 12.25 ± 0.69 days at 25.9°C, but only 10.9 ± 0.63 days at 22.3°C and 6.9 ± 1.13 days at 19.8°C (Saad et al. 1977). One to four

generations occur in California, depending on host availability (Quayle 1911; Smith & Compere 1928; Bartlett 1978).

Reports of the effectiveness of *Scutellista caerulea* as a biocontrol agent vary. Waterhouse & Sands (2001), Badary & Abd-Rabou (2011) ranked it as an effective natural enemy of black scale, whilst Spooner-Hart (2005) in Australia and Tena (2007) in Spain suggested that, despite high levels of parasitism (>80% of adult female hosts), its impact on populations of black scale may be low. They attributed this to populations reaching high levels of parasitism too late to prevent scale outbreaks, and the size of the *Scutellista caerulea* population which is controlled by the size of the black scale population (i.e., the availability of prey) (Spooner-Hart 2005, Tena 2007). In South Australia, *Scutellista caerulea* was the third most-abundant parasite (after *Euryischomyia flavithorax* and *Metaphycus lounsburyi*, respectively). Broughton & Learmonth (2012) observed that *Scutellista caerulea* larvae and pupae emerged year-round, with populations peaking in March–April in near Perth in south-western Western Australia. In Western Australia, the parasitism exceeded 60% in June 2007, but was usually around 20 per cent Broughton & Learmonth (2012).

A number of insects from the genus *Metaphycus* are also parasitoids of black scale in Australia. *Metaphycus helvolus* is a polyphagous, solitary or gregarious endoparasitoid of a wide range of soft scale genera, including black scale (Bartlett 1978; Viggiani 1978; Malipatil et al. 2000). It has been introduced directly and indirectly into olive growing regions world-wide for the biological control of black scale (Argov & Rossler 1993), including Australia (Bartlett 1978) and is now, according to Malipatil et al. (2000), widely distributed in Queensland, New South Wales, Victoria, and South Australia. However, it was not reared from black scale sampled from 23 olive groves in South Australia between March and May in 2005 (Baker & Hardy 2005). *Metaphycus lounsburyi* (s.s.) is a gregarious endoparasitoid and is native to southern Africa (Guerrieri & Noyes 2000). Hosts, include *Saissetia oleae* and other soft scales (Guerrieri & Noyes 2000). The parasitoid has been introduced USA, Europe, Israel (Guerrieri & Noyes 2000) and Australia (as *Metaphycus bartletti*) Malipatil et al. 2000). It has been recorded in Western Australia (Margaret River and Gingin), Queensland (Millmerran) (Spooner-Hart 2005), Victoria (Irymple) and South Australia (Paringa and Loxton) (Malipatil et al. 2000). It has been recorded in Western Australia (Margaret River and Gingin), Queensland (Millmerran) (Spooner-Hart 2005), Victoria (Irymple) and South Australia (Paringa and Loxton) (Malipatil et al. 2000).

Some entomopathogens, especially *Lecanicillium lecanii* can destroy high densities of black scale in late summer and autumn in humid conditions (Smith et al. 1997).

Several species of ants (Hymenoptera: Formicidae) feed on the honeydew produced by *Saissetia oleae*. This activity disrupts natural control of the scale by arthropods that parasitise or prey on it (Smith & Compere 1926; Compere 1940; Smith 1942; Flanders 1943; Flanders 1951; Milne 1974; Hely et al. 1982; Dao 2012; Dao et al. 2014). It is clear that more than one species of ant can be found in a single grove or orchard, such as four species occurring at a grove in Western Australia (Broughton & Learmonth 2012). It has been suggested that ants can be vectors of entomopathogenic fungi Dao (2012) and Dao et al. (2014).

Biological control of black scale in Australia

At least 24 species of beneficial insects, including 22 parasitoid wasp species, have been released for black scale control (Waterhouse & Sands 2001) particularly in citrus, with at least 15 parasitoid species recorded in association with black scale in Australia (Malipatil et al. 2000). While natural enemies generally provide effective biological control of black scale in commercial citrus orchards, biological control of black scale in olive groves is often insufficient to maintain the pest below an economically damaging density (Baker & Hardy 2005), possibly because of the nature of the host trees, the different orchard ecosystems, or possibly because of management practices (including pesticide application). Consequently, attempts were made to mass rear and release *Metaphycus* species previously found successful in citrus. Altman & Baker (2000) undertook HAL FR05017 Biological Control of Black Scale in Olives 2005-2009, in which 2 species of *Metaphycus* spp. were mass reared and released in 26 groves in WA, SA and Vic. While there were mixed results of

parasitoid establishment, options for inundative release were abandoned as uneconomic, and the cultures were subsequently discontinued (Altman, pers. comm. 2017).

A number of research questions regarding black scale in olives and citrus, especially in the Australian context, are currently being investigated by Western Sydney University PhD student, Phuong Sa. In particular, she is determining using morphological and molecular means, the species complex of black scale associated with olives and citrus in temperate Australia and also aims to confirm the number of nymphal instars, the key parasitoids of black scale, in particular *S. caerulea* (and its variation with respect to introduction). Furthermore, she is investigating the impact of tree nutrition (particularly foliar N) on scale biology, and this interaction with *S. caerulea*.

Chemical management of black scale

Historically, oil sprays have formed the backbone of sustainable scale management in IPM programs, particularly in citrus (Hely et al. 1982; Smith et al. 1997; Beattie et al. 2002). These largely replaced use of highly disruptive treatments, including fumigation with hydrogen cyanide and cover sprays of organophosphates. Well-targeted use of highly refined paraffinic, petroleum-derived oils, now commonly referred to as horticultural mineral oils, can be highly effective in managing black scale. The quick-break oils asphyxiate emerging crawlers and settling nymphs by blocking of spiracles (Beattie et al. 2002). Furthermore, oils are benign to natural enemies (Beattie et al. 2002; Nicetic et al. 2001). However, timing to target these susceptible stages is key to success, and requires good monitoring; effective spray coverage is also essential, and recommendations are for application rates of >1000L/ha of 1-2% v/v oil sprays. To target emerging crawlers, especially early and late in the season when cooler temperatures mean the period of emergence is extended, there is a recommendation for 2 applications 10 days or 2 weeks apart. Other non-petroleum derived oils, including plant-derived and fish oils are also efficacious (Beattie et al. 2002), but are used on a much limited scale. The second group of chemicals targeted at scales as well as other homopterous and some other species are the insect growth regulators. Of these, fenoxycarb and pyriproxyfen have been shown to be efficacious, with anecdotal evidence that well-timed application of the latter product to target crawlers can provide suppression of black scale even beyond one season. A maximum of two applications of these IGRs is mandated. A number of horticultural oils as well as pyriproxyfen are registered for use against black scale in olive, and there is a current permit for fenoxycarb PER 82184 (expiry Dec 2018). There has been concern over the impacts of insect growth regulators, particularly fenoxycarb, on natural enemies (Grenier & Plantevin 1990; Liu & Chen 2001). As scale infestations are commonly sporadic and scattered in groves, early detection and spot spraying of infested trees provides both economic and environmental benefits. Management of ants, such as by the use of baits containing pyriproxyfen, can be critical to effective scale biological control as part of an IPDM program.

Olive lace bug

The olive lace bug, *Froggattia olivinia* Froggatt (Hemiptera: Tingidae) (OLB), is an Australian sap-sucking insect first described feeding on the underside of leaves of its native host, *Notelaea longifolia* Vent. in NSW. While most tingids are typically host specific, *F. olivinia* was initially reported by Froggatt (1901) to have “transferred its attentions” from its native host in eastern NSW and SE Qld to cultivated olive, *Olea europea*, and remarked “if the olive is ever largely cultivated in Australia this might become a very serious pest” (Froggatt 1901). This prediction has now occurred, with olive lace bug being recorded as a serious pest in many parts of eastern Australia (Hely et al. 1982; Spooner-Hart et al. 2002; 2007; 2010; Hall et al. 2012). It has spread from its original distribution, probably with movement of plant material, and was reported for the first time in South Australia in December 1999, followed by a confirmed infestation in Western Australia in April 2002 (Hardie et al. 2004), where it is now established (<https://www.agric.wa.gov.au/olives/olive-lace-bug-western-australia>, accessed 24/04/2018). It is a serious pest in many parts of eastern Australia (Hely et al. 1982; Spooner-Hart et al. 2002; 2007; 2010; Hall et al. 2012). In many parts of Australia, there appears to be 3-4 generations per season, with generational time decreasing northwards.

While other reported host plant species (including claret ash, *Fraxinus angustifolia*, green olive tree,

Phyllyrea latifolia, (Peter Gillespie NSW Dept Agr., pers. comm.) and osmanthus, *Osmanthus fragrans*) all belong to the family Oleaceae, movement from its indigenous host to introduced hosts is poorly understood. There is also evidence to indicate that there are differences in lacebug tolerance between olive cultivars, and that stressed trees are more attractive and more severely damaged than healthy trees.

Although *F. olivina* is an important pest species, apart from that reported by Spooner-Hart *et al.* (2002; 2007), little is known about its biology, including its alternative hosts (although all confirmed hosts at present are in the Oleaceae) and its natural enemies, with nothing confirmed to exhibit significant impacts on lace bug infestations. Adults are mottled brown, 3 mm in length, with large clubbed antennae and a highly punctured upper body surface. *F. olivina* is responsible for chlorotic spotting and yellowing of leaves, and in heavy infestations leaf drop and dieback. Eggs are laid on the underside of leaves in clusters close to the mid-vein and are commonly covered with tar-like excrement. Highly spined nymphs emerge in spring (first cohort), piercing the leaf surface and feeding on cell contents. There are 5 nymphal instars which can complete their life cycle in as little as 5-6 weeks, depending on climatic conditions (Spooner-Hart *et al.* 2002).

Limited information is available on natural enemies of *F. olivina*. There are anecdotal reports of predation by ants, an as yet unidentified assassin bug (Family Reduviidae) and small insectivorous birds, and green lacewings, but none of these have been confirmed to exhibit significant impact on lace bug infestations. The green lacewing, *Mallada signata*, has been observed in the field attacking immature stages (Spooner-Hart *et al.* 2007). While there have been several reports of commercial releases of *M. signata* (Brigid McClelland, Comvita Pty Ltd, pers. comm.; Andrew Laing, Marraweeny Olives), results are variable and no definitive studies have been undertaken to determine their effectiveness.

Tingids internationally have been reported to have a number of natural enemies, although bug nymphs forming feeding aggregates on abaxial leaf surfaces, such as *F. olivina*, are notably free of parasites and predators (Oliver *et al.*, 1985). The most commonly reported enemies are egg parasites/parasitoids (e.g., Gordh & Dunbar 1977; Livingstone & Yacoub 1983a, b; Costa *et al.* 2003; Puttler & Triapitsyn 2006; Santos & Freitas 2008; Santos *et al.* 2012; Peña *et al.* 2009; 2012). The tiny mymarid wasp, *Anagrus takeyamus* (Hymenoptera: Mymaridae) is a known parasitoid of azalea and andromeda lace bugs (Braman *et al.*, 1992). When this wasp completes its development, it exits through a round hole it chews in the end of the lace bug egg (Balsdon *et al.*, 1996). Several predators have also been reported, in particular mirids (Heteroptera: Miridae) (Neal *et al.* 1991; Henry *et al.* 2009; Holguin *et al.* 2009). The mirid genus *Stethocornus* in particular has been reported to attack lace bugs, with six of the eight known species obligate predators (Carayon, 1960). Another mirid predator, *Deraeocoris nebulosus* (Uhler), may be important in reducing populations of the oak lace bug, *Corythucha arcuata*, and is also reported to feed on the hawthorn lace bug, *Corythucha cydoniae*. Green lacewings (Humeres *et al.* 2009; Ji *et al.* 2011; Nair & Braman 2012) a cecidomyiid fly (Gagné *et al.* 2008), and spiders (Filho *et al.* 2008) have also been recorded as predators of tingids. A Hort Innovation/macadamia industry-funded project (MC130008) is investigating biology and genetics of the endemic macadamia lace bug, *Ulonemia* spp. but there is no indication that natural enemies are included in the investigations.

Reports have suggested that field populations of adults and nymphs of sycamore lace bug, *Corythucha ciliata*, are attacked by three entomopathogenic fungi *Beauveria bassiana*, *Verticillium* (= *Lecanicillium*) *lecanii* and *Paeceilomyces farinosus* (Arzone *et al.*, 1987; Tavella & Arzone, 1987). Sevim *et al.* (2013) evaluated isolates of *B. bassiana* and *Metarhizium anisopliae* against the sycamore lace bug, with one *B. bassiana* isolate showing high efficacy. There are no reports of entomopathogenic fungi attacking olive lace bug in the field, although in 2004, we observed several specimens in a Western Sydney laboratory culture had died as a result of accidental infection by an Australian strain of *M. anisopliae* that was being evaluated for control of azalea lace bug, *Stephanitis pyrioides*.

Although numerous olive lace bug populations have been sampled from commercial olive groves, home gardens and non-olive hosts around Australia for a number of years, there has been no observation of predation or parasitism, other than the earlier reported activity of *M. signata*. This is a similar result to a major survey of tingids in Missouri USA by Sheeley and Yonke (1977), who recorded no natural enemies. However, given that eastern Australia is centre of origin for this species, it is hypothesised that natural enemies exist, especially on populations infesting its original host, within this region. Furthermore, there is evidence that native predators and possibly parasites are able adapt to new, exotic arthropod host species (e.g., Ji et al. 2011) in respect to the tingid *C. ciliata* in China; Steiner & Goodwin (1998) and Steiner et al. (2003) in respect to the thrips *Frankliniella occidentalis* in Australia).

Of particular concern is the movement of *F. olivina* into olive groves in NSW and Qld from surrounding native vegetation where the native host is present, as well as movement between groves or nurseries to groves. Determining the original source of these populations is important to prevent the further spread of *F. olivina* as well as assisting in the management of this species, which is difficult to control. As a result, preliminary investigations were recently conducted to determine origins of a number of widely-distributed *F. olivina* populations, using cytochrome oxidase I (COI) as a mitochondrial molecular marker (King et al. 2013). Intra-specific variation was detected between regions and locations, with more recorded between specimens from locations in SE Qld than from NSW and ACT. These results are consistent with intra-specific variation exceeding 2% detected in 27 of 344 species of heteropterans (Park et al. 2011). No variation was found between specimens from different Hunter Valley populations, nor was any variation detected between populations on different host plants within the same location. All specimens were also screened for the endobacterium, *Wolbachia*, but none was detected. It is possible that some of the unaccountable variation between specimens from the same region may be the result of the movement of plants between locations, including products of the nursery industry. The movement of olive processing equipment around locations may be another explanation for this variation.

Chemical management of olive lace bug

Insecticides have been a major management strategy of lace bugs worldwide, because many of their hosts are ornamental species with low thresholds for cosmetic damage, including in home gardens. These historically have included organophosphates, carbamates, some synthetic pyrethroids, but particularly neonicotinoids. There are a number of insecticides registered for azalea lace bug in Australia, primarily for home garden use, including organophosphates (dimethoate, omethoate, maldison), carbamates (carbaryl), synthetic pyrethroids (beta cyflurin) and neonicotinoids (imidacloprid) (APVMA, www.apvma.gov.au, accessed 23/06/2018). The Australian macadamia industry, faced with increasing problems with the native macadamia lace bug, *Ulonemia* spp., has resorted to “old” chemistry, namely the organophosphates diazinon and trichlorfon, as well as the organic option of pyrethrum for its management (http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0006/529161/Macadamia-plant-protection-guide.pdf, accessed 16/04/2018; https://portal.apvma.gov.au/permits?p_auth=k0mUVado&p_p_id=permitsportlet_WAR_permitsportlet&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_pos=1&p_p_col_count=3&permitsportlet_WAR_permitsportlet_javax.portlet.action=search, accessed 16/04/2018). A number of registered insecticides have been shown to be efficacious against OLB in the field (Spoonier-Hart & Tesoriero RIRDC PRJ-003557/HAL PROJECT OL13002 (2014)), and several of these are registered or permitted in olives the timing of applications for effective management is problematic, especially for growers without effective monitoring systems and a range of chemical options are available for both conventional and organic growers. The current insecticides permitted for use for olive lace bug in Australian are the neonicotinoid clothianidin (PER14897 (expiry Mar 2023), the organophosphate dimethoate PER 13999 (expiry Mar 2019), the synthetic pyrethroid esfenvalerate PER81949 (expiry May 2021), natural pyrethrum PER81870 (expiry Oct 2019), and insecticidal soap PER14414 (expiry Sept 2023). The latter two products are acceptable for organic production. However, timing of applications and effective spray coverage is

critical for success of many of these options, and most are broad-spectrum and IPM-disruptive. This issue can be managed by early detection and spot spraying of hot-spots. Olives are essentially wind pollinated and flowers are not regarded as attractive to honeybees. Petroleum and plant oil sprays can reduce crawlers, but are ineffective beyond 2nd nymphal instar (unpublished data), and are not registered for this use. There are some anecdotal reports of suppression of populations after application of potassium bicarbonate, although there is no definitive data. Non-chemical management options include restricting new infestations from nearby forests or groves, including on equipment, and trying to avoid stressing trees. Green lacewings are commercially available and may be of some use in suppressing populations.

Anthracnose

Anthracnose in olives is caused by the fungal pathogens *Colletotrichum* spp. was identified in the 2005 survey as the third most important olive disease, although the most important in Qld and NSW. However, since that time, it has been recorded causing serious damage in previously apparently free areas, such as Victoria, and South Australia, especially during periods of extended wet conditions while trees are at a susceptible stage of development; it has now been recorded in all olive growing states (Spooner-Hart 2007; Sergeeva et al. 2011). Anthracnose on olive is considered to be the most important fruit disease of olives worldwide (Moral et al. 2009).

The genus *Colletotrichum* includes a number of plant pathogens of major importance, causing diseases of a wide variety of woody and herbaceous plants. It has a primarily tropical and subtropical distribution, although there are some high-profile species affecting temperate crops. The taxonomy of *Colletotrichum* has been under revision for a long time, most recently using molecular as well as morphological, cultural and virulence/ host specificity data. Cannon et al. (2012) reviewed *Colletotrichum* systematics, focusing on species-level data and the major clades. However, the status of species complexes, species/subspecies etc. remains in dispute. As Cannon et al. (2012) stated “The future for *Colletotrichum* biology will be reliant on consensus classification and robust identification tools”.

With regard to olive anthracnose, the causative *Colletotrichum* species appear to fall into a number of major clusters, the *acutatum* s.l. complex and the *gloeosporoides* s.l. complex, with ongoing dispute about the number of species or sub-species present in each. Molecular investigations on the *C. acutatum* (A) complex identified five different groups associated with olive anthracnose (Martin & Garcia-Figueres 1999; Sreenivasaprasad & Talhinhas 2005), now recorded as new species, namely *C. acutatum* s.s., *C. clavatum*, *C. fiorinae*, *C. rhombiforme*, and *C. simmondsii* (Shivas & Tan 2009; Faedda et al. 2011; Damm et al. 2012b). There is further dispute that *C. simmondsii* itself is a species complex (Damm et al. 2012b). A review of the *gloeosporoides* s.l. complex by Weir et al. (2012) accepted 22 species plus one subspecies, with *C. kahawae* subsp. *ciggaro* and *C. theobromicola* being recorded from olives in Australia. Subsequently, Schenaa et al. (2014) investigated species of the *C. gloeosporioides* complex associated with olive anthracnose and found that two, *C. gloeosporioides* s.s. and isolates of *C. theobromicola* were somewhat pathogenic, and a further five were weakly pathogenic. Again, *C. theobromicola* was recorded from Australia. In the midst of this taxonomic confusion, Cacciola et al. (2012) in reviewing olive anthracnose, reported that the species or genotypes of *Colletotrichum* that have been indicated as responsible for olive anthracnose in different countries are *C. gloeosporioides*, *C. acutatum* s.s., *C. fiorinae*, *C. simmondsii* and *C. clavatum*. The situation in Australia remains unclear, although a series of *C. acutatum* s.l. olive isolates from New South Wales, South Australia, Queensland and Western Australia were identified mainly as *C. acutatum* s.s., with a few *C. simmondsii* (Cacciola et al. 2012).

Some earlier work in Australian groves with anthracnose-symptomatic fruit conducted prior to these taxonomic revisions (Spooner-Hart 2007) reported 14 different *Colletotrichum* “isolates” of the *acutatum* and *gloeosporioides* complexes, as well as the melon anthracnose pathogen *C. orbiculare*. These isolates caused different types of symptoms on the drupes, and there was variability within each of the complexes, with different isolates displaying different appearance, colour (pigment production),

growth rates and, more concerningly, different tolerances to copper. Roca et al. (2007) reported *Colletotrichum* generally shows a high tolerance to copper compared to other olive pathogens. Furthermore, while some Australian groves only recorded one *Colletotrichum* species present, many other groves had both species, and/or multiple isolates.

Anthrachnose is primarily regarded as a fruit rot, because this is where the majority of the symptoms are observed and where the major losses occur. Anthrachnose is a latent disease; this means that infection may occur long before symptoms are observed. The physiological processes that occur during ripening of various fruits, including olives triggers the quiescent stage to become active. The most typical symptoms of olive anthrachnose is fruit rot and mummification; under moist, humid conditions infected fruits show a soft to dark brown rot often initially expressed as soft, circular, sunken spots, with a “target” appearance, followed by abundant production of an orange gelatinous matrix (sometimes referred to as “soapy fruit”). Under dry conditions, fruit may not display these symptoms, but desiccate and mummify. Affected fruits fall prematurely and mummies remain attached to the tree (Cacciola et al. 2012). Green fruit is not as susceptible to infection. Apart from the drupes themselves, fruit peduncles (Oliviera et al. 2005) and twigs (Graniti et al. 1993) can become infected. Moreover, leaves and flowers may also be infected (Moral et al. 2009; Cacciola et al. 2009), and this has been recorded in Australia (Sergeeva et al. 2008a, b). Visibly affected fruit cannot be processed into table olives, and oil from infected fruit is likely to have lower quality (higher free fatty acid and peroxide values) (Iannota et al. 1999; Cacciola et al. 2012). These quality problems may also occur with symptomless fruit.

Anthrachnose regularly causes fruit rot in districts with summer-autumn rainfall, where it can be very severe in seasons suitable for its development, but can also be severe in other locations when conditions are conducive to its outbreak and spread. Germination of *Colletotrichum acutatum* s.l. occurs between 5-30°C, optimum growth 20-27°C, and infection of drupes between 20-30°C and over 93% humidity (Cacciola et al. 2012). Hot, dry conditions inhibit infections. Primary infections of flowers and young fruit may cause drop, or result in latent infections. The subsequent production of conidia in acervuli from infected material is the main propagule by which the infection spreads, through secondary infections. The conidia are commonly dispersed by rain drops or wind-blown rain. Drupes damaged by insects such as fruit flies or by hail are more prone to infection (Graniti et al. 1993; Sergeeva & Spooner-Hart 2010) although fruit flies are not a major problem in most of the Australian olive-growing areas. Inoculum is carried over-winter particularly in infected mummified fruit, leaves and twigs. There is evidence that fallen mummified fruit or infected leaves are unlikely to be a major reservoir of inoculum; mummified fruit or infected leaves and twigs that remain on the tree are likely to be the primary source (Moral et al. 2010; Cacciola et al. 2012).

There is anecdotal evidence from around the world, including Australia, that there is varying susceptibility to anthrachnose by different olive cultivars. A number of studies have investigated this, in particular Moral and Trapero (2009) and Moral et al. (2017) using the World Collection of Olive Cultivars Cordoba, Spain, as well as Talhinas et al. (2015) in Portugal. Moral et al. (2017) evaluated 308 cultivars and categorized them into highly susceptible (66 cvs), susceptible (83) moderately susceptible (66), resistant (61) and highly resistant (32). They recorded commonly grown Australian cultivar Frantoio as highly resistant, Picual as resistant, and Arbequina, and Barnea as moderately susceptible. This contrasts with a preliminary study by Tesoriero and Spooner-Hart (Spooner-Hart 2015), in which cv. Barnea was shown to be highly susceptible to anthrachnose infection, particularly when compared with cvs Manzanillo and Arbequina, and that cv. Picual was also relatively susceptible to this disease. Field observations in Australia overwhelmingly indicate Barnea is a highly susceptible cultivar here, and as a result, it has fallen into disfavor. Other cultivars reported by Australian growers to be susceptible to anthrachnose field infestation are Jumbo Kalamata and Manzanillo; it should be noted that Moral et al. (2017) classified Manzanilla de Sevilla as susceptible.

Management of anthrachnose

Historically, copper-based fungicides have been used around the world, including Australia, to protect

against anthracnose outbreaks. Spray treatments in spring can prevent blossom blight and early fruit infections and reduce inoculum for fruit infections in autumn. Moreover, they are also effective against other fungal diseases such as peacock spot, grey mould as well as suppressing bacterial infections, including olive knot. Sprays with copper-based fungicides have no adverse effects on flowering and fruit set (Roca et al. 2007; Spooner-Hart, unpublished data). However, due to their protective activity, the timing of application is crucial, and under heavy inoculum pressure, results can be poor. Furthermore, in Europe, there is increasing restriction on use of copper fungicides in olives (Cacciola et al. 2012). In Australia, several copper oxychloride fungicides are registered for anthracnose in olives, and Permit PER11360 (expires Nov 2021) permits use of cupric hydroxide, cuprous oxide and tribasic copper sulphate for anthracnose and various fungal leaf spots. On olives the withholding period for copper fungicides is 1 day. Other protectant fungicides, registered for anthracnose control in other horticultural crops include chlorothalonil (Group M5) and mancozeb (Group Y) (APVMA, www.apvma.gov.au accessed 22/4/2018).

The other most commonly used fungicide group against anthracnose is the strobilurins (Group 11). The most widely used is of these is azoxystrobin (Cacciola et al. 2012; APVMA apvma.gov.au accessed 22/4/2018). Azoxystrobin has had irregular permitted use in olives since an emergency permit in response to a major epidemic in 2015, and has current permit PER14580, expires Aug 2019. Following HAL OL06000 Safe use of fungicides to manage berry fruit rot diseases for sustainable oleiculture (Spooner-Hart 2009) and RIRDC PRJ-003557/HAL PROJECT OL13002 Evaluation of Key Chemicals for Pest Management in the Olive Industry Spooner-Hart & Tesoriero (2014) the dual fungicide Aero® (metiram (Group M3) + pyraclostrobin) was found to be highly efficacious, even more so than azoxystrobin, and has permitted use via PER 14908 (expires March 2020). However, reported strobilurin resistance in *Colletotrichum* spp. (e.g., Inada et al. 2008) has resulted in restricting strobilurin applications to two foliar applications per season with a minimum 21 day interval. The use of copper products for disease control in olives still has merit given they sometimes gave rise to a significant disease reduction. Furthermore, protectant chemicals with multi-site activity such as copper and metiram reduce the risk of resistance to the strobilurins developing in populations of *Colletotrichum* spp.

There have been a number investigations on biological control of *Colletotrichum* spp. with antagonistic bacteria and yeasts (e.g., Preto et al. 2017; Unnithan & Thammaiah 2017; Lahkar et al. 2018), but to date there has been limited commercial success for field infections.

Non-chemical management practices for anthracnose include removal of mummified fruit, early harvesting especially of susceptible varieties, and pruning trees for more open canopy for air movement and sunlight access. Some growers have taken the more drastic step of removal and replacement of susceptible varieties, such as Barnea, in their orchards. Higher olive planting densities also favour faster disease progress through the grove (Morel et al. 2012). Thus, growers faced with a season conducive to anthracnose and with susceptible varieties need to develop season-long (as well as long-term) management plans for anthracnose in their groves.

Extension of IPDM

Extension aims to bring about positive change on farms and in agriculture. This largely involves the use of processes to facilitate learning and change within the agricultural community. These processes, or ‘extension methods’, include groups, media, field days, education, advice, facilitation, lead farmers, focus farms, demonstrations, videos, publications and more.

IPM is a knowledge-intensive management approach and conventional extension methods that focus on technology are unlikely to meet the needs for grower’s learning about agro-ecosystems necessary for implementation of IPM. Furthermore, there is debate around how to optimise funding and human resources for farmer development: for example, to employ the methodology of identifying the key industry innovators and only assisting them with a view to them being exemplars of best practice for their neighbours, or whether to employ these resources towards the marginal, laggards or the least

interested farmers with a view to “pulling up their socks”. The community-based approach has been employed effectively in a number of including Australia, as well as the successful Farmer Field School approach promulgated by FAO, particular in developing countries. Kilpatrick et al. (2003), for example, reviewed effective methods for Tasmanian farmer groups in defining best practices for sustainable agriculture.

However, engaging with all farmers is not necessarily possible. A number of studies of enhanced learning/change processes on farm have reported how on farm change is influenced by the farmers’ personal, family, business, industry and regional characteristics. Vancley (2004) argues that farming is a social activity with distinctive farming styles. The author advocates that the social context within which farm management occurs must be understood if research and extension are to be successful. Other authors focus on the need to understand and address the needs of the farm family, and the farm family business rather than the individual farmer (Fulton and Champion 1999; Reeve and Black 1998; Kilpatrick 2003, Kilpatrick et al. 2003). Nicetic (2015) argued that the often ideological, belief that all farmers want to participate and should be put first (Chambers, 1983) led to what Cook and Kothari (2001) called the “tyranny” of participation. In reality the participation of farmers in learning and research processes depends on characteristics of individual farmers and their livelihood situations, their expectations from participatory interventions, their experiences from previous interventions and the opportunity costs of their time. These characteristics are influenced by the political, social and economic situation in which stakeholders live (Neef & Neubert 2011). In fact, Nicetic (2015) states that involving farmers who do not feel the need or wish for change can contribute to making farmer development programs ineffective. This means that the most effective approach for extending IPDM is to provide a range of communication strategies and networks that cater for both social and individual learners.

Biosecurity

Although not directly part of the current literature review, quarantine, surveillance and recognition of key pests and diseases (including exotic species) is. Furthermore, incursion of a serious exotic pest such as olive fly, usually results in eradication programs and in the case of pest establishment, use of often IPM-disruptive pesticides. The five High Priority Pests in the current Olive Biosecurity Plan (Plant Health Australia, 2016) are olive fly (*Bactrocera oleae*), olive moth (*Prays oleae*), leaf scorch (*Xylella fastidiosa* subsp. *multiplex* (with vectors)), olive quick decline (*Xylella fastidiosa* subsp. *pauca* (with vectors) and Verticillium wilt (defoliating strain) (*Verticillium dahliae*).

The most important pest of olives worldwide is olive fly, *Bactrocera oleae* (Gmelin) (Diptera: Tephritidae) (López-Villalta, 1999). It is endemic to the Mediterranean and Africa, and more recently has established in California and Mexico, where it was first reported in the late 1990s (Yokoyama, 2015). Management of this pest is continuous and problematic, particularly because it attacks green fruit, including aerial insecticide sprays, but more recently trapping using pheromones and chromotrophic sticky traps, McPhail traps, and baiting (Yokoyama, 2015). Olive fly is a highly concerning biosecurity risk, because if it were to arrive it could readily disperse with minimal assistance. Olive moth, *Prays oleae* (Bernard) (Lepidoptera: Yponomeutidae). It attacks inflorescences and fruit. It is, however, currently restricted to the Mediterranean and Western Asian regions. There are currently no national diagnostic protocols, surveillance program, fact sheets or contingency plans for either of these pests, although these activities are scheduled in the Olive Biosecurity Plan.

The bacteria *Xylella fastidiosa* subsp. became a high priority olive pest, following its detection causing olive quick decline syndrome subsp. *pauca* (Loconsole 2014) and leaf scorch subsp. *multiplex* (Saponari et al. 2013) in the Apulia region of Italy. *Xylella fastidiosa* is the number one National Priority Plant Pest <http://www.agriculture.gov.au/pests-diseases-weeds/plant>, and was the subject of an International Symposium in Brisbane in May 2017. Ongoing surveillance and training programs, including for industry, are underway, and a national diagnostic protocol, surveillance programs, fact sheets and contingency plan are in place, although are not strain-specific.

The defoliating strain of *Verticillium dahliae* (pathotype D) spread in southern Spain olive groves in the early 2000s, especially in new plantings (Mercado-Blanco et al. 2002; Navas-Cortés et al. 2008). Recent reports confirm that a cotton defoliating strain of *V. dahliae* (VCG-1A) is present in Australia (<http://www.insidecotton.com/xmlui/bitstream/handle/1/1393/Defoliating%20vert%20alert%20April%202015%20FINAL.pdf?sequence=1&isAllowed=y> accessed 18/11/2017), although planned testing to determine whether this strain is virulent on olive has not been conducted.

Knowledge gaps

Knowledge gaps and recommended future research work identified for the Australian olive industry, with regard to the three targeted species are listed below.

Black scale

There were no high priority knowledge gaps identified for black scale. A number of formerly key gaps, especially in relation to the biology of black scale, species complex of black scale in olive and citrus orchards and the black scale parasitoids in southern Australia, and impact of tree nutrition on black scale and their parasitoids have recently been undertaken by WSU PhD student Phuong Sa, who is scheduled to submit her thesis later this year, and publish a number of scientific papers from her work. Furthermore, there has been considerable work conducted overseas, particularly in the Mediterranean and USA, as well as in Australia on black scale biology, ecology and management in both olives and citrus.

Olive lace bug

As olive lace bug is a native species, there is a paucity of information on its biology and ecology, although international work on other tingid species provides directions for new research. Key knowledge gaps include:

Detailed studies on basic biology, growth, development and reproduction under different environmental conditions. Outcomes will be better understanding the key factors determining field population dynamics and resultant plant damage, as well as improving prediction of emergence of generation cohorts to best target susceptible life stages.

Major survey for natural enemies. No such survey has been conducted to date. Outcomes are conservation of natural enemies, and their potential use for inoculative or inundative biological control.

Investigating factors influencing spread and introduction of lace bug into areas where it didn't previously exist. This work should include population genetics and molecular identification of origin of new incursions. Outcomes will enable establishment of better biosecurity/quarantine strategies to limit further spread of lace bug.

Anthracnose

Systematic surveying for species of *Colletotrichum* associated with olive anthracnose around Australia. In light of recent taxonomic revisions of this genus, further work needs to be undertaken in Australia. Outcomes will better define the species mix and their characteristics, particularly their virulence in olives. It will also assist in aligning Australian studies with international research.

Assessing tolerance of different *Colletotrichum* species and isolates to copper and strobilurins. As these two fungicide groups are currently relied on for anthracnose management, the findings will support development of resistance management programs.

Development of a disease forecasting model for olive anthracnose. The environmental conditions that favour the development of olive anthracnose have been determined in Europe and can be modelled to predict when disease is likely to be expressed and spread. However, such models are empirical and would need to be validated in any given production area. Outcome will provide forewarning of likely epidemics, as well as optimise timing of fungicide applications and other management strategies.

Investigation of alternative fungicide groups (conventional and organically acceptable) for anthracnose management. This will provide alternatives for fungicide rotation as well as options in the event of widespread resistance to the strobilurins or to copper.

Investigate the impact of increasing tree density (especially super-high density plantations) on epidemiology and management of anthracnose. As most recent of new olive plantings are high or superhigh density, it is important for the industry to be aware of and plan IPDM strategies in the case of deleterious effects associated with increased planting density.

REFERENCES

- Andrews EA 1930. Honeydew reflexes. *Physiological Zoology* 3: 467-484.
- Argov Y, Rössler Y 1993. Biological control of the Mediterranean black scale, *Saissetia oleae* (Hom: Coccidae) in Israel. *Entomophaga* 38: 89-100.
- Argyriou LC 1963. Studies on the morphology and biology of the black scales *Saissetia oleae* (Bernard) in Greece. *Annales de l'Institut Phytopathologique Benaki* 5: 353-377.
- Badary H, Abd-Rabou S 2011. Role of pteromalid parasitoid *Scutellista caerulea* (Fonscolombe) (Hymenoptera: Pteromalidae) for biological control of the soft scale insects (Hemiptera: Coccidae) in Egypt. *Egypt. Academic Journal of Biological Sciences* 4: 49-58.
- Baker G, Hardy J 2005. Survey of black scale parasitoids in South Australian olive groves. Entomology Unit. SARDI. Waite Campus, Adelaide Australia.
- Balsdon JE, Braman SK, Espelie KE 1996. Biology and ecology of *Anagrus takeyanus* (Hymenoptera: Mymaridae), an egg parasitoid of the azalea lace bug (Heteroptera: Tingidae). *Environmental Entomology* 25: 383-389.
- Bartlett BR 1978. Coccidae. In: Clausen CP (ed.), *Introduced Parasites and Predators of Arthropod Pests and Weeds*. United States Department of Agriculture. Agriculture Handbook 480 Washington DC: United States of America Department of Agriculture. pp. 70, pp. 545.
- Bess HA 1958. The green scale, *Coccus viridis* (Green) (Homoptera: Coccidae), and ants. *Proceedings of the Hawaiian Entomological Society* 16: 349-355
- Beattie GAC, Watson DM, Stevens ML, Rae DJ, Spooner-Hart RN 2002. *Spray Oils Beyond 2000*. University of Western Sydney, Australia.
- Blumberg D, Swirski E and Greenberg S 1975. Evidence for bivoltine populations of the Mediterranean black scale *Saissetia oleae* (Olivier) on citrus in Israel. *Israel Journal of Entomology* 10: 19-24.
- Bodenheimer F 1951. *Citrus Entomology in the Middle East*. Dr. W. Junk, The Hague, Netherlands. pp. 380-387.
- Botha J, Learmonth S 2011. Olive lace bug. http://www.agric.wa.gov.au/objectwr/imported_assets/content/pw/ph/dis/olb_infosheet.pdf
- Briales MJ, Campos M 1988. Analysis of the spatial distribution of the various stages of *Saissetia oleae* (Oliv.) on olive tree in Granada. *Journal of Applied Entomology* 105: 28-34.
- Broughton S, Learmonth S 2012. Management of black scale and apple weevil in olives, Rural Industries Research and Development Corporation No 12/019.
- Cacciola SO, Faedda R, Sinatra F, Agosteo GE, Schena L, Frisullo S, Magnano di San Lio G 2012. Olive anthracnose. *Journal of Plant Pathology* 94: 29-44.
- Cakmak O, Bashan M, Bolu H 2007. The fatty acid compositions of the predator *Piocoris luridus* (Heteroptera: Lygaeidae) and its host *Monsteira uncostata* (Heteroptera: Tingidae) reared on almond. *Insect Science* 14: 461-466.

- Cannon PF, Damm U, Johnston PR, Weir BS 2012. *Colletotrichum* – current status and future directions. *Studies in Mycology* 73: 181-213.
- Chambers R 1983. Rural development: putting the last first. Harlow: Prentice Hall.
- Compere H 1925. New chalcidoid (Hymenopterous) parasites and hyperparasites of the black scale, *Saissetia oleae* Bernard. *University of California Publications in Entomology* 3: 295-326
- Compere H 1926. New coccid-inhabiting parasites (Encyrtidae, Hymenoptera) from Japan and California. *University of California Publications in Entomology* 4: 1-30.
- Compere H 1940. Parasites of black scale, *Saissetia oleae*, in Africa. *Hilgardia* 13: 387-425.
- Cook B, Kothari U 2001. Participation: The new tyranny? Zed Books: London.
- Costa VA, Pereira C, Batista Filho, A 2003. Preliminary studies on parasitism of *Leptopharsa heveae* (Hemiptera: Tingidae) eggs in rubber tree in Pindorama, SP, Brazil. *Arquivos do Instituto Biológico (Sao Paulo)*, 90: 205-207. (English abstract)
- Dal Santo, P AgAware Consulting 2009. Olive Industry Strategic Agrichemical Review Process, Rural Industries Research & Development Corporation, Canberra.
- Damm U, Cannon PF, Woudenberg JH, Johnston PR, Weir B, *et al.* 2012. The *Colletotrichum boninense* species complex. *Studies in Mycology* 73: 1-36.
- Dao TH. 2012. Ecology of red scale (*Aonidiella aurantii* (Maskell) [Hemiptera: Sternorrhyncha: Diaspididae]) in citrus orchards on the Central Coast of New South Wales. PhD Thesis, University of Western Sydney.
- Dao HT, Meats A, Beattie GAC, Spooner-Hart R 2014. Ant-coccid mutualism in citrus canopies and its effect on natural enemies of red scale. *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae). *Bulletin of Entomological Research* 104: 137-142.
- Faedda R, Agosteo GE, Schena L, Mosca S, Frisullo S, Magnano di San Lio G, Cacciola SO 2011. *Colletotrichum clavatum* sp. nov. identified as the causal agent of olive anthracnose in Italy. *Phytopathologia Mediterranea* 50: 283-302.
- Filho PE, Rinaldi IM, Feres RJ 2008. Predation and immobilization of the lace bug *Leptopharsa heveae* (Drake & Poor) (Hemiptera: Tingidae) in the silk of space web spiders (Araneae: Theridiidae) and hunting spiders (Araneae: Salticidae). *Revista de Agricultura (Piracicaba)* 83: 189-196. (English abstract)
- Flanders SE. 1943. The Argentine ant versus the parasites of the black scale. *California Citrograph* 23: 117, 128, 137.
- Flanders SE 1951. The role of the ant in the biological control of homopterous insects. *The Canadian Entomologist* 83: 93-98.
- Froggatt WW 1901. Notes on selected Australian Hemiptera (Plant bugs). *Agricultural Gazette of New South Wales*. 12: 1592-1601.
- Gagné RJ, Peña JE, Acevedo FE 2008. A new lestadiplosine (Diptera: Cecidomyiidae) preying on the avocado lace bug, *Pseudacysta perseae* (Heteroptera: Tingidae) in Southern Florida. *Florida Entomologist* 91: 43-48.

- Gordh G, Dunbar DM 1977. A new *Anagrus* important in the biological control of *Stephanitis takeyai* and a key to the North American species. *The Florida Entomologist* 60: 85-95.
- Graniti A, Frisullo S, Pennisi AM, Magnano di San Lio G, 1993. Infections of *Glomerella cingulata* on olive in Italy. *Bulletin OEPP/EPPO* 23: 457-465.
- Grenier S, Plantevin G 1990. Development modifications of the parasitoid *Pseudoperichaeta nigrolineata* (Dipt., Tachinidae) by fenoxycarb, an insect growth regulator, applied onto its host *Ostrinia nubilalis* (Lep., Pyralidae). *Journal of Applied Entomology* 110: 462-470
- Guerrieri E, Noyes JS 2000. Revision of European species of genus *Metaphycus* Mercet (Hymenoptera: Chalcidoidea: Encyrtidae), parasitoids of scale insects (Homoptera: Coccoidea). *Systematic Entomology* 25: 147-222.
- Gullan PJ 1997. Relationships with ants. In: Ben-Dov Y, Hodgson CJ (eds), *Soft scale insects: their biology. Natural Enemies and Control* 7B, Amsterdam: Elsevier. 351-373.
- Hall B, Tesoriero L, Spooner-Hart R 2012. Diseases and disorders of olives in Australia. *Acta Horticulturae* 949: 323-327.
- Haniotakis GE 2005. Olive pest control: Present status and prospects. *IOBC/WPRS Bulletin* 28: 1-9.
- Hardie, DC, Poole MC, Botha JH, Spooner-Hart R, Taylor RL 2004. Olive lace bug: *Froggattia olivinia* Froggatt [Hemiptera: Tingidae] Farmnote no. 82/2003, Western Australian Dept. of Agriculture.
- Hely PC, Pasfield G, Gellatley JG 1982. Insect pests of fruit and vegetables in NSW. Department of Agriculture, New South Wales.
- Henry TJ, Peña JE, Long D, Acevedo F 2009. *Stethocomus praefectus* (Hemiptera: Miridae): first North American records of an old world plant bug predacious on avocado lace bug, *Pseudacysta perseae* (Hemiptera: Tingidae), in Florida. *Proceedings of the Entomological Society of Washington*, 111: 98-105.
- Holguin CM, Peña JE, Henry TJ, Acevedo F 2009. Biology of *Stethocomus praefectus* (Distant) (Heteroptera: Miridae), a newly established predator of the avocado lace bug, *Pseudacysta perseae* (Heteroptera: Tingidae), in Florida. *Florida Entomologist* 92: 54-57.
- Hort Innovation 2016. Olive industry strategic investment plan Horticulture Innovation Australia Limited, Sydney.
- Humeres DC, Morse JG, Stouthamer R, Roltsch W, Hoddle MS 2009. Evaluation of natural enemies and insecticides for control of *Pseudacysta perseae* (Hemiptera: Tingidae) on avocados in Southern California. *Florida Entomologist* 92: 35-42.
- Iannota N, Perri E, Serinni R, Tocci C 1999. Influence of *Colletotrichum gloeosporioides* (Penz.) and *Camarosporium dalmatica* (Thum) attacks on olive quality. *Acta Horticulturae* 474: 573-576.
- Ji R, Wang B, Lou Y 2011. Predators of *Corythucha ciliata* (Say) in Hangzhou and the predation of *Chrysoperla nipponensis* (Okamoto) larvae. *Chinese Journal of Biological Control* 27: 32-37. (Abstract in English)
- Kennett CE 1986. A survey of the parasitoid complex attacking black scale *Saissetia oleae* (Olivier) in central and northern California (Hymenoptera: Chalcidoidea; Homoptera: Coccidae) *Pan-Pacific Entomologist* 62: 363-369.

- Kim HJ, Lee EJ, Park SH, Lee H-S & Chung N 2014. Biological control of anthracnose (*Colletotrichum gloeosporioides*) in pepper and cherry tomato by *Streptomyces* sp. A1022. *Journal of Agricultural Science* 6, 54-62.
- Kilpatrick S 2003. Facilitating sustainable natural resource management: Review of the literature Discussion Paper D3/2003 CRLRA Discussion Paper Series ISSN 1440-480X.
- Kilpatrick S, Bond L, Bell R, Knee J, Pinkard G 2003. Effective farmer groups for defining best practices for sustainable farming. Australasia Pacific Extension Network www.regional.org.au/au/apen/2003/refereed/024kaineg.htm# (Accessed 23/03/2018)
- King J, Riegler M, Spooner-Hart R 2013. Determining origins of populations of *Froggattia olivinia* (Hemiptera: Tingidae) (olive lace bug) using cytochrome oxidase I (COI) as a mitochondrial molecular marker. 44th Australian Entomology Society AGM and Scientific Conference, Adelaide, 29 September 2-October 2013.
- Lampson LJ, Morse JG. 1992. A survey of black scale, *Saissetia oleae* (Homoptera: Coccidae) parasitoids (Hym: Chalcidoidea) in Southern California. *Entomophaga* 37: 373-390.
- Lin, Y-P Tree D, Cook LG 2017. Is it here yet? A search for the Mexican black scale in Australia. Proceedings Australian Entomological Society 48th AGM and Scientific Conference, Terrigal, New South Wales, Australia.
- Liu T-X, Chen T-Y 2001. Effects of the insect growth regulator fenoxycarb on immature *Chrysoperla rufilabris* (Neuroptera: Chrysopidae). *Florida Entomologist* 84: 628-633.
- Livingstone D, Yacoob M. 1983a. New subgenus of *Epoligosita* (Hym: Trichogrammatidae) an egg parasite of Tingidae (Het.) from Southern India. *Entomophaga* 28: 213-216.
- Livingstone D, Yacoob M. 1983b. New subgenus of *Lathromeromyia* (Hym: Trichogrammatidae) an egg parasite of Tingidae (Het.) from India. *Entomophaga* 28: 303-308.
- Loconsole G, Potere O, Boscia D, Altamura G, Djelouah K, Elbeaino T, et al. 2014. Detection of *Xylella fastidiosa* in olive trees by molecular and serological methods. *Journal of Plant Pathology* 96: 7-14.
- López-Villalta M 1999. Olive pest and disease management. International Olive Oil Council, Madrid, Spain
- Malipatil MB, Dunn KL, Smith D. 2000. An illustrated guide to the parasitic wasps associated with citrus scale insects and mealybugs in Australia. Department of Natural Resources and Environment. Institute for Horticultural Development, Victoria 3176.
- Martín MP, García-Figueres F. 1999. *Colletotrichum acutatum* and *C. gloeosporioides* cause anthracnose on olives. *European Journal of Plant Pathology* 105: 733-741.
- Mendel Z, Podoler H, Rosen D. 1984a. Population dynamics of the Mediterranean black scale, *Saissetia oleae* (Olivier), on citrus in Israel. 5. The crawlers. *Journal of the Entomological Society of South Africa* 47: 23-34
- Mendel Z, Podoler H, Rosen D. 1984b. Population dynamics of the Mediterranean black scale, *Saissetia oleae* (Olivier), on citrus in Israel. 4. The natural enemies. *Journal of the Entomological Society of South Africa* 47: 1-21.

- Mercado-Blanco J, Rodríguez-Jurado D, Pérez-Artes E, Jiménez-Díaz RM 2002. Detection of the defoliating pathotype of *Verticillium dahliae* in infected olive plants by nested PCR *European Journal of Plant Pathology* 108: 1-13.
- Moral J, de Oliveira R, Trapero A, 2009. Elucidation of the disease cycle of anthracnose caused by *Colletotrichum acutatum*. *Phytopathology* 99: 548-556.
- Moral J, Jurado-Bello J, Sánchez MI, de Oliveira R, Trapero A 2012. Effect of temperature, wetness duration, and planting density on olive anthracnose caused by *Colletotrichum* spp.. *Phytopathology* 102: 974-981.
- Moral J, Trapero A 2009. Assessing the susceptibility of olive cultivars to anthracnose caused by *Colletotrichum acutatum*. *Plant Disease* 93:1029-1036.
- Moral J, Xaviér C, Roca LF, Romero J, Moreda W, Trapero A 2014. La Antracnosis del olivo y su efecto en la calidad del aceite. *Grasas y aceites* 65 (English abstract) doi: <http://dx.doi.org/10.3989/gya.110913>
- Moral J, Xaviér CJ, Viruega JR, Roca LF, Caballero J, Trapero A 2017. Variability in susceptibility to anthracnose in the world collection of olive cultivars of Cordoba (Spain). *Frontiers in Plant Science* 8: 1892 doi: 10.3389/fpls.2017.01892.
- Nair S, Braman SK 2012. Integration of insecticides with the natural enemy *Chrysoperla carnea* (Stephens) for management of azalea lace bug (Hemiptera: Tingidae). *Journal of Entomological Science* 47: 278-281.
- Navas-Cortés JA, Landa BB, Mercado-Blanco J, Trapero-Casas JL, Rodríguez-Jurado D, Jiménez-Díaz RM 2008. Spatiotemporal analysis of spread of infections by *Verticillium dahliae* pathotypes within a high tree density olive orchard in southern Spain. *Phytopathology* 98: 167-180.
- Neal JW, Haldemann RH, Henry TJ. 1991. Biological control potential of a Japanese plant bug *Stethoconus japonicus* (Heteroptera: Miridae), an adventive predator of the azalea lace bug (Heteroptera: Tingidae). *Annals of the Entomological Society of America* 84: 287-293.
- Neef A. and Neubert, D (2011). Stakeholder participation in agricultural research projects: a conceptual framework for reflection and decision-making. *Agricultural Human Values* 28: 179-194.
- Nicetic O 2015. The utility of the farmer field school as a platform for communication and partnership in agricultural research and development. PhD Thesis, University of Queensland.
- Nicetic O, Watson DM, Beattie GAC, Meats A, Zheng J 2001. Integrated pest management of two-spotted mite *Tetranychus urticae* on greenhouse roses using petroleum spray oil and the predatory mite *Phytoseiulus persimilis*. *Experimental & Applied Acarology* 25: 37-53.
- Oliver JE, Neil JW, Lusby WR, Aldrich JR, Kochansky JP 1985. Novel components from secretory hairs of azalea lace bug *Stephanitis pyrioides* (Hemiptera: Tingidae) *Journal of Chemical Ecology* 11, 1223-1228.
- Oliveira R, Moral J, Bouhmidi K, Trapero A, 2005. Caracterización morfológica y cultural de aislados de *Colletotrichum* spp. causantes de la antracnosis del olivo. *Boletín de Sanidad Vegetal Plagas* 31: 531-548.
- Orphanides GM 1990. Bioecology of the black scale, *Saissetia oleae* (Olivier) (Homoptera: Coccidae) in Cyprus. Technical Bulletin 112. Agricultural Research Institute Ministry of Agricultural and Natural Resources.

- Park D-S, Footitt R, Maw E, Hebert PDN 2011. Barcoding Bugs: DNA-based identification of the true bugs (Insecta: Hemiptera: Heteroptera). *PLoS ONE* 6(4): 18749.
- Pellizzari G. 1997. Coccid pests of olive. In: Ben-Dov Y, Hodgson CJ (eds), *Soft Scale Insects: Their Biology, Natural Enemies and Control*. Vol. 7B. Elsevier. Amsterdam. pp. 217-227.
- Peña JE, Duncan RE, Roltsch WJ, Carillo D 2012. Mortality factors of the avocado lace bug, *Pseudacysta perseae* (Heteroptera: Tingidae). *Florida Entomologist* 95: 179-182.
- Peña JE, Triapitsyn SV, Long D, Evans GA, Roltsch WJ 2009. First record of *Erythmelus klopomor* (Hymenoptera: Mymaridae) as a parasitoid of the avocado lace bug, *Pseudacysta perseae*. *Florida Entomologist* 92: 394-395.
- Plant Health Australia Ltd (2016) Biosecurity Plan for the Olive Industry (Version 2.0 – October 2016). Plant Health Australia, Canberra, ACT.
- Preto G, Martins F, Pereira JA, Baptista P 2017. Fungal community in olive fruits of cultivars with different susceptibilities to anthracnose and selection of isolates to be used as biocontrol agents. *Biological Control* 110: 1-9.
- Puttler B, Triapitsyn SV 2006. A new species of *Anagrus* (Hymenoptera: Mymaridae) from Missouri (USA), egg parasitoid of *Ciruthucha marmorata* (Hemiptera: Tingidae). *Entomological News* 117: 25-30.
- Quayle HJ 1911. The black scale. Bulletin 223. Berkeley. California: University of California Publications. pp. 151-200.
- Quayle HJ 1938. Insects of Citrus and other Subtropical Fruits. Ithaca, New York: Comstock Publishing Co. pp.104-123.
- Roca LF, Moral J, Viruega JR, Ávila A, Oliveira R, Trapero A 2007. Copper fungicides in the control of olive diseases. *Olea* 26, 48-50.
- Sands DPA, Lukins R, Snowball GJ 1986. Agents introduced into Australia for the biological control of *Gascardia destructor* (Newstead) (Hemiptera: Coccidae). *Australian Journal of Entomology* 25: 51-59.
- Santos RS, Freitas S 2008. Parasitism of *Erythmelus tingitiphagus* (Soares) (Hymenoptera: Mymaridae) in *Leptopharsa heveae* Drake & Poor (Hemiptera: Tingidae). *Neotropical Entomology* 37: 571-576.
- Santos RS, Costa VA, Silva JM, Freitas S 2012. Population dynamics of *Leptopharsa heveae* (Hemiptera: Tingidae) and *Erythmelus tingitiphagus* (Hymenoptera: Mymaridae) in rubber tree plants. *Revista Colombiana de Entomologia* 38: 314-319 (English abstract)
- Saponari M, Boscia D, Nigro F, Martelli GP 2013. Identification of DNA sequences related to *Xylella fastidiosa* in oleander, almond and olive trees exhibiting leaf scorch symptoms in Apulia (southern Italy). *Journal of Plant Pathology* 95: 668
- Schena L, Mosca S, Cacciola SO, Faedda R, Sanzani SM, G. E. Agosteo GM, Sergeeva V, Magnano di San Lio G. 2014. Species of the *Colletotrichum gloeosporioides* and *C. boninense* complexes associated with olive anthracnose. *Plant Pathology* 63: 437-446.
- Sergeeva V, Hall B, Tesoriero L, Spooner-Hart R 2011. Olive diseases and disorders in Australia and

- New Zealand pp 357-377, in Schena L, Agosteo GE, Cacciola SO (eds). Olive diseases and disorders. Transworld Research Network, Kerala, India. ISBN 978-81-7895-539-1
- Sergeeva V, Spooner-Hart R 2010. Anthracnose and Queensland fruit fly in olives. *The Olive Press* 16: 23-24.
- Sergeeva V, Spooner-Hart R, Nair NG 2008a. First report of *Colletotrichum acutatum* and *C. gloeosporioides* causing leaf spots of olives (*Olea europaea*) in Australia. *Australasian Plant Disease Notes* 3: 143-144.
- Sergeeva V, Spooner-Hart R, Nair NG 2008b. Evidence of early flower infection in olives (*Olea europaea*) by *Colletotrichum acutatum* and *C. gloeosporioides* causing anthracnose disease. *Australasian Plant Pathology* 3: 81-82.
- Sevim A, Demiri I, Sonmezi E, Kocaceviki S, Demirbagi Z 2013. Evaluation of entomopathogenic fungi against the sycamore lace bug, *Corythucha ciliata* (Say) (Hemiptera: Tingidae). *Turkish Journal of Agriculture & Forestry* 37: 595-603.
- Sheeley RD, Yonke TR 1977. Biological notes on seven species of Missouri tingids (Hemiptera: Tingidae). *Journal of the Kansas Entomological Society* 50: 342-356.
- Shivas RG, Tan YP 2009. A taxonomic re-assessment of *C. acutatum* introducing *C. fioriniae* comb. et stat. nov. and *C. simmondsii* sp. nov. *Fungal Diversity* 39: 111-122.
- Simmonds HW 1951. Observations on the biology and natural control of black scale of citrus *Saissetia oleae* (Bern.) in South Australia. *Journal of Department of Agriculture in South Australia* 54: 339-340.
- Smith BJ 2009. Influence of nitrogen, phosphorus and potassium on the severity of strawberry anthracnose crown rot. *Acta Horticulturae* 842: 235-237.
- Smith D, Beattie GAC, Broadley R 1997. Citrus Pests and Their Natural Enemies: Integrated Pest Management in Australia, Brisbane: Queensland Department of Primary Industries.
- Smith H, Compere H 1928. A preliminary report on the insect parasites of the black scale, *Saissetia oleae* (Bern.). University of California Publications in Entomology 4: 232-334.
- Spooner-Hart R 2005. Sustainable pests and disease management in Australian olive production RIRDC Publication 05/080 Rural Industries Research & Development Corporation, Canberra.
- Sreenivasaprasad S, Talhinhas P, 2005. Genotypic and phenotypic diversity in *Colletotrichum acutatum*, a cosmopolitan pathogen causing anthracnose on a wide range of hosts. *Molecular Plant Pathology* 6: 361-378.
- Spooner-Hart R, Tesoriero L, Hall B 2007. Field guide to olive pests, diseases and disorders in Australia. Rural Industries Research & Development Corporation, Canberra, Australia. 68 pp.
- Spooner-Hart R, Tesoriero L, Hall, B Page F, Learmonth, S, Conlan, D. 2002. Progress towards pest and disease management in Australian olive production *Advances in Horticultural Science* 16: 218-224.
- Steiner MY, Goodwin S 1998. Methods for collecting and rearing thrips (Thysanoptera) and their natural enemies. *Australian Journal of Entomology* 37: 101-106.
- Steiner MY, Goodwin S, Wellham TM, Barchia IM, Spohr LJ 2003. Biological studies of the

- Australian predatory mite *Typhlodromips montdorensis* (Schicha) (Acari: Phytoseiidae), a potential biocontrol agent for western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae). *Australian Journal of Entomology* 42: 124-130.
- Stevens MM, James DG, O'Malley, KJ, Coombes NE 1998. Seasonal variations in foraging by ants (Hymenoptera: Formicidae) in two New South Wales citrus orchards. *Animal Production Science* 38: 889-896.
- Talhinhas P, Gonçalves E, Sreenivasaprasad S, Oliveira H 2015. Virulence diversity of anthracnose pathogens (*Colletotrichum acutatum* and *C. gloeosporioides* species complexes) on eight olive cultivars commonly grown in Portugal. *European Journal of Plant Pathology* 142: 73-83.
- Tena A 2007. Black scale *Saissetia oleae* (Homoptera: Coccidae) on citrus and olives: population structure and biological control. PhD Thesis. Universidad Politécnica De Valencia. Spain.
- Tena A, Soto A, Garcia-Mari F 2008. Parasitoid complex of black scale *Saissetia oleae* on citrus and olives: parasitoid species composition and seasonal trend. *Biological Control* 53: 473-487.
- Tranfaglia A 1977. Étude des espèces de *Saissetia* dans le bassin Méditerranéen (Homoptera, Coccoidea, Coccidae). *Fruits* 32: 545-547.
- Unnithan RR, Thammaiah N 2017. *In-vitro* evaluation of fungicides and antagonists against the growth of *Colletotrichum musae*. *Environment & Ecology* 35: 3252-3255.
- Waterhouse DF, Sands DPA 2001. Classical biological control of arthropods in Australia. ACIAR Monograph 77. Canberra, Australia. pp. 249-259.
- Way MJ 1963. Mutualism between ants and honeydew-producing Homoptera. *Annual Review of Entomology* 8: 307-344.
- Weir B, Johnston PR, Damm U 2012. The *Colletotrichum gloeosporioides* species complex. *Studies in Mycology* 73: 115-180.
- Wilson F. 1960. A review of the biological control of insects and weeds in Australia and Australian New Guinea. Technical Communication No. 1. Commonwealth Institute of Biological Control. England. Commonwealth Agricultural Bureaux. 102p
- Yokoyama V 2015. Olive fruit fly (Diptera: Tephritidae) in California table olives, USA: Invasion, distribution, and management implications. *Journal of Integrated Pest Management* 6:14. doi: 10.1093/jipm/pmv014.

Appendix 2. Report on base-line survey

REPORT ON OLIVE IPDM BASELINE SURVEY

INTRODUCTION

The national IPDM survey, was conducted in June 2018. A copy is provided as an Appendix in this report. It contained 30 questions in five sections:

- Orchard/grove attributes
- Pests & Diseases
- Integrated Pest & Disease Management
- Biosecurity
- Future Extension

There were 130 survey responses, with a good distribution of respondents, especially across the key olive-growing states. Victoria, NSW and SA growers were the most numerous (Table 1). The grower responses equated to >75% of Australian olive production, so should be highly representative of the industry as a whole.

Table 1. Number and % of growers responding to the IPDM survey

State	No. growers	% Growers
NSW	33	25%
QLD	3	2%
SA	22	17%
TAS	8	6%
VIC	45	35%
WA	17	13%
NO RESPONSE	2	2%
TOTAL	130	100%

ORCHARD ATTRIBUTES

There was a mix of traditional non-irrigated, low density and medium/high density plantings across all states, as well as super-high density plantings in SA and NSW (Table 2).

Table 2. Grove planting density

State	Traditional, non-irrigated <200 trees/ha	Low density (201-300/ha)	Medium/High density (301-1000/ha)	Super high density (>1000/ha)
NSW	21%	64%	12%	6%
QLD	67%	33%	0%	0%
SA	27%	41%	27%	14%
TAS	13%	25%	63%	0%
VIC	24%	58%	20%	0%
WA	18%	76%	6%	0%

All	23%	55%	20%	4%
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The most common age of plantings was >10 years old, but with substantial number of new, non-bearing plantings in NSW and Victoria (Table 3).

Table 3. Age distribution of olive trees in groves around Australia

State	Young, not bearing	Young and bearing (to 5 years)	5-10 years	10-20 years	>20 years
NSW	46.7%	4.4%	6.7%	38.6%	3.6%
QLD	0.0%	0.0%	14.7%	85.3%	0.0%
SA	0.1%	7.7%	23.7%	64.4%	4.0%
TAS	0.0%	0.9%	0.7%	98.4%	0.0%
VIC	15.7%	13.4%	23.7%	47.0%	0.2%
WA	3.4%	2.5%	1.1%	82.1%	10.9%

The majority of growers (62%) were olive oil producers, with the next most common category being oil and table olive producers (32%); only 6% produced table olives only.

The most commonly grown cultivars (based on number of trees, and order) were: Picual, Arbequina, Barnea, Coratina, Frantoio, Leccino, Manzanillo, Koroneiki and Kalamata. However, it should be remembered that Arbequina and Koroneiki are two of the major cultivars used in super high density plantings, so the tree number figures over-represent the area planted.

While less than 10% of respondents were registered organic or in conversion, 20% expressed interest in possibly growing organically and almost half indicated that they use organic practices but are not registered organic (Table 4).

Table 4. Organic status of olive growers

	Growers
Registered organic grower	8.6%
In conversion	0.8%
Interested in growing organically but currently conventional	19.5%
Not interested in growing organically	25.0%
Use organic practices but not registered organic	46.1%
Registered organic grower	100.0%

PESTS AND DISEASES

Insect pests

The most important insect pests are presented in Table 6, and diseases in Table 7. Their importance was scored as a combination of frequency of their nomination multiplied by their relative importance (scored from 1-5 points, with 5 being the most important). Thus, the higher the score, the more important nationally.

The three major insect pests were (in order): black scale (with associated ant activity), olive lace bug and weevil. The most widely distributed pest (reported in all states) was black scale, with olive lace bug a major pest in NSW, Qld, WA and some parts of Victoria. Interestingly, where both black scale and olive lace bug co-existed, lace bug was frequently ranked of higher importance. Weevil was a problem in WA, and less in SA and Vic.

Table 6. Most important insect pests in olives

Pest	Score	Key States
1. Black scale/Ants	602	All
2. Olive lace bug	211	NSW, Qld, WA, Vic (SA, Tas)
3. Weevil/ Curculio beetle	49	WA, SA, Vic

Diseases

The three most important diseases/disorders were, in order, anthracnose, peacock spot and dieback. Anthracnose scored less than half than black scale, and was reported in all states except Tasmania. Peacock spot was most commonly reported in the south-eastern states. Dieback a symptom associated with a number of pests and diseases including black scale, olive lace bug, anthracnose, peacock spot and grey mould (*cercospora* spot) as well as soil-borne pathogens, as well as adverse environmental conditions

Table 7. Most important diseases in olives

DISEASE STATUS	SCORE	KEY STATES
1. Anthracnose	267	All except Tas
2. Peacock spot	139	Tas, NSW, SA, Vic
3. Dieback	102	Qld, NSW, WA
4. Phytophthora/ Verticillium wilt	62 60	NSW, Vic, SA, WA
5. Others: Cercospora/ Grey mould, Olive knot		

The most commonly used pesticides for the major pests and diseases were (in order):

BLACK SCALE

Spray Oils (various)

Admiral® (pyriproxyfen)

Insegar® (fenoxycarb)

LACE BUG

Pyrethrum

Spray Oils (various) *

Confidor (imidacloprid) **

* Not registered against this pest, but registered in olives

** Not registered in olives

Samurai (clothianidin)

Dimethoate

WEEVIL

Avatar® (indoxacarb)* (expired 2016)

Dominex® (alpha-cypermethrin)

Spray Oils (various) *

ANTHRACNOSE

Copper (various)

Amistar® (azoxystrobin)

Aero® (pyraclostrobin + metiram)

PEACOCK SPOT

Copper (various)

PHYTOPHTHORA

Phosphorous (Phosphonic) Acid

Approximately two-thirds of respondents indicated that pesticides were important or very important for pest and disease management (Table 5).

Table 5. Importance of pesticides in olive pest and disease management

Importance of pesticides	Growers
Very important-main control	34%
Quite important	32%
Relatively unimportant	16%
Not used at all	15%

The most common equipment for application of pesticides in groves was air blast applicators (41%), followed by hand-held (including hand wand from tractor-drawn equipment) (36%), then boom sprayers (19%).

Growers obtained their information on pesticide use from a wide range of sources, but the most common was the AOA website (Fig 1).

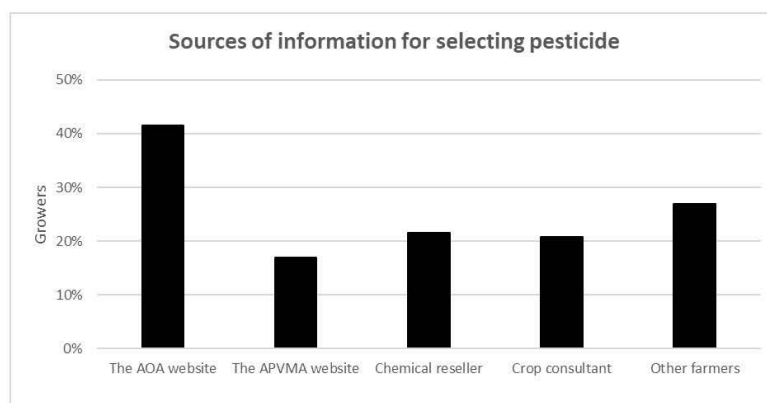


Fig 1. Sources of information for selecting pesticides

IPDM

With regard to growers' knowledge of IPDM, approximately 30% indicated they knew quite a lot or knew it well, with almost 50% indicating they knew only a little, and 14% knowing nothing.

Nevertheless, approximately 50% of growers indicated that implemented at least some IPDM practices against black scale and associated ant activity. Other insect pests against which IPDM practices were applied were olive lace bug and weevils. A number of these IPDM strategies were nominated when prompted in the question (in order): cultural practices for tree health (pruning, plant nutrition, irrigation); spraying based on monitoring; encouraging/supporting beneficial species; sanitation/removal of sources of infection; and use of selective pesticides.

Less growers implemented IPDM practices against diseases, with the key target diseases anthracnose/fruit rots (17%) and leaf diseases (peacock spot) (13%).

Over 80% of respondents indicated they monitored for pests and diseases in their grove, with visual observations the most common practice, with one third of growers also utilising meteorological conditions to predict outbreaks, especially of fungal diseases.

Eighty percent of growers stated they were confident in identifying important pests, compared with 62% confident in identifying diseases and disorders and 70% confident they can monitor their grove. This compared with just over 40% being confident in identifying beneficial species.

There was a wide range of sources of IPDM information used by growers, with the AOA and local Associations being the most frequent, followed by other growers and industry newsletters and journals (Fig 2).

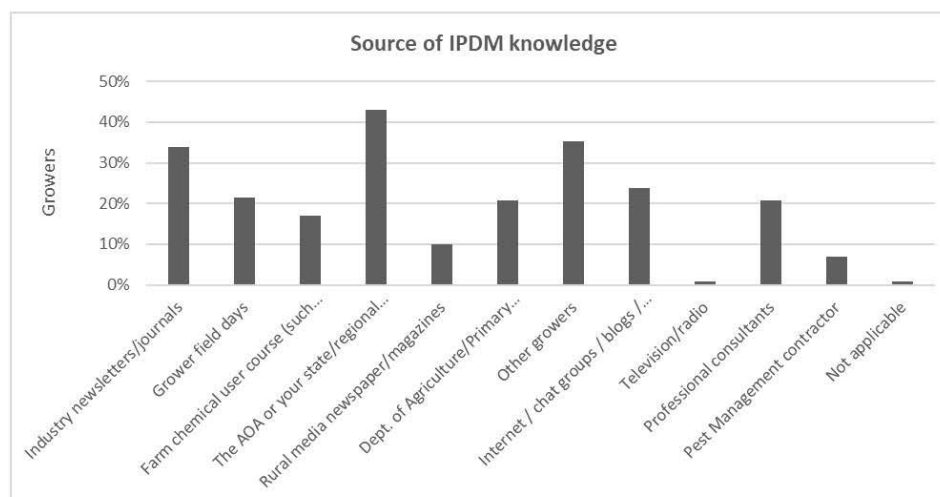


Fig 2. Sources of information for IPDM

BIOSECURITY

With regard to biosecurity, approximately half of respondents had vehicle wash down facilities on their grove, but only 18% had a farm biosecurity preparedness plan and 12% had read the current version of Biosecurity Plan for Olive industry. Other biosecurity issues they raised was biosecurity risks associated with olive harvesters travelling to different groves, olive processors (both inheriting problems especially if they are processing for other growers on a grove site; and the risk of transmission of pests and diseases from processors via contaminated bins)

Olive processors (for and by)

Overseas travellers (both ways)

FUTURE EXTENSION MATERIALS

When asked about preferred method of IPDM information other than field days, responses were evenly distributed between web-based tutorials (52%), an IPDM best practice manual (59%) and 1 page fact sheets (54%).

CONCLUSION/DISCUSSION

The survey was highly successful, in its capture of a substantial number of growers, representing more than 75% of the olive production in Australia, and with a range of production systems. The results should therefore be representative of the industry as a whole.

The three major plant protection problems were black scale, olive lace bug and anthracnose. This is heartening, as these three are the major focus of the current project.

However, responses indicated that different states and even different regions may have different plant protection problems. For example, weevils are a problem in WA and NSW; whereas olive lace bug is not a major problem in SA, southern Vic or Tas. Growers experienced greater difficulty in identifying diseases than they did insect pests. This is not surprising; it may also explain why there was a high score for some generic symptoms such as dieback, in that growers did not associate other symptoms such as mild chlorosis or underleaf discolouration with leaf fungal diseases that in turn might have led to the dieback. As a result, the project team have broadened the range of pests and particularly diseases we include in our field day presentations.

While growers indicated they still rely on pesticides as the main plant protection measure, it was pleasing to see that they are already implementing a number of IPDM practices. These include monitoring and spraying based on monitoring; implementing cultural practices for optimising tree health; encouraging/supporting beneficial species; sanitation/removal of sources of infection; and use of selective pesticides. However, it was disappointing to see some of the new pesticides that are now under permit were not being widely utilised and growers using older or less efficacious pesticides, or even pesticides not registered for use. This is an issue that has been partially addressed at the field days and will be further emphasised in the other extension materials.

The lack of knowledge and implementation of biosecurity was disappointing, but unsurprising. The team will now include a web-based tutorial on biosecurity, and the industry's OliveCare® program is also increasing its coverage of this topic.

Finally, it appears that the range of extension activities planned for this project are well supported by olive growers.

APPENDIX. OLIVE GROWER IPDM SURVEY

NATIONAL OLIVE GROWER IPDM SURVEY 2018

Please note there are a total of 30 questions

Orchard Attributes

Question 1: Please insert postcode of your property location _ _ _ _ _

Question 2: Is the planting in your grove

- Traditional, non-irrigated <200 trees/ha
- Low density (201-300/ha)
- Medium/High density (301-1000/ha)
- Super high density (>1000/ha)

Question 3: How old are the trees in your grove? If you have a number of plantings, please include all (i.e. number in each category).

- Young, not bearing
- Young and bearing (to 5 years)
- 5-10 years
- 10-20 years
- >20 years

Question 4: What is the number of trees for your 4 main varieties

- Arbequina _____
- Arbosana _____
- Barnea _____
- Coratina _____
- Correggiola _____
- Frantoio _____
- Hardy's Mammoth
- Hojiblanca
- Jumbo Kalamata
- Kalamata
- Koroneiki
- Leccino
- Manzanillo
- Mission
- Nevadillo (Blanco)
- Paragon
- Pendolino
- Picholine
- Picual
- UC13A6

- Verdale
- Other (please name)

Question 5: Name up to 2 of your most problematic varieties with regard to pests and diseases and name the pest or disease

Variety _____ Pest or disease _____

Variety _____ Pest or disease _____

Question 6: Are you

- Olive oil producer
- Table olive producer
- Both oil and table producer
- Other (please name)

Question 7: Are you interested in organic olive production?

- Registered organic grower
- In conversion
- Interested in growing organically but currently conventional
- Not interested in growing organically

Pests and diseases in your orchard

Question 8: Select up to 5 of the most economically damaging insect pests in your grove, numbering your selections from 1 to 5 with 1 the most important

- Ants _____
- Black scale _____
- Caterpillars _____
- Curculio beetle/apple weevil
- Fruit fly
- Grasshoppers
- Green vegetable bug
- Olive bud mite
- Olive lace bug
- Red scale
- Rutherglen bug
- Other (please name) _____

Question 9: Select up to 5 of the most the most economically damaging important diseases are present in your grove, numbering your selections from 1 to 5 with 1 the most important

- Anthracnose _____
- Cercospora spot/grey mould _____
- Nematodes
- Olive Knot
- Peacock spot
- Phytophthora root rot

- Verticillium wilt
- Other leaf spots (not above)
- Other fruit diseases/disorders
- Die back
- Other, please name _____

Question 10: • Name any other important pests (not insects or diseases) in your grove

Question 11: How important are pesticides (include any organically acceptable inputs, e.g. pyrethrum, copper, oil sprays as well as conventional pesticides) to your overall pest-management program?

- Very important-main control
- Quite important
- Relatively unimportant
- Not used at all

Question 12: Which insecticides (traditional or organic) do you use to control the below listed olive insect pests (please list all)

- Black Scale _____
- Olive lace bug _____
- Weevil _____
- Other pests (please name) _____

Question 13: Which fungicides do you use to control the following olive diseases (please list all)

- Anthracnose/fruit rot _____
- Peacock spot _____
- Other leaf fungal diseases (e.g. Cercospora/grey mould) _____
- Phytophthora root rot _____
- Verticillium wilt _____
- Other diseases (please name) _____

Question 14: Which methods of pesticide application do you or your contractor use?

- Boom spray
- Oscillating boom
- Air blast
- Hand held applicator (including wand from tractor-drawn sprayer)
- Other (e.g. through irrigation, granular, drenching, aerial etc., please name)

Question 15: How do you select the appropriate chemical to use for particular pests and diseases (select major source)?

- The AOA website
- The APVMA website
- Chemical reseller
- Crop consultant
- Other farmers

- Other (please name) _____

Integrated Pest and Disease Management

Question 16: How much do you know about integrated pest and disease management (IPDM)?

- Nothing
- Only a little
- Quite a lot
- Understand it well

Question 17: Where did you obtain your knowledge of Pest and Disease Management? (please select up to 3 most important)

- Industry newsletters/journals
- Grower field days
- Farm chemical user course (such as Chem Cert/ AgVet Chemical users training)
- The AOA or your state/regional olive association
- Rural media newspaper/magazines
- Dept. of Agriculture/Primary industries
- Other growers
- Internet / chat groups / blogs / YouTube
- Television/radio
- Professional consultants
- Pest Management contractor
- Other (please specify)
- Not applicable

Question 18: Are you confident you can:

Identify important pest insects?

- Yes
- No

Identify important diseases and disorders?

- Yes
- No

Identify beneficial species?

- Yes
- No

Effectively monitor your grove?

- Yes
- No

Question 19: How important is IPDM to your current overall pest and disease control program?

- Very important-main strategy
- Quite important
- Relatively unimportant-minor factor
- Unimportant
- Used to use but not using currently

Question 20: Against which insect pests do you currently use IPDM practices?

- Scale Insects
- Ants
- Olive Lace Bug
- Beetles/weevils/Moths
- Grasshoppers
- Mites
- Bugs (e.g. Green vegetable, Rutherglen)
- Fruit Fly
- Other (please name)
- Not applicable

Question 21: Against which diseases do you currently use IPDM practices?

- Anthracnose, Fruit Diseases
- Leaf Diseases (Peacock spot, grey mould etc)
- Root and Stem Diseases
- Other (please name)
- Not applicable

Question 22: Which techniques do you believe are effective control methods in your IPDM program (please select all answers that are relevant to you)?

- Encouraging/supporting beneficial species
- Introducing beneficial species
- Cultural practices: irrigation/pruning/plant nutrition etc
- Removal of sources of infection/overwintering pests or diseases
- Barriers or traps.
- Spraying based on monitoring rather than predetermined schedule
- Pest monitoring devices/practices
- Spot spraying
- Use of selective pesticides
- Rotating pesticide groups
- Selection of tolerant/resistant olive varieties
- Other (e.g. use of oils, organic methods/mixtures) please name_____

Question 23: Do you monitor any of the following diseases in your crop ?

- Leaf diseases
- Fruit diseases
- Root and Stem diseases
- Other (please name) _____

Question 24: Is your disease prediction and monitoring based on any of the following:

- Field observation
- Weather (including meteorological data)
- Outside consultants/pest and disease scout
- Other (please name) _____

Question 25: Do you monitor any of the following insect pests in your crops?

- Scale insects
- Ants
- Olive lace bug
- Grasshoppers
- Weevils
- Bugs
- Mites
- Fruit fly
- Other (please name) _____

Question 26: Which of the following methods do you use to monitor insect presence in your crop?

- Crop or sample plant inspection
- Coloured sticky traps (Yellow, white, blue)
- Pheromone traps
- Light traps
- Weather (including meteorological data)
- Drone or other imaging technology
- Other (please name) _____

Question 27: Do you have natural enemies of pests in your crop?

- Yes
 - Scale parasitoids
 - Scale eating caterpillar
 - Ladybirds
 - Green lacewings
 - Spiders
 - Other, please name _____
- No
- Unsure

Question 28:

- a. Name any beneficial insects that you think are present.
- b. Name any beneficial species you have introduced.

Biosecurity

Question 29: With regard to biosecurity:

a. Do you have grove machinery wash down facilities?

- Yes
- No

b. Do you have an on farm biosecurity preparedness plan?

- Yes
- No

c. Have you read the current (version 2.0, 2016) Biosecurity Plan for the Olive Industry Version

- Yes
- No

Future extension

Question 30: We will be conducting IPDM workshops and developing extension materials in this project.

a. What topics would you like to see covered in the workshops, or extension materials? Please rank up to 5 most important with 1 being most important.

- Identification of pests and diseases_____
- Identification of beneficial species_____
- Monitoring for pests and diseases_____
- Biology and life cycles of key pests and diseases
- Chemical options for pest and disease management
- Organic options for pest and disease management
- Tree health and nutrition
- Cultural practices to minimise pests and diseases
- Biosecurity
- Other (please name)_____

b. Apart from workshops, how else would you like to access IPDM information?

- Web-based tutorials
- An IPDM best-practice manual
- Flyers (1 page factsheets) on major pests and diseases
- Other (please name)_____

Please add any other comments/information you would like to provide

**THANKYOU FOR COMPLETING THIS SURVEY AND PROVIDING INFORMATION TO BETTER INFORM
OUR EXTENSION ACTIVITIES FOR THE INDUSTRY**

**WE WILL PROVIDE REGULAR UPDATES ON THE IPDM PROJECT AND ITS ACTIVITIES VIA HORT
INNOVATION AND THE AOA**

Appendix 3. Report on workshops/field days

REPORT ON OLIVE IPDM FIELD DAYS

Ten IPDM workshops/field days have been held. These were at Marulan NSW (10/8/2018), Lovedale-Hunter Valley NSW (12/8/2018), Perseverance –Toowoomba Qld (3/11/2018), Pomonal/Grampians Vic (16/11/2018), Roseworthy SA (24/11/2018), Launceston Tas (1/12/2018), Bright/Mt Buffalo Vic (1/2/2019), Mornington Peninsular/Red Hill Vic (3/2/2019); New Norcia WA (15/2/2019), and Margaret River WA (17/2/2019). Overall, more than 270 growers attended, with numbers ranging from 12 in Queensland to 41 at Marulan NSW. Numbers of participants at each field day are provided later in this report. Participant feedback has been very good (see later in this report and Article in R&D Highlights, Appendix 3).

Format and topics for field days

Discussions were held in collaboration with the AOA and the state/regional associations to determine appropriate timing, venues and format of the field days. Because of the part-time nature of many of the medium and smaller growers whom we wished to interact with, it was recommended that field days be held on Fridays or the weekend. Also, we realised that to optimise attendance, we should offer a range of complementary topics (especially tree health, and biosecurity) in a whole day field day, as opposed to a half day stand-alone IPDM workshop. An additional interesting topic was use of drone technology for grove management, including pest and disease monitoring.

The IPDM component was comprised of four sections:

- Principles and Practices of IPDM including feedback from the national survey (after the first field day, we held this session prior to lunch)
- Key arthropod pests and their management
- Key diseases and disorders and their management
- Field walk and discussion. Included IPDM and grove management, demonstration of drone technology

A colour copy of the IPDM presentations was provided at registration, and the AOA provided a 10X hand lens to each participant.

A participant feedback form (see later in this report) was sent to participants of Field Days 1 and 2, and was completed at the end of all subsequent field days. A collated summary of this feedback is provided later in the report.

Following the formal closing of the workshop, an informal dinner or barbecue was provided for additional grower-grower and grower-speaker networking.

TYPICAL FIELD DAY PROGRAM

08:30 Registration

08:45 Welcome, Housekeeping, and Overview of Field Day Program

Greg Seymour, CEO, AOA, Field Day Convenor.

09:00 Risk Management, Biosecurity, Continuous Improvement & Technical Support,

Peter McFarlane, OliveCare® Administrator, and AOA Biosecurity Representative;

Greg Seymour, Convenor, Olive Industry Risk and Crisis Management Committee:

- Risk Management, Industry Risk and Crisis Management Plan;
- Fostering Industry Biosecurity Threat Awareness and Preparedness;
- OliveCare® Code of Best Practice;
- Maintaining Producer Access to Registered Pesticides and 'Minor Use Permits' for use in Olive Groves.

09:30 Q & A Session

09:40 Grove Management Checklist – Healthy Trees to Support an IPDM Program,

Michael Thomsett, Horticultural Consultant and AOA President*

- Irrigation;
- Nutrition & Soil Health;
- Pruning/ Tree Management.

10:10 Q & A Session and Morning Tea

10:30 Product Quality and Market Development,

Michael Thomsett, Peter McFarlane, Sarah Gray, Convenor, Olive Wellness Institute, Greg Seymour

- Australian International Olive Awards and Regional Olive Competitions;
- The Tastebook™ Sensory Training Program.
- Industry Generic Promotions Programs;
- Olive Wellness Institute Project

11:30 Q&A Session

11:40 IPDM Session 1

Dr Robert-Spooner-Hart

- Principles and Practices of IPDM

12:30 LUNCH

1:15 IPDM Session 2

Dr Robert Spooner-Hart and Dr Len Tesoriero

- Monitoring for pests, diseases and beneficial species
- Biology and life cycles of key pests and diseases
- Factors influencing pest and disease spread and incidence in groves
- Strategies for conventional and organic management
- Advantages and disadvantages of management strategies
- Importance of timing, application and targeting of interventions.

14:45 Drive to IPDM Field Activities

15:00 IPDM Grove Walk

Owner/manager, Dr Robert-Spooner-Hart and Dr Len Tesoriero

- Introduction to grove by owner/manager
- Grove walk and discussion
- Insect identification
- Disease identification
- Grove management and drone exhibition

16:30 Drive Back to Venue

16:45 Review of Field Visit; Q & A Session

Dr Robert Spooner-Hart and Dr Len Tesoriero

- Field day participants are invited to send images of insect or disease issues on their grove to Dr Spooner-Hart one week prior to the event. Feedback will be provided in a group Q&A session without identifying the senders of the images.
- Questions will also be taken without notice on any aspect of pest and disease management from participants during this session.
- Questions/ comments about any of the topics covered during the day

17:15 Evaluation and Concluding Remarks, Greg Seymour

17:30 Post Field Day Networking BBQ

Field day participants are invited to join the field day speakers at an informal get-together at the Perseverance Hall after the field day concludes. This function will provide an opportunity for participants to get one-on-one with the experts to discuss issues of relevance to their own groves and businesses. Meals and drinks are included in Field Day Fee.

20:00 Field Day Close

This field day is part of a national program in the project: An integrated pest and disease management extension program for the olive industry (OL17001). The project is funded by Hort Innovation, using the Hort Innovation olive industry research and development levy, and contributions from the Australian Government

MODIFICATIONS TO STANDARD PROGRAMS

- In Roseworthy SA, the session on **Grove Management Checklist – Healthy Trees to Support an IPDM Program**, was only presented briefly, as Michael Thompson was unable to travel to the venue because of a cancelled flight. In Launceston Tas, this session was given by Jim Rowntree, Longridge Olives, SA.
- In Roseworthy SA, SARDI plant pathologist Barbara Hall attended the field day and presented local information on olive diseases in the formal session and the field walk.
- In New Norcia and Margaret River WA, Stewart Learmonth and Alison Mathews from DPIR WA attended the field days and presented local information on olive pests, particularly weevils, in the formal sessions and the field walks. In addition, following discussion of the impact of soil health on tree health and IPDM in some previous field days, an additional session on soil carbon was presented by Andy Gulliver from C-Wise.

Feedback from IPDM field days

Attendance at the field days was very good, with grower attendance from 12 to 40, depending on the location. The number of attendees were: Marulan NSW (N1) 41; Lovedale NSW (N2) 28; Perseverance Qld (Q) 12; Pomonal Vic (V1) 20; Roseworthy SA (S) 37; Launceston Tas (T) 25, Mt Buffalo/Bright Vic (V2) 36, Red Hill/Mornington Peninsular Vic (V3) (37); New Norcia WA (W1) (14); and Margaret River WA (W1) (25).

Written feedback from attendees was sought at all field days. The feedback form is provided below. Summary responses for the management of the field days and the IPDM components are provided, as an average (mean) response (with scores from 1-5, with 5 being excellent) for each venue. Venues are identified by their designated initials above. Although there were some venue differences (especially relating to comfort of the venue (e.g. hall/shed and weather, and also with the grove used for the field walk), all activities scored an overall mean of 4.5 or above, with the IPDM Principles & Practice and Olive Pests and Diseases sessions scoring highest at 4.8/5.

ORGANISATION OF FIELD DAY

N1 4.4; N2 4.7; Q 4.7; V1 4.8; S 4.7; T 4.9; V2 4.3; V3 4.9; W1 4.8; W2 4.8; **Mean 4.7**

VENUE AND CATERING

N1 4.3; N2 4.3; Q 4.8; V 4.3; S 4.8; T 4.7; V2 4.5; V3 4.5; W1 4.9; W2 4.8; **Mean 4.6**

RISK MANAGEMENT/BIOSECURITY

N1 4.3; N2 5.0; Q 4.4; V 4.4; S 4.7; T 4.7; V2 4.4; V3 4.3; W1 4.0; W2 4.4; **Mean 4.5**

IPDM GENERAL PRINCIPLES & PRACTICE

N1 4.6; N2 5.0; Q 4.8; V 4.6; S 4.6; T 4.9; V2 4.5; V3 4.9; W1 4.8; W2 4.8; **Mean 4.8**

OLIVE PESTS & DISEASES

N1 4.6; N2 5.0; Q 4.9; V 4.7; S 4.8; T 4.8; V2 4.6; V3 4.9; W1 4.7; W2 4.9; **Mean 4.8**

FIELD SESSION

N1 4.2; N2 5.0; Q 4.7; V 4.4; S 4.0; T 4.8; V2 4.6; V3 4.8; W1 4.7; W2 4.5; **Mean 4.6**

OVERALL FIELD DAY COMMENTS

Exchange between growers

A very good day

Useful, new to the industry

Grove management, pest and disease management

ID of pests and diseases

Chemical updates

Changing practices as a result of the field day

More observations

More monitoring (many times)

Employing an IPM person

Develop a pest and disease management plan

Improve my scale management

More open canopies

Pruning

Biosecurity

ANY OTHER COMMENTS

I think the course in this format is highly recommendable and of great use to growers

Thank you for coming to Queensland

Thanks for coming here

A very good day, thanks

Format excellent

Good to meet real experts who impart useful knowledge

Good talking to people (many times)

A website for information

Robert and Len were really good to listen to

Needed a better grove than NOVA (Roseworthy)

Good to see a well-managed organic grower (Margaret River)

Well organised (many times)

Excellent speakers (many times)

Thank you (many times)

Appendix 4. Report on Master Class

REPORT ON MASTERCLASS

A two-day Master Class was conducted on 25-26 September 2019 at the Hawkesbury campus of Western Sydney, Richmond NSW. Attendance was free, and offered morning tea and lunch as well as printed copies of all of the presentations. A wide advertising campaign was conducted throughout the industry, via the AOA and featured in the August and September issues of Grove Innovation (see Appendix 1); additionally, it was advertised through the Hort Innovation and Western Sydney University communications channels as well as via direct contact with key organisations providing consultancy services and agrichemical chemical suppliers to the Australian olive industry.

There were only three attendees; although two of them represented the largest olive producer. Several other registrants withdrew prior to the Master Class.

PROGRAM

The program included six highly experienced experts, four from Western Sydney: Robert Spooner-Hart; Prof Andrew Beattie, adjunct professor (biological control of scales, spray oils in IPM); Dr Paul Milham, formerly NSW DPI, now Adjunct Research Fellow (soil chemistry, leaf analyses); Dr Tom Jeffries (soil health and microbiology) and project team members Len Tesoriero, NSW DPI and Barbara Hall SARDI (plant pathology). Following feedback from the field days, in addition to direct information on the biology and sustainable management of pests and diseases of olives, it included information related to soil health and impacts on plant health that had been presented to a recent Soils Master Class. It also featured the latest findings on black scale biology and its natural enemies in Australia, from a recently completed WSU PhD study. There was a detailed presentation and discussion on the potential for use of horticultural spray oils for management of olive pests, in particular black scale. The program also scheduled a hands-on laboratory session in the second half of Day 1, in which the participants were provided access to live specimens of all the key pests and diseases, and discussions by the presenters on symptoms of damage, diagnosis, life stages, different strains of *Colletotrichum*, and identification of bacterial ooze from active olive knot.

There was adequate time for discussion, both formally and informally, facilitated by the small number of attendees. Len Tesoriero, Barbara Hall and Robert Spooner-Hart joined the participants for dinner on Day 1, where further discussions took place.

The detailed Master Class program is provided on the following page.



IPDM MASTER CLASS PROGRAM 25-26 SEPT 2019

DATE	TOPIC	PEOPLE
WED 25 SEPT		
9-9.15	Welcome, Introduction	
9.15-9.45	IPDM Project, symptoms	Robert Spooner-Hart
9.45-10.00	Morning tea	
10.00-12.00	Olive diseases	Len Tesoriero & Barbara Hall
12.00-12.30	Lunch	
12.30-1.30	Lace Bug, Black scale biology	Robert
1.30-4.30	Diagnostics in laboratory	All
5.30-drinks/dinner		
THUR 26 SEPT		
08.45-9.00	Feedback from Day 1 activities	Robert
9.00-10.00	Soil microbiology	Dr Tom Jeffries
10.00-11.00	Soil chemistry	Dr Paul Milham
11.00-11.30	Morning tea	
11.30-12.30	Oil sprays and their role in arthropod management (esp. scales).	Dr Andrew Beattie
12.30-1.00	Lunch	
1.00-1.30	Black scale management: biological control.	Robert/Andrew
1.30-2.00 pm	Current and possible future agrichemical options (including organic) for olive pests and pathogens	Robert, Len, Barbara
2.00-3.00	Biosecurity: pest and disease threats	Robert, Len,
3.00-3.45	Diagnostics	
3.00-3.45	Group discussions on future actions and presentations	All
3.45-4.00	Wrap up, participant feedback	



Participant Survey

IPDM MASTER CLASS

Your name (optional): _____

ORGANISATION OF MASTER CLASS

Please rate the organisation overall organisation of the Master Class, where 1 is poor and where 5 is excellent:

1 2 3 4 5 (4.0)

What aspects of the overall Master Class organisation could be improved, if any?

Please rate the venue and food/catering:

1 2 3 4 5 (4.0)

What if anything would you like to see improved

More healthy snacks

DAY 1

PESTS AND DISEASES PRESENTATIONS

Please rate the usefulness of the Pests and Diseases Presentations where 1 is poor/not very useful and where 5 is excellent/very useful:

1 2 3 4 5 (5.0)

What was the most valuable part of this session?

Presentations on black scale, verticillium wilt

What was the least valuable session of this session?

Any additional comments/suggestions?

PEST/DISEASE PRACTICAL/LABORATORY SESSION

Please rate the usefulness of the Session where 1 is poor/not very useful and where 5 is excellent/very useful:

1 2 3 4 5 (4.0)

What was the most valuable part of this session?

Signs of parasitism on black scale, detailed disease diagnosis

What was the least valuable session of this session?

Any additional comments/suggestions?

DAY 2

SOIL BIOLOGY & CHEMISTRY IN THE CONTEXT OF PLANT HEALTH

Please rate the usefulness of the soil biology and chemistry session where 1 is poor/not very useful and where 5 is excellent/very useful:

1 2 3 4 5 (3.0)

What was the most valuable part of this session?

Discussion about how to choose a competent analytical laboratory

What was the least valuable session of this session?

Basic discussion about soil organic matter

Any additional comments/suggestions?

General soil science good as refresher, but probably of more interest to growers that do not know much about soil health. More info about soil nutrients and deficiency on trees.

OIL SPRAYS + IPM

Please rate the usefulness of this session where 1 is poor/not very useful and where 5 is excellent/very useful:

1 2 3 4 5 (5.0)

What was the most valuable part of this session?

Oil sprays and scale monitoring

What was the least valuable session of this session?

History of oil use

Any additional comments/suggestions?

Very useful session

BIOSECURITY

Please rate the usefulness of the session where 1 is poor/not very useful and where 5 is excellent/very useful:

1 2 3 4 5 (4.0)

What was the most valuable part of this session?

It was good to learn about other pest and disease threats to the Australian olive industry

What was the least valuable session of this session?

Any additional comments/suggestions?

OPTIONS FOR CURRENT AND FUTURE AGRICHEMICALS (CONVENTIONAL/ORGANIC OPTIONS)

Please rate the usefulness of the session where 1 is poor/not very useful and where 5 is excellent/very useful:

1 2 3 4 5 (5.0)

What was the most valuable part of this session?

What was the least valuable session of this session?

Any additional comments/suggestions?

OVERALL MASTER CLASS

Did you learn new information from the Master Class? (if yes, please elaborate)

I learned a lot of new information, even though I already have experience. I probably learned as much as the formal presentations from personal discussions with Robert, Len and Barbara.

Will you be changing any practices as a result of the field day? (if yes, please elaborate)

Will discuss potential changes with management, to follow more IPDM

Discuss about modifying black scale monitoring. Also discuss options for oil sprays

Do you have any other comments?

Thank you for conducting the class, even if there were few of us. It was relevant and worthwhile.

Overall, the Master Class was very productive training to update and increase my knowledge with recent research in the field and to evaluate current management methods.

THANK YOU FOR YOUR PARTICIPATION AND FOR RESPONDING TO THE SURVEY

Appendix 5. IPDM flyers

BLACK SCALE, *Saissetia oleae*

Adult Size: 3–5 mm

Biology and damage: This species is widely distributed in Australia. First generation crawlers normally emerge in late spring-early summer, earliest in the north. Two or three generations occur per year, with more in northern parts. Hot, dry weather reduces the survival of crawlers. Scales attack leaves and twigs, resulting in leaf drop, reduced tree vigour and twig dieback in heavy infestations. Ants and sooty mould are commonly associated with the production of honeydew by adults and nymphs of black scale. The movement of ants up a trunk is indicative of active black scale in the tree, even if the scales are not obvious.



Major natural enemies: Black scale has many natural enemies that can play an important role in its management in olive groves. These include small parasitic wasps such as *Metaphycus* spp. and *Scutellista caerulea*; ladybirds, lacewing larvae and the scale-eating caterpillar. Parasitised scales may show exit holes once the wasps have emerged.

Management: If required, black scale can be targeted by judicious use of spray oils or insect growth regulators. Sprays need to be targeted at crawlers and young nymphal stages, so timing is critical for effective management. This makes monitoring for crawler development important. Opening up tree canopies exposes crawlers to greater likelihood of dehydration, and also to access by sprays targeted against them. Management of black scale will reduce ant problems, and vice-versa.



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OLIVE LACE BUG, *Froggattia olivinia*

Size: Adults 3 mm

Biology and damage: An Australian native species recorded in NSW, Qld, Vic, SA, WA and most recently Tas. Adults are mottled brown. There are two to four generations per year. Spiny nymphs occur in clusters on undersides of leaves; the first generation commonly emerge from leaves in spring. All stages attack leaves with piercing mouthparts, causing yellow spotting. Black tar spots occur on undersides of leaves. Leaf drop and twig dieback may occur in severe infestations.



Natural enemies: Few have been recorded; green lacewings have been observed predating on lace bug nymphs, and spiders on adults and birds may also be predators. The native green lacewing *Mallada signata* is commercially available, and some growers have released it in their groves.

Management: If required, lace bug can be targeted by judicious use of insecticides. Several, including pyrethrum and potassium soap may be organically acceptable inputs. Sprays need to be targeted at young nymphal stages, so monitoring for nymphal hatch of especially the first generation in spring is important. Opening up tree canopies exposes nymphs to greater likelihood of dehydration, and also to access by sprays targeted against them. Stressed trees are more susceptible to lace bug attack, so maintaining healthy trees assists in management of this pest.

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WEEVILS

APPLE WEEVIL, CURCULIO BEETLE (*Otiorhynchus cribricollis*) in inland NSW, SA & WA
GARDEN WEEVIL (*Phlyctinus callosus*), mainly in WA

Size: 7–9 mm

Biology and damage: Apple weevil is the major weevil pest in olives. Adults are nocturnal and flightless, emerge from the ground in summer and climb trees to chew leaf margins, creating a typical scalloped appearance. Severe infestations can damage growing tips, and reduce yield, especially in young trees. The soil-dwelling legless white-bodied larvae may feed on plant roots, but there are no reports of serious damage to olives.



Apple weevil damage

Apple weevil larva (top) and adult

Apple weevil fibre trap

Management: Check new plantings for leaf and stem feeding. Confirm whether these weevils are the cause by observations at night or by digging around the base of trees during the day. Butt sprays of a permitted insecticide can be used. An effective alternative to insecticide is the use of either a sticky or a fibrous barrier applied to the tree trunk. In the latter case, apple weevils become enmeshed in the fibres. Sticky material such as polybutene will help exclude garden weevil adults but not apple weevil. It is phytotoxic to olive trees and needs to be placed on a substrate such as plastic.

Poultry, including guinea fowl have been reported to contribute to garden weevil control in orchards and vineyards.

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OLIVE ANTHRACNOSE

Caused by certain species of the fungus *Colletotrichum* - sometimes referred to as species complexes of *C. acutatum* and *C. gloeosporioides*.

Biology and damage

Anthracoise is a globally important disease of olives - and many other fruit and vegetable crops. Olive losses are due to reduced yields and poor oil quality. *Colletotrichum* spp. can survive on plant surfaces without infection - called epiphytic survival. Infected shoots, stems and leaves can be symptomless. In wet weather disease symptoms develop - drying and wilting of leaves, defoliation, and dieback of branches. Severe infection can cause reduced tree vigour. Spores spread with rain splash while insects may also passively spread spores on their bodies. Infection of flowers and young fruit occurs in spring (optimum temperatures 17-20°C) in wet conditions (up to 48 hr). Fruit infections are superficial and remain dormant - latent infections. In wet autumns and as fruit ripen, sunken lesions develop and masses of conidia (spores) form – seen as greasy pink, orange or brown areas on the fruit surface – called ‘soapy olive or soapy fruit’.



Ripe fruit with sunken lesions and gelatinous salmon pink spore masses. Lesions may have a faint concentric pattern.



Yellowish-brown ‘Soapy olive’ symptoms

Management

Prune to remove infected branches and to open tree canopies to air & sun. Remove or cover dropped leaves and fruit with compost; remove mummified fruit on trees. Timing fungicide applications is important - preventative treatments in winter; and preventative or eradicated products in spring, summer and autumn - depending on occurrence and duration of wet weather. Grow less susceptible varieties. Harvest fruit early, particularly if wet weather is expected or occurs near ripening. Balance plant nutrition – avoid excess nitrogen and ensure calcium levels are adequate. Note calcium becomes unavailable to plants under very wet or dry soil conditions – so regular watering or good drainage are important when fruit are developing to prevent deficiency.

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CERCOSPORA LEAF MOULD

(also called Cercospora Leaf Spot, Cercosporiosis or Cercosporiose)

Caused by the fungus *Pseudocercospora cladosporioides*

Biology and damage

It is very common in Australian olive groves but rarely causes significant losses, particularly if tree health is maintained by optimising nutrition and irrigation. It is a slow degenerative disease often taking several years for trees to significantly decline. It can cause delayed fruit ripening and decreased oil yield. Initial infections occur during late winter with rainy weather – younger leaves are most susceptible. The optimum temperature for spores to germinate is between 15-25°C (average 22°C). There can be a long latent period before symptoms develop – up to 11 months! – it depends on the weather – a wet spring favours disease development. Rainy weather in late summer and throughout autumn favours spore formation and further spread to leaves and fruit. Leaves turn yellow and may have dead brown areas – mostly in the inner or lower parts of the canopy. Infected leaves may drop. A diffuse lead-grey mould develops on the leaf under-surface – mostly visible on young leaves. It can rarely cause a fruit infection – small (<5mm) sunken grey-brown spots – although spots may be larger in some varieties, darker and not sunken.



Yellow infected leaves are easily dislodged when touched



Lead-grey fungal growth on leaf under-surface

Management

Remove or cover dropped leaves with compost, or shred leaves and apply N fertiliser to hasten breakdown in winter. Prune branches to open the tree canopy to air/sun. Timing is important for fungicide applications in winter & spring and when rain expected in late summer. Recent research in Europe found the biocontrol bacterium *Bacillus subtilis* was effective (various strains of this and similar bacteria were sprayed on trees at regular intervals through the year). Some olive varieties are more tolerant to this disease – e.g. *Arbequina* and *Picual*. Some olive varieties are very susceptible – e.g. *Hojiblanca*.

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PEACOCK SPOT (Olive Leaf Spot)

Caused by *Fusicladium oleaginum* (*Spilocaea oleaginea*)

Biology and damage

Occurs worldwide and is the most common disease of olives. This disease is common in regions that experience wet and humid spring conditions – particularly coastal and warm temperate regions of Australia. Infection of leaves occurs mostly in winter & spring during wet weather (optimum temperatures 15-21°C, >98% Relative Humidity and a wet leaf surface for 1-2 days). Spores cannot germinate >25°C. Infections can remain dormant until autumn if conditions are dry – called a ‘latent infection’. After periods of wet weather lesions develop and conidia (spores) form on the leaf surface. Spores spread with water splash & with insects such as bookworms (Order *Psocoptera*) which live in leaf litter & on leaves. Olive varieties differ in susceptibility – e.g. *Hojiblanca*, *Picual*, *Arbequina* & *Manzanillo* are more susceptible; *Lecchino* is more resistant.



Spots can develop a dark outline, concentric markings or a yellow halo. Infected leaves yellow before dropping.



Under moist weather conditions developing fruit can also be infected – although this isn’t common

Management

Prune branches to open tree canopy to air and sun. Remove or cover dropped leaves with compost - or shred leaves and apply N fertiliser to hasten breakdown in winter. Timing is important for fungicide application when wet weather is expected (especially in late winter & spring). Grow tolerant olive varieties. Maintain balanced plant nutrition in spring – high nitrogen and low potassium levels in leaves favour infection.

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OLIVE WOOD ROTS AND DIEBACK

Infections by a wide range of plant pathogens or certain physiological disorders can cause dieback of olive tree branches or trunk rots that may result in tree death. Unfortunately, symptoms of the various diseases and disorders can look very similar requiring laboratory testing and sometimes extensive investigations of root systems, soil conditions and weather records to determine if any particular pathogen or otherwise was the primary cause. The situation is further complicated by the fact that many common fungi and bacteria can be residents in or on woody plant tissue and only cause diseases when plants are stressed or where wounds allow their entry. In recent years there has been an increased awareness of these types of diseases particularly in European and American olive production. Following are key fungal pathogens that have been described as causing dieback diseases of olives overseas: *Neofabraea*, *Neofusicoccum*, *Cytospora* and *Diplodia* spp. Similar fungal species are known to occur in Australia but they have not been systematically studied on olives. In addition, the bacterial pathogen *Xylella fastidiosa* can cause dieback and tree death overseas and is described separately in a biosecurity flyer. Frost and sun scald can be particularly damaging to young trees while wounds from pruning, shaking, herbicides, mechanical weed controls and animal grazing can be important entry points for opportunistic pathogens.

Following is a list of fungi and bacteria (in addition to fungi causing Peacock spot, Anthracnose and *Cercospora* leaf mould which are described in separate flyers) found associated with branch dieback and trunk rots in Australia:

Disease	Pathogen	Symptoms
Trunk and stem dieback	<i>Botryosphaeria</i> sp.	Stem cankers and dieback
White wood rot	<i>Pycnoporus coccineus</i>	Trunk rot with orange bracket fungus
Charcoal rot	<i>Macrophomina phaseolina</i>	Root rot and seedling dieback
Phytophthora rot	<i>Phytophthora</i> spp.	Root and/or trunk rot
Rhizoctonia rot	<i>Rhizoctonia</i> spp.	Root rot and seedling dieback
Verticillium wilt	<i>Verticillium dahliae</i>	Root rot and branch dieback
Bacterial shoot blight	<i>Pseudomonas syringae</i>	Shoot dieback
Bacterial trunk rots	<i>Pseudomonas</i> spp., <i>Xanthomonas</i> spp., <i>Ralstonia solanacearum</i>	Wound cankers, trunk rot and dieback

Management

Prune branches during dry weather conditions to allow wound sites to dry and callus. Pruned branches should be removed – they can be mulched and composted. This is particularly important if *Verticillium* wilt has been detected since this fungus can be present in small branches and twigs. Ensure mechanical shakers are not damaging trunk tissue during harvest. Protect young trees from sun scald and frost injury. Ensure soil drains freely to avoid waterlogging and subsequent root pathogen infections.

	 Bacterial infection of olive stem
 Phytophthora rot of young olive stem	 Brown vascular tissue caused by <i>Verticillium dahliae</i> infection

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EXOTIC PESTS AND DISEASES OF OLIVES

There are many pests and diseases both of olives and other crops overseas that are potential threats to the olive industry. The Biosecurity Plan for the Olive Industry (Version 2.0 – 2016) ([link](#)) lists five High Priority pests:

1. Olive fly (*Bactrocera oleae*). Olive fly is the most important pest of olives worldwide. It is widely distributed in the Mediterranean basin, northern and southern Africa, Western Asia, including India and Pakistan, and Northern America (California and Mexico). The female lays eggs in fruit, often when it is green, and developing larvae (maggots) burrow, usually causing fruit drop. Pupation commonly occurs in fruit. Adult flies resemble Queensland Fruit Fly, but have black markings on their wing tips.

2. Olive moth (*Prays oleae*). Olive moth is widespread in Mediterranean countries including northern Africa, and other European locations. The only host is olive and close relatives. Adult moths are silvery grey, and have long antennae. Green or light brown larvae can grow to 8 mm. The pupal stage is protected by loose silk webbing. There are normally 3 generations per season, attacking flower buds and flowers, fruit and leaves, respectively. Damage symptoms include frass (faecal pellets and webbing), or leaf mining.



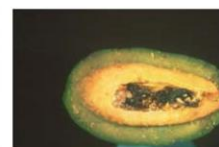
Olive fly adult



Olive fly larva and damage



Olive moth adult



Olive fly larva damage

3. Leaf scorch (*Xylella fastidiosa* subsp. *multiplex* (with vectors)) and 4. Olive quick decline (*Xylella fastidiosa* subsp. *pauca* (with vectors)). The bacteria live in the plant xylem (water-conducting) vessels inhibiting the uptake of water and nutrients which leads to disease symptoms that look like water stress – called leaf scorch. A particular strain of *X. fastidiosa* subsp. *pauca* causes trees to dieback - killing them – called Olive Quick Decline Syndrome (OQDS). OQDS was first reported in olives in southern Italy in 2013, but has since been reported more widely, including in Brazil. Most introductions of *X. fastidiosa* occur with the movement of infected plant material. Once present, xylem-feeding insect vectors are the primary pathway by which the disease spreads.

5. Verticillium wilt (*Verticillium dahliae* (exotic defoliating strains)) One strain of this soil-borne fungus has been distinguished as the 'defoliating strain' (DS) on cotton in the USA. It causes wilt and death of olive trees in California and parts of Europe. Leaves in infected trees can drop when green or turn brown - often with a downward rolling along leaf margins – symptoms appear from autumn to late spring. Only some limbs or branches of a tree may be affected, giving the tree a patchy or one-sided appearance. Trees (particularly younger ones) often die or linger with reduced vigour.



Leaf scorch



Olive quick decline



Verticillium wilt (DS) infected grove



Verticillium wilt infected tree

If you suspect a new pest, call the Exotic Plant Pest Hotline on 1800 084 881

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Appendix 6. End-of-project survey

REPORT ON FINAL OLIVE IPDM SURVEY

INTRODUCTION

A second national end-of-project IPDM survey was conducted September 2020. It contained 23 questions in four sections (see Appendix at end of this report):

- Orchard/grove attributes
- Pests & Diseases
- Integrated Pest & Disease Management (including Participation in olive IPDM project activities)
- Biosecurity

A number of these questions were common with the baseline (2018) survey, to enable consistency with regard to farm attributes, and particularly to enable comparisons between grower-expressed knowledge on pests and diseases and IPDM prior to and after the project interventions. There were also several questions directly related to participation in and grower outcomes from the project's activities. Most importantly, this survey aimed to determine the project's impact and how effectively it met its objectives of more informed and more engaged growers with respect to IPDM.

There were 47 survey responses, compared with 130 responses in the original survey. This reduced number is likely, at least in part, due to "survey fatigue" associated with the substantial increase in on-line communications as a result of COVID-19 restrictions on travel and personal engagement. Nevertheless, there was a good distribution of respondents, especially across the key olive-growing states. Victoria, NSW and SA growers were again the most numerous (Table 1).

**Table 1. Number and % of growers responding to the final IPDM survey
(baseline survey numbers in brackets)**

State	No. growers	% Growers
NSW	10 (33)	21.3 (25)
QLD	1 (3)	2.1 (2)
SA	11 (22)	23.4 (17)
TAS	3 (8)	6.4 (6)
VIC	15 (45)	31.9 (35)
WA	7 (17)	14.9 (13)
NO RESPONSE	0 (2)	0 (2)
TOTAL	47 (130)	100

ORCHARD ATTRIBUTES

There was a similar mix between the two surveys of traditional non-irrigated, low density and medium/high density plantings across all states, as well as super-high density plantings in SA and NSW.

The majority of growers, viz. 51% (cf. 62%) were olive oil producers, with the next most common category being oil and table olive producers at 38.3% (32%); only 8.5% (6%) produced table olives only. Most larger growers produced oil only.

The most commonly grown cultivars were also similar to the 2017 survey Picual, Arbequina, Barnea, Corregiola, Frantoio, Leccino, Manzanillo, Koroneiki and Kalamata.

While almost 22 % (cf. <10%) of respondents were registered organic or in conversion, an additional 46% (25%) of conventional growers expressed an interest in growing organically. While many of these are smaller growers, it emphasises the importance of the project targeting this sector of the industry for extension information on sustainable pest and disease management.

PESTS AND DISEASES

Insect pests

The three major insect pests identified in the 2020 survey were the same as those in the 2017 survey, namely (in order): black scale (with associated ant activity), olive lace bug and weevil. The most widely distributed pest (reported in all states) was black scale, with olive lace bug a major pest in NSW, Qld, WA and some parts of Victoria. Weevil was a problem in WA, and less but increasing in SA and Vic.

Diseases

Interestingly, however, there was a change in the three most important diseases/disorders reported. Whilst anthracnose was still the major disease, cercospora leaf mould was the second most important (previously this had been peacock spot). This is unsurprising to the project team, because we discovered widespread distribution of cercospora during the field day activities, although its economic damage was difficult to determine. As a result, we developed a tutorial and a flyer on this disease. Dieback was the next most common disease/disorder. However, this condition is associated with a number of pests and diseases including black scale, olive lace bug, anthracnose, peacock spot and cercospora leaf mould, soil-borne pathogens, as well as adverse environmental conditions, so it is difficult to diagnose the most likely cause(s). Peacock spot was relegated to the fourth most important disease in the survey. It is possible that any leaf spot/leaf drop prior to our project activities was attributed to peacock spot; clearly, this has been a major achievement of the project in rectifying this issue. However, it may have also led to an over-inflated concern about cercospora leaf spot (see Discussion).

Pesticides

While nearly 70% (cf. 66%) of respondents indicated that pesticides were important or very important for pest and disease management, these included organic chemical options. As a result, the selection and appropriate use of chemical options remains an important extension issue for the industry.

The most common equipment for application of pesticides in groves confirmed air blast applicators predominated 48% (41%), followed by hand-held (including hand wand from tractor-drawn equipment) 29% (36%), then boom sprayers 24% (19%).

IPDM

Participation in project activities

Seventy-nine percent (37/47) of the respondents participated in at least one other IPDM project activity. Of those that did, the most common activity was participating in the first survey, in field days/workshops, attending the webinar and accessing the project outputs on the AOA's website OliveBiz (particularly the Field Guide and IPDM Manual) (Table 2).

Table 2. Participation in olive IPDM project activities.

Activity	Percentage participation
The previous (2018) project survey	64.86%
Attended a field day	64.86%
Attended the Masterclass	8.11%
Attended the Webinar	35.14%
Accessed video(s) of Field Day presentations via OliveBiz	18.92%
Accessed new on-line tutorials	13.51%
Accessed new on-line flyers	21.62%
Accessed the revised Field Guide	32.43%
Accessed the IPDM Manual	32.43%
Direct contact with the project researchers	18.92%

Amongst the growers that participated in project activities, 89% responded that their knowledge been improved as a result. Common responses were improved pest, disease and beneficial identification, better understanding of biology and life cycles, information on alternatives to chemicals, planning of spray timing, and access to project output materials.

When growers were asked whether their IPDM practices have changed, or are anticipated to change as a result of their participation in the project, 60% responded that they would change; 23% were unsure. The most common responses were increased emphasis on monitoring and record keeping, better tree health and canopy management, and investigating options (including organic ones) to chemicals before undertaking pest and disease control options.

Growers' knowledge and practices

With regard to the growers' current knowledge of IPDM, approximately 52% indicated they knew it well or quite a lot, compared to 30% in the 2018 survey. Ninety-three percent (cf. 80%) stated they were confident in identifying important pests, compared with 88% (62%) confident in identifying diseases and disorders and 54% (40%) being confident in identifying beneficial species. Furthermore, 80% (70%) are confident they can monitor their grove. These are substantial improvements from the baseline data, and is an excellent outcome for the project in just over two years.

Ninety-three percent (cf. 80%) of respondents indicated they monitored for pests and diseases in their grove, with visual observations the most common practice, with one third of growers also utilising meteorological conditions to predict outbreaks, especially of fungal diseases. One grower is using drone or other imaging technology

With regard to implementing IPDM practices (including monitoring), the most common problems were (in order) black scale and associated ant activity, leaf diseases, olive lace bug, fruit diseases and rots and root and stem diseases. This is similar to the 2018 survey, but with an apparent increase in leaf disease monitoring.

BIOSECURITY

With regard to biosecurity, over 71% (cf. 50%) had vehicle wash down facilities on their grove, 34% (18%) had a farm biosecurity preparedness plan and 45% (12%) had read the current version of Biosecurity Plan for Olive industry. Sixty-two percent agreed they assessed visitors before, or on, arrival for the risk that they might bring a pest or disease onto their property (question not asked in 2018). The surprisingly substantial increase in implementing biosecurity activities can, in part, be attributed to the project's activities including producing a tutorial on the topic, including a section in the IPDM manual, and including exotic pests and diseases in a tutorial, flyer, and as a major section in the Field Guide. It was undoubtedly also influenced by communications from the *OliveCare*® Administrator, Peter MacFarlane (including at the project field days), and increasing concern over the serious exotic olive disease *Xylella fastidiosa* (including contributions to project activities by the Program Manager, National Xylella Preparedness Program, Craig Elliot).

ADDITIONAL FEEDBACK

In addition to positive comments on the project, there were a number of useful comments. One related to the need for continual updating of the project outputs, another requested a Master Class and another suggested even more emphasis on tree health.

CONCLUSION/DISCUSSION

This final survey, while having fewer respondents than the initial 2018 baseline survey, still represents a substantial portion of the Australian olive industry, in terms of number of growers, a nationwide distribution relative to production, and particularly the total production/area of production. Seventy-nine percent of the respondents participated in at least one IPDM project activity.

The current survey shows there have been some substantial changes in the IPDM space since the baseline survey, over only 2 years. First, there has been a deal of learning from the project's activities. This conclusion is based on direct participant feedback and is further supported by their responses to other survey questions. The vast majority of growers (89%) responded that their knowledge had been improved as a result of participation in the project, particularly with regard to improved pest, disease and beneficial species identification, better understanding of biology and life cycles of pests and diseases, information on alternatives to chemicals for pest and disease management, optimising timing of interventions such as spray applications, as well as access to the project's output extension materials. Second, 60% of grower project participants indicated they have already or will change their IPDM practices as a result of the project, in areas such as monitoring and record keeping, tree health and maintenance, and investigating/ selecting better options for pest and disease management.

Further evidence supporting this feedback include:

- Increased grower confidence in identifying key pests and diseases, beneficial species, and their ability to monitor groves.
- An increased percentage (>90%) of growers now indicating that they monitor for pests and diseases in their grove.
- A change in the status of cercospora leaf mould to a significant leaf pathogen. Prior to this project, cercospora was regarded by industry as a minor problem, and peacock spot was regarded as the major foliar disease. However, our substantial field day program showed it to be more widespread than previously believed. We therefore produced information on this disease and its causal pathogen. It is possible that our response caused a disproportionate grower response whereby many foliar problems, especially those associated with chlorosis of older leaves and leaf drop are now interpreted as cercospora leaf mould rather than peacock spot or another cause; hence, its enhanced disease status. Hopefully, our project outputs that clearly describe the different symptoms of these pathogens, together with the strong recommendation to obtain definitive disease diagnoses from qualified laboratories in the event of uncertainty, will alleviate this issue.
- A substantial increase in adopting farm biosecurity, including developing a farm biosecurity preparedness plan, limiting access to visitors, providing vehicle wash down facilities and reading the current version of Biosecurity Plan for Olive industry. This can be attributed to the current project, as well as other AOA activities.

APPENDIX

NATIONAL OLIVE GROWER IPDM SURVEY 2020

Please note there is a total of 23 questions

Orchard Attributes

Question 1: Please insert postcode of your property location ____

Question 2: Is the planting in your grove (please select major plantings only)?

- Traditional, non-irrigated <200 trees/ha
- Low density (201-300/ha)
- Medium/High density (301-1000/ha)
- Super high density (>1000/ha)

Question 3: How old are the trees in your grove? If you have a number of plantings, please include all (i.e. number in each category).

- Young, not bearing
- Young and bearing (to 5 years)
- 5-10 years
- 10-20 years
- >20 years

Question 4: What is the number of trees for your 4 main varieties?

- Arbequina _____
- Arbosana _____
- Barnea _____
- Coratina _____
- Correggiola _____
- Frantoio _____
- Hardy's Mammoth
- Hojiblanca
- Jumbo Kalamata
- Kalamata
- Koroneiki
- Leccino
- Manzanillo
- Mission
- Nevadillo (Blanco)
- Paragon
- Pendolino
- Picholine
- Picual
- UC13A6

- Verdale
- Other (please name)

Question 5: Are you

- Olive oil producer
- Table olive producer
- Both oil and table producer
- Other (please name)

Question 6: Are you interested in organic olive production?

- Registered organic grower
- In conversion
- Interested in growing organically but currently conventional
- Not interested in growing organically

Pests and diseases in your orchard

Question 7: Select **up to 5** of the most economically damaging insect pests in your grove, numbering your selections from 1 to 5 **with 1 the most important**

- Ants
- Black scale
- Caterpillars
- Curculio beetle/apple weevil
- Fruit fly
- Grasshoppers
- Green vegetable bug
- Olive bud mite
- Olive lace bug
- Red scale
- Rutherglen bug
- Other (please name)_____

Question 8: Select **up to 5** of the most the most economically damaging important diseases are present in your grove, numbering your selections from 1 to 5 **with 1 the most important**

- Anthracnose
- Cercospora leaf mould/leaf spot
- Nematodes
- Olive Knot
- Peacock spot
- Phytophthora root rot
- Verticillium wilt
- Other leaf spots (not above)
- Other fruit diseases/disorders
- Die back

- Other, please name _____

Question 9: How important are pesticides (include any organically acceptable inputs, e.g. pyrethrum, copper, oil sprays as well as conventional pesticides) to your overall pest-management program?

- Very important-main control
- Quite important
- Relatively unimportant
- Not used at all

Question 10: Which methods of pesticide application do you or your contractor use?

- Boom spray
- Oscillating boom
- Air blast
- Hand held applicator (including wand from tractor-drawn sprayer)
- Other (e.g. through irrigation, granular, drenching, aerial etc., please name)

Integrated Pest and Disease Management

Question 11: Have you participated in any of the following IPDM project activities?

- The previous (2017) project survey
- Attended a field day
- Attended the Masterclass
- Attended the Webinar
- Accessed video(s) of Field Day presentations via OliveBiz
- Accessed new on-line tutorials
- Accessed new on-line flyers
- Accessed the revised Field Guide
- Accessed the IPDM Manual
- Direct contact with the project researchers

Question 12: Has your knowledge been improved from your participation in the project? If yes, in which ways?

Question 13: How much do you now know about integrated pest and disease management (IPDM)?

- Nothing
- Only a little
- Quite a lot
- Understand it well

Question 14: Have any of your IPDM practices changed, or do you anticipate any will change, as a result of your participation in the project? If yes, in which ways?

Question 15: Are you confident you can:

Identify important pest insects?

- Yes
- No

Identify important diseases and disorders?

- Yes
- No

Identify beneficial species?

- Yes
- No

Effectively monitor your grove?

- Yes
- No

Question 16: How important is IPDM to your current overall pest and disease control program?

- Very important-main strategy
- Quite important
- Relatively unimportant-minor factor
- Unimportant
- Used to use but not using currently

Question 17: Which techniques do you believe are effective control methods in your IPDM program?
(please select all answers that are relevant to you)

- Encouraging/supporting beneficial species
- Introducing beneficial species
- Planting inter-row species/ cover crops to improve biodiversity
- Cultural practices: irrigation/pruning/plant nutrition etc.
- Removal of sources of infection/overwintering pests or diseases
- Barriers or traps
- Spraying based on monitoring rather than a predetermined schedule
- Monitoring practices/devices
- Spot spraying
- Use of selective pesticides
- Use of oil sprays
- Rotating pesticide groups

- Selection of tolerant/resistant olive varieties
- Other (e.g. organic methods/mixtures) please name _____

Question 18: Do you monitor for any of the following pests or diseases in your crop?

- Ants
- Fruit diseases/fruit rots
- Fruit fly
- Leaf diseases
- Mites
- Olive knot
- Olive lace bug
- Root and stem diseases
- Scale insects (e.g. black scale)
- Weevils
- Other (please name) _____

Question 19: Which of the following methods do you use to monitor or predict pest and disease issues in your crop?

- Field observation/ crop or sample plant inspection
- Weather (including meteorological data)
- Outside consultants/pest and disease scout
- Drone or other imaging technology
- Coloured sticky traps (yellow, white, blue)
- Light or pheromone traps
- Other (please name) _____

Question 20:

a. Do you have natural enemies of pests in your crop?

- Yes
 - Scale parasitoids
 - Scale eating caterpillar
 - Ladybirds
 - Green lacewings
 - Spiders
 - Other, please name _____
- No
- Unsure

b. If you have introduced any beneficial species into your grove, please name them.

Biosecurity

Question 21: With regard to biosecurity:

a. Do you have grove machinery wash down facilities?

- Yes
- No

b. Do you have an on farm biosecurity preparedness plan?

- Yes
- No

c. Do you assess visitors before, or on, arrival for the risk that they might bring a pest or disease onto your property from another property that they have visited?

- Yes
- No

d. Have you read the current (version 2.0, 2016) Biosecurity Plan for the Olive Industry?

- Yes
- No

Question 22: If you have answered **No** to either 19a, b or c above, please name any barriers or difficulties in implementing these practices on your grove

Question 23: We are in the final stages of completing the IPDM project.

Please add any other comments or information you would like to provide

If you wish to access any of the project's IPDM educational materials, please go to
<https://olivebiz.com.au/ipdm-project-outputs/>

**THANKYOU FOR COMPLETING THIS SURVEY AND PROVIDING INFORMATION TO BETTER INFORM
FUTURE EXTENSION ACTIVITIES FOR THE AUSTRALIAN OLIVE INDUSTRY**

Appendix 7. Other project communications

Article 1

News

Field days provide the missing link

**Hort
Innovation**
Strategic levy investment

**OLIVE
FUND**

The olive-levy funded project: 'An integrated pest and disease management extension program for the olive industry' (OLI7001) incorporates a national field day program, aimed at addressing the difficulties many small to medium growers face in managing pests and disease. Feedback from the first events is that there's much more value in the field days than just new information.



AUSTRALIAN OLIVE
ASSOCIATION LTD

The New South Wales round of integrated pest and disease management (IPDM) field days were a great success, providing valuable information on grove management techniques. Equally as important for many attendees, they also provided the opportunity to get together and discuss 'life in olives' with other growers.

Learning, confirming and connecting

Peter O'Clery nurtures 2000 trees at Homeleigh Grove, 10km north of Canberra on the ACT/NSW border. He's been in the olive game since 1999, producing EVOO and about a tonne of table olives each year. He said the Marulan field day was about learning, confirming and connecting.

"We learned quite a lot about lace bug. We have what I'd say is a minor infestation of it but we want to hit it cleanly and we learned about that," he said.

"We learned that there was a time when you used to go in and hit all the trees in a grove but now you just hit the ones which are infected with something. We've got scale and were hitting it with everything but then decided that's not necessary, so that's the



Participants honed their identification skills out in the grove during the field days, including looking at the various stages of black scale.

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News

way we've always gone since, and it was good to have that confirmed.

"We found out where the research is going, and came away with practical knowledge that we'll use in dealing with lace bug. And again, one of the key points was getting confirmation that what we're doing in the grove is correct - along with things that you probably learned a good while ago but you weren't absolutely certain about. A lot of what we learned was when the trees were younger, and they weren't quite as important then as maybe they are today."

Also among O'Clery's highlights was "the broad catch up with others".

"Most of us put our oils in various shows and that provides one level of benchmarking. The other is how you're actually going compared with others in your region - are you travelling roughly on the same course and if not, why not?" he said.

"So in addition to research updates and hearing the IPDM experiences of other growers, one particular benefit of the field days is reconnecting with regional growers. With the demise of regional olive associations, the field days enable us all to re-establish links with other producers in our regions and catch up on where people are and what they are doing.

"There's also the opportunity to discuss issues pertaining to our specific region - who is who in the small world of processing and/or harvesting, what new support services are available locally, what new equipment we need/have experience with as our harvests have got bigger, etc.

"That's an important part of information sharing: along the way you learn the mistakes people have made and some of the successes that are worthwhile pursuing.

"I think field days are very important in terms of sharing information and knowledge. Otherwise, you read material and most of it sinks in but you don't have someone to discuss it with - and sometimes you skim it and don't go back to it. That kind of material came up at the field day and was discussed, which brings it further forward in your mind."

Problem solved

Avtar Singh runs Treetops Plantation in the NSW Riverina district. With 95,000 trees in production, the company is the largest table olive producer in Australia and also produces EVOO. He's been working with olives since 2008 and found the answer to a previously baffling problem at the Marulan field day.

"Last year we had some soft nose problems and I learned that it's to do with irrigation," he said.

"I talked to the guys and they gave us some ideas for new methods of irrigation which will be more efficient and stop the soft nose."

"I also learned that table olives are even



Mike Thomsett's demonstration on the use of drones for grove monitoring was part of the AOA's extended field day program.

more sensitive to management practices, and that you need to do things a little bit different depending on the weather and the temperature, etc. We do look at that but we need to take the conditions into consideration even more and maybe change some things."

Singh said that while soft nose is the only significant problem they have in the grove, the opportunity to discuss it in detail was invaluable.

"It's a very specific problem and it was important to have that one-on-one opportunity to speak with people about it," he said.

"We're now going to take the ideas they gave us back and trial three different

methods in the grove, and see which works best."

Knowledge = confidence

Alan Smith has a grove of 450 trees at Quorrobolong, near Cessnock in NSW's Lower Hunter region, and therefore has "quite a bit of disease pressure". Anthracnose is a particular issue due to the humidity.

The grove was originally planted in the mid-1990s to both table olive and oil varieties, however Anthracnose got the better of the Manzanilla and it was subsequently replanted with Coratina. So Smith now only produces oil, along with

The program

Value-adding growers' travel to the field days, the AOA has included an additional range of topics to the integral IPDM project information, creating a full and comprehensive day of learning and networking. Sessions include:

- Risk management and Biosecurity
- Grove management checklist: Irrigation; Nutrition and soil health; Pruning/tree management
- Product quality improvement; OliveCare best practice
- Tastebook™ sensory training program
- Market development: Everyday campaign; Industry generic promotions programs
- IPDM plenary session: Principles and practices of IPDM; Monitoring for pests, diseases and beneficial species; Biology and life cycles of key pests and diseases; Factors influencing pest and disease spread and incidence in groves; Strategies for conventional and organic management - advantages and disadvantages; Importance of timing, application and targeting of interventions.
- IPM field activities: Grove walk and discussion; Insect and disease identification; Grove management.

Q & A sessions throughout the day provide for group discussions on both the topics covered and any other aspects of pest and disease management, while the informal post-event networking dinner provides an opportunity for participants to get one-on-one with the experts to discuss issues of relevance to their own groves and businesses.

News



The IPDM field days saw "growers in one grove having a good chat" - an infrequent opportunity much appreciated by the attendees.

olives for home consumption from the grove's one Kalamata tree.

A scientist by trade, with 16 years of experience in the grove, he said he gained a lot from the field day.

"I learned the ins and outs of olive lace bug and black scale in great detail. We generally deal with it without a lot of science about it: this linked the practical with a bit of theory to give us a more structured way of managing pests and diseases," he said.

"Black scale and olive lace bug are pressing issues in this valley, so those discussions were really valuable.

"And on the practical side, particularly with black scale, it was getting out the little magnifying glass and looking at the various stages of the black scale - and then understanding that you spray the surrounding trees and not the ones showing very obvious signs of attack, because it's already moved on from those ones to the next trees. So you go out in layers because if you don't you have it pop up in the next row."

Overall, Smith said, he came away feeling better equipped to monitor his grove and act appropriately on issues.

"The most useful thing is, when you walk into a grove, having the confidence to assess exactly what's going on - whether it's black scale or lace bug," he said.

"Knowing that bit of science behind it gives you the ability to identify what the issue is with confidence, and another layer of knowledge about how to approach the issue."

More, please

So would our growers attend other field days in the future?

O'Clery: "When possible, yes. Ours is a fairly lonely existence, isn't it: you meet other growers at markets etc but that's not a place where

Continuing IPDM Field Day Schedule

Qld	3 November - Toowoomba
VIC	16 November - Geelong area
	18 November - Wangaratta/Shepparton
SA	24 November - McLaren Vale
TAS	1 December - Launceston - Glendale Olives, White Hill
WA	15 February 2019 - Gin Gin
	17 February 2019 - Margaret River

you discuss your problems - and to some extent there's an element of competition in that commercial setting. The field days allow those important discussions to happen.

"The organisers need to be commended for running these events. It was a good team and I think they did an incredibly good job. I hope this sort of thing becomes a pretty regular occurrence."

Singh: "I think field days are a better way of sharing information. You talk to each other and everyone shares the knowledge they have about a situation.

"I always want to talk to other guys - I'd go in the future."

Smith: "I'm a fan of field days. The Hunter Olive Association has had a number over the years and from my observation, having the growers in one grove having a good chat brings out things they might be a bit reluctant to talk about. You can be talking about one thing and it'll bring out all sorts of issues from other groves.

"I think they're terrific and I'd definitely attend others."

More information and registrations: www.alivebiz.com.au

Article 2

6

R&D INSIGHTS

Interest in IPDM proves strong at NSW field days

Olive growers from around the southern states of Australia have cemented their interest in integrated pest and disease management (IPDM) at sessions held last month as part of recent field days in New South Wales.

The first, hosted at 'Daisy Bank Grove' at Big Hill near Marulan, drew an impressive crowd of 41 growers. Another was held at Adina Vineyard and Olive Grove at Lovedale and attracted nearly 28 IPDM enthusiasts.

Attendees travelled from as far as South Australia and Victoria to attend the regional New South Wales events.

The workshops were held as part of Hort Innovation Olive Fund project, *An integrated pest and disease management extension program for the olive industry* (OL17001).

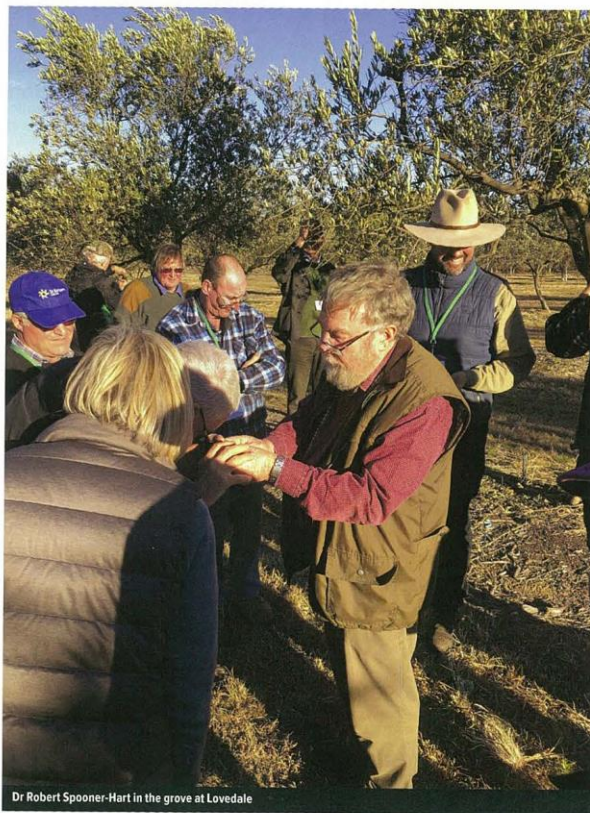
Lead researchers Dr Robert Spooner-Hart from Western Sydney University and Dr Len Tesoriero led the plenary sessions, followed by grove walks and Q&A sessions.

Dr Spooner-Hart said those who attended were a mix of growers who are already actively engaged with IPDM and others who were interested in finding out more about new management practices.

"It was incredibly exciting to have such a large variety of conventional and organic growers in the shed, all interested in the principles and practices of IPDM," Dr Spooner-Hart said.

"Based on that, we covered strategies for conventional and organic management, as well as the different advantages and disadvantages of certain management strategies.

"We also presented on the theory around monitoring for pests, diseases and beneficial species,



Dr Robert Spooner-Hart in the grove at Lovedale

as well as the biology and life cycles of key pests and diseases and the factors influencing pest and disease spread and incidence in groves.

"The importance of timing, application and targeting of interventions was a topic that created great engagement with the attendees also, specifically around how to best time applications. The current status of number one biosecurity pest, *Xylella* (that causes Olive Quick Decline) was also discussed."

Dr Spooner-Hart said the grove walk that followed the plenary session offered a highlight of the field day, including a demonstration showing how drones can be used to monitor diseases and pests in olive groves, and assist with overall grove management.

"All attendees – myself included – found this of tremendous interest," he said.

"The demonstration offered an insight into how drones can obtain

images that can show exactly what is going on in the grove, and we were then able to use the images taken on the day to further discuss IPDM options based on those drone photos.”

As part of the project, a survey was completed in June 2018 to help the research team identify current IPDM knowledge and needs, and the results were shared at the workshop.

“One of the key questions in the survey was asking olive growers what they believed to be the key pests and diseases of note,” Dr Spooner-Hart said.

“We learned via the survey that black scale, olive lace bug and anthracnose were all identified as the top three pest and disease issues for those who responded, and these are the same three major pests and diseases that our project is focusing on.

“It’s great to know that we are directly addressing key concerns of industry and providing the resources to deal with them.

“We will conduct another survey in the final year of the research project to ask growers how much more adept at IPDM techniques they feel they are, and how their management style may have changed.”



Field day attendees at Marulan

The IPDM workshops at Marulan and Lovedale formed part of the broader Australian Olive Association field days, which included sessions on biosecurity, risk management, irrigation, nutrition and soil health, tree management, product quality improvement and market development.

AOA CEO Greg Seymour said the attendee numbers were incredibly pleasing.

“It was a credit to industry and their commitment to ensuring

best practice in the groves,” Mr Seymour said.

“Each session offered growers new and interesting information, and each topic had relevance to each other, allowing them to go home with a new and inspired toolkit of information to try in their own groves, which is what these field days are all about.”

Dr Robert Spooner-Hart agreed.

“As IPDM specialists, it’s one thing for us to talk about the importance of tree health, but to have biosecurity and other grove management experts also presenting on the day made it an excellent exchange of information for growers,” he said.



Dr Robert Spooner-Hart delivers the IPDM workshop at Marulan

Research Recap

PROJECT NAME: An integrated pest and disease management extension program for the olive industry (OL17001)

PROJECT AIM: To provide Australian olive growers access to current, practical information and instruction for implementing integrated pest and disease management (IPDM) strategies in the grove.

RESEARCH PARTNER: Western Sydney University

FUNDING: Hort Innovation Olive Fund

PROJECT STATUS: Ongoing

Article 3

R&D INSIGHTS

THE LATEST UPDATES ON R&D WITHIN THE OLIVE INDUSTRY | MARCH 2019



R&D Insights contains the latest levy-funded R&D project updates, research findings and related industry resources, which all happen under the Hort Innovation Olive Fund.

Hort Innovation partners with leading service providers to complete a range of R&D projects to ensure the long-term sustainability and profitability of the olive industry.



Get on top of the detail at AOA Olive Oil Processing Workshop

“Success at the plant depends on details” ... and those important details are exactly what you’ll learn about at the AOA Olive Oil Processing Workshop, being held in April in Boort, Victoria.

Making great EVOO is all about ensuring quality at every stage of the process, so the comprehensive two-day course covers every aspect of processing quality, from grove management for optimal fruit quality to best-practice processing and storage. Along the way you’ll learn a lot about olive oil chemistry, and no doubt find the answers the many of the “why did/does that happen to my oil?” questions you’ve always wanted to ask.

Guiding participants through this wealth of information are international processing consultant Pablo Canamasas and award-winning producers Peter and Marlies Elcher of Salute Oliva. Their combined expertise and practical experience will ensure that complex detail is presented in a user-friendly format, making this a course for growers and processors at every stage and capacity.

Key elements

Pablo Canamasas said that, while the course is broad-ranging in its content, several key elements will be firmly in focus across the two days.

“Regardless of whether you are a small or large facility, or whether you want to produce quality or volume, success at the plant depends on your knowledge on the actual olive fruit,” he said.

“You need to understand the fruit condition at arrival in order to select the best possible equipment adjustments to achieve the desired results. Understanding fruit maturity, fruit moisture and fruit size is key to your chances of being efficient at the plant. For this reason, understanding fruit condition will take a significant part in the course.

“The second most important aspect



The IPDM team got literally to the root of grove issues at the Ponsonby field day. A struggling tree was removed for inspection and discussion by (from left) horticultural consultant Mike Thornsett, Louise and Mark McKenzie, disease expert Dr Len Teschero and grower owner David Margetson.

IPDM Field Day program: it's a wrap

The last of the AOA integrated pest and disease management (IPDM) Field Days has been run but the effects are reverberating in groves across the country.

The national program was organised by the AOA and Western Sydney University as part of the olive levy-funded project: *An integrated pest and disease management extension program for the olive industry* (OL17001) and saw a team of industry experts travel across the country for a series of intensive day-long workshops. Combining focussed IPDM information with product quality, marketing and broader grove management topics, the events provided an "olive-growing 101" overview in a single day.

Project lead Dr Robert-Spooner Hart said the program was an unmitigated success.

"We had close to 300 attendees over the 10 workshops, with numbers in

the high 20s to mid-30s at most and peaking at 47. Given the size of the industry, that's fantastic," he said.

"And it wasn't just the locals that were coming: some people travelled huge distances for the opportunity to attend because they weren't able to make it to one closer to them. One guy at the Mornington Peninsula event had come from Sydney, and in Bright we had people from Griffith, Wagga and Goulburn. That was really impressive."

And the attendees were in turn impressed, Spooner-Hart said.

"Feedback scores were 4.5/5 overall – very good to excellent – for pretty much all of the activities. General comments were that they liked that there was a mix of topics, and that the info on grove management linked to pest and disease; and they liked the whole day experience, going out into the field for part of it rather than just a show and tell inside.

"Many said how great it was to talk to other growers, and also to talk to us in an informal session. They thought that was really good, to be able to talk to us one-on-one, rather than stick their hand up in a crowd and ask what they might think is a dumb question or of no interest to anyone else.

"And teaming with the AOA really worked. We might have got half the numbers turning up if we just did IPDM over half a day, but we had both new and experienced growers who've come and listened to IPDM, to grove and quality management, to marketing, and took it all in.

"Another important thing is that we went to some places that felt they'd been neglected. People in Queensland and WA are normally expected to travel to the east but we've been proactively reaching growers all over the country – 'We'll come and see you, have a chat and see what your issues are.' That's exactly what we needed to do with



Detailed knowledge of the life cycle of olive pests was part of the empowering information shared by Dr Spooner Hart at the field days.



The next stage of the project will see the production of easy-reference fact sheets on issues including black scale.

Missed the Field Days?

All the presentations from the AOA IPDM Field Day program, and the video of the Roseworthy, South Australia event, are available for viewing at any time on the [OliveBiz](http://olivebiz.com.au) website – www.olivebiz.com.au

Research Recap

PROJECT NAME: : *An integrated pest and disease management extension program for the olive industry (OL17001)*

AIM: Develop, co-ordinate and provide industry with appropriate IPDM extension services focussed on sustainable management of black scale, olive lace bug and anthracnose

RESEARCH PARTNER: Western Sydney University

FUNDING: Hort Innovation Olive Fund

PROJECT DURATION: Three years

KEY ACTIVITIES TO DATE:

- Grower survey conducted to identify current IPDM knowledge gaps
- Initial extension materials developed
- Program of 10 IPDM field days held across six states
- Field day video produced

IPDM and that's why we went out there, so we could meet with the local growers and have them talk about the local issues, and then provide information specific to those issues and their needs.

"And we went to a mix of groves, from New Norcia which is 150 years old to a grove that was five years old, so we got to see a whole lot of different things: we were eyeballing all across Australia, looking at different pest and disease problems, and we learned a lot. So we're now in a good position to put together further documentation which will be part of the larger IPDM program."

Dr Spooner-Hart said he believes the collaboration with the AOA is key to the program's success, in both the short and long-term.

"I wanted to work with the AOA because we didn't want a project that would just end with a final report. We wanted to leave a legacy for the industry and something that would be ongoing, updated and accessible. The logical way to do that was to work with the industry association, and the industry association is the logical repository for all the information in the long term."

"The presentations are already available on the industry information website, *OliveBiz*, and we want to get a number of other formats of information out to growers as well. We're looking at web-based tutorials, which they can go to any time, and single page fact sheets – a potted 'Everything you want to know about black scale'."

We hope to give that kind of information out to pesticide

distributors as well, so they have copies to hand out to people asking about pest and disease management.

"We're also going to put out an IPDM management manual – sort of a 'how to' - and we're going to update the field guide, both in terms of information and the way it's available, so it'll be accessible electronically. A lot of people these days just want to download something on their phones."

"Then at the end of it all we're going to be doing another survey to find out if things have changed - and if they have changed, whether it's because they know more, and then we want to know what they're doing differently. In other words, we want to know how much of a difference we've made."

"The key thing is that all of that is going to be available through the AOA – and available to the whole industry, with the opportunity for whoever comes after me to have it in a form that's easy to edit and update."

"This is a project about results now and then longevity. It's putting all of these things in place so that there's good information readily available to the industry, and with the opportunity to be updated as needed."

"It's about empowering people, and you're empowered when you have the knowledge. It's not rocket science but it's really giving growers that sense of confidence in their own abilities."



National Xylella Co-ordinator Craig Elliott (right) headed to WA as part of the AOA IPDM Field Day roadshow, joined by team members (from left) Peter McFarlane, Mike Thomsen and Dr Robert Spooner. Hart in Russell Lewis's Chapman River Olivesgrove.



Xylella Co-ordinator gets straight to work

Just weeks after his appointment to the role, National Xylella Co-ordinator Craig Elliott headed to WA as part of the AOA's IPDM Field Day roadshow, meeting olive growers and speaking with them about the biosecurity needs of our industry.

"It was a really good week and a big learning curve for me getting out on the ground with the olive growers," he said.

"I don't have a strong background in olive production - which is actually a good thing, because it means there hasn't been a really big outbreak of disease in Australia."

Elliott gave field day participants a summary of the risk posed by Xylella in Australia, and the work being done to protect against an incursion.

"Xylella is now the number one plant biosecurity threat for Australia, and the olive industry is particularly vulnerable," he said.

"The Australian government is taking extra steps to stop it coming in but, being a bacteria, there's still a very good chance we'll be dealing with it sometime in the future.

"Given what happened to olive production in the south of Italy, that means it should be front of mind for the olive industry. Growers need to be aware of the risk and to have biosecurity measures in place at their own property. That's imperative: every grower needs to put a biosecurity plan in place and implement it.

"One of the first questions I put out to the growers at the workshop was how many were aware of Xylella and about half said they were. That's actually a big uptake for this sort of message

but it means we've still got 50% of the industry to get it out to.

"And we need to get those crucial biosecurity practices happening across the board: things like having a secure, clean area where access is restricted and a dirty area where people come and get cleaned down.

"Growers have to be really aware that this is likely to come into Australia, to be ready to deal with it and to be active in how they're managing their properties."

Project plans

Elliott said that, while the project has only recently rolled out, there's plenty of action happening already.

"In terms of the work we'll be doing, we're looking at what the impacts would be in Australia, and how we could contain and eradicate it here," he said.

"It's still very early days but we've also started some discussion with researchers about understanding the native vectors, and therefore how it might be carried here, and we're looking at using remote sensors for detection.

"The focus is on creating the best methodologies and practices to ensure we detect it early and respond quickly."

And after spending a week in the field together, AOA CEO Greg Seymour said he's confident that Elliott can do that.

"He's really got his head around the situation. It's one of the most complex jobs in Australia and they've picked the right bloke to handle it," Seymour said.

"The olive industry can feel very confident that he will give us the best chance possible of staying Xylella free."

Research Recap

PROJECT NAME: *Xylella* co-ordinator (MT17006)

PROJECT AIM: To ensure national awareness of the threat of *Xylella fastidiosa*, and to develop cross-sectoral biosecurity preparedness and prevention strategies

PROJECT PARTNER: Plant Biosecurity Research Initiative (PBRI)

FUNDING: Hort Innovation Apple and Pear, Avocado, Citrus, Cherry, Dried Grape, Nursery, Olive, Prune, Raspberry and Blackberry, Strawberry, Summerfruit and Table Grape Funds

PROJECT TIMEFRAME: Ongoing

KEY INFORMATION:

- *Xylella fastidiosa* is the current #1 plant biosecurity risk for Australia
- Australia is currently free of *Xylella* but it has recently spread across olive-producing European countries
- To date destruction of infected plant material and control of carriers are the only control methods
- Key to Australia's protection from *Xylella* is the ability for early detection, with containment and eradication tools at the ready

Article 4

OliveBiz

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WSU-AOA IPDM Field Day resources online and accessible 24/7

Mar 19, 2019 | Grove Innovation News |

The national program of WSU-AOA integrated pest and disease management (IPDM) Field Days was completed in mid-February, with around 300 growers attending the 10 events held across the six olive-growing states.

Organised and run by the Australian Olive Association and Western Sydney University as part of the olive levy-funded project: *An integrated pest and disease management extension program for the olive industry (OL17001)*, the program saw a team of industry experts travel across the country for a series of intensive day-long workshops.

While focussed particularly on IPDM information around black scale, olive lace bug and anthracnose, the workshop programs also included product quality, marketing and broader grove management topics, providing an “olive-industry 101” overview in a single day.

Project lead Dr Robert Spooner-Hart rated the program as an unmitigated success, for both the collective learning resulting from the field days themselves and also the opportunity to extend that learning to the wider industry – and into the future.

“I wanted to work with the AOA because we didn’t want a project that would just end with a final report,” he said.

“We wanted to leave a legacy for the industry and something that would be ongoing, updated and accessible. The logical way to do that was to work with the industry association, and the industry association is the logical repository for all the information in the long term.”

To that end, the presentations from the AOA IPDM Field Day program and the video of the Roseworthy, South Australia event are now available for viewing at any time on the *OliveBiz* website. Anyone who missed out on attending the field days, and those wanting to review or reference specific information, can access them all directly [here](#).

This project has been funded by Hort Innovation, using the Hort Innovation olive research and development levy, co-investment from the Australian Olive Association and contributions from the Australian Government.

<https://olivebiz.com.au/wsua-aoa-ipdm-field-day-resources-online-and-accessible-24-7/>

Appendix 8. AOA formal feedback on project



Dr Robert Spooner-Hart

Via email

19 October 2020

Industry Feedback on IPDM Project OL17001

Dear Dr Spooner-Hart,

Now that the IPDM project OL17001 is coming to a close, I'd like to provide some feedback on the strategic outcomes of the project from an industry, and industry development perspective.

The key strategic imperatives for the Australian olive industry are improved grove productivity and the production of ultra-high-quality olive products that can drive an improvement in entity profitability. Furthermore, the industry has embraced the concept of sustainable production.

In simple terms, the achievement of these objectives requires improved management of olive groves and processing facilities. Improved management begins with recognition of the need to improve, followed by access of quality information, and finally an environment that builds confidence of the manager, and fosters the implementation of improved management techniques.

OL17001 ticks all of these boxes. The attendance numbers and engagement levels of producers is testimony to the strategic applicability of the project. The final survey responses reporting high levels of adoption of IPDM management recommendations provide the evidence for a well-executed project.

The industry is grateful that such high-quality outputs from the project have been posted on the industry's OliveBiz website and have been provided in a form that can be updated from time to time when new information becomes available.

I have noted in industry events such as workshops, field days and conferences over the past couple of years that the IPDM message is resonating strongly with producers. The "lessons" learned by producers at the IPDM/AOA field days are top of mind, judging by the comments and questions incorporating aspects of IPDM management e.g. if I do x, how will that impact my IPDM program?

Finally, the relaxed, personal, and interactive nature of the field events led by you and Dr Len Tesoriero made the experiences memorable and enjoyable for growers and has provided the benchmark for all our subsequent extension activities.

Yours sincerely,

A handwritten signature in blue ink, appearing to read 'G. Seymour', with a stylized flourish underneath.

Greg Seymour
Chief Executive Officer
04 7676 0160