Final Report

Citrus industry IPDM extension program

Project leader:

Andrew Creek

Report authors:

Andrew Creek, Emily Pattinson and Rachelle Johnstone

Delivery partner:

NSW Department of Primary Industries and Regional Development

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Citrus industry IPDM extension program (CT19011)

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Level 7
141 Walker Street
North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

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Public summary

The Citrus industry (integrated pest and disease management) IPDM extension program (CT19011) was a 4-year project, that commenced in 2021 and was delivered by New South Wales Department of Primary Industries and Regional Development (NSW DPIRD), Queensland Department of Primary Industries (QDPI), the Agricultural Produce Commission (WA), Riverina IPM and Biological Services.

An IPDM strategy aims to manage pests and diseases using a combination of biological, cultural and chemical control options to produce high-quality fruit while minimising harmful effects on the environment. Pest and disease management decisions are based on economic thresholds, and multiple pest management tools are often used.

IPDM strategies are under pressure to meet export market requirements, like pests of quarantine concern and very low tolerances of rind blemish. Consumers desire food production with reduced chemical use and environmental sustainability. Withdrawal of chemical registrations and the availability of effective new chemistry are a risk to pest management practices of Australian citrus growers. The objective of this project was to increase the adoption of IPDM strategies to support a sustainable citrus industry by improving citrus growers and crop advisors' knowledge of citrus pests and diseases.

Initially, the extension program team surveyed the IPDM practices of citrus growers nationally. Differing regional needs and IPDM practices were identified. Demonstration sites were established to investigate alternative IPDM strategies to manage pests and diseases of regional concern. The demonstration sites were used to host some of the 55 IPDM monitoring workshops or seasonal farm walks that the extension program facilitated nationally over the project period. Far North Queensland successfully established an IPDM grower Facebook group and used this medium to promote IPDM discussion and knowledge sharing, demonstration site progress and upcoming events.

Far North Queensland and the Riverina have maintained an active information broker group by meeting at least twice annually with rural supply store horticulturists and crop advisors to discuss seasonal pest and disease issues. The robust farm advisor network facilitated suitable sites for demonstrations and seasonal farm walk events. The advisor network also encouraged participation and assisted the promotion of upcoming IPDM events to citrus growers.

The IPDM knowledge transfer to rural supply store horticulturists and citrus growers nationally, was supported by the publication of 30 online fact sheets. Most fact sheets are about priority pests and diseases (10 of which were printed). Fact sheets that focused upon the core principles of IPDM and published tables clearly showing the insecticide, miticide and fungicide toxicity ratings to natural enemies in the orchard, were of high priority. Additionally, IPDM knowledge transfer was assisted with 4 IPDM posters (printed) and 6 industry magazine articles. The IPDM extension program published 8 IPDM focused videos and hosted 4 pest and disease webinars with experts, that profiled IPDM research.

A 130-page field guide 'Pests, beneficials, diseases and disorders in citrus: a field identification guide' has been published, with 2000 copies distributed by via rural supply store horticulturist networks. The field guide features 70 of the most common insect pests, key beneficials, citrus diseases and disorders of citrus.

The IPDM extension program team actively engaged with the citrus community through Citrus Australia regional forums, the Australian Citrus Congress and the many IPDM focused events facilitated by the extension team in their respective regions. Evaluation data from participants of pest identification and monitoring workshops and seasonal farm walks indicated that their confidence to manage pests and disease had improved by participating in project events. Printed fact sheets were used at seasonal farm walks and the printed IPDM posters were popular with growers and citrus packing sheds.

Keywords

Citrus, Integrated Pest and Disease Management (IPDM), sustainability, monitoring, Oriental spider mite, California red scale, Citrus black spot, Citrus gall wasp.

Introduction

The Citrus industry IPDM program (CT19011) aimed to increase the citrus industry's knowledge of insect pests and diseases and how to control them using Integrated Pest and Disease Management (IPDM) strategies. An IPDM strategy

aims to manage pests and diseases using a combination of biological, cultural and chemical control options to produce high-quality fruit while minimising harmful effects on the environment. Biological control options (beneficials) in citrus include using natural enemies – parasitoids, predators, and pathogens that attack pests. Cultural control options are orchard management practices that support pest and disease control and include managing weeds and tree skirting for Fuller's rose weevil. Pest and disease management decisions are based on economic thresholds, and multiple management tools are often used.

Consumers are seeking food produced with reduced chemicals and environmental sustainability. At the same time, citrus growers are under pressure to maximise first-class pack-out of fruit and to also meet strict export requirements. In some cases, the need for chemicals to manage key pests can lead to secondary pest flares and additional chemical use.

To understand the scope of the issue, the project surveyed the IPDM practices of Australian citrus growers and identified region-specific priority pests and diseases, along with associated knowledge gaps. Data was obtained on the pesticide use by growers specific to the citrus type produced. The survey data also revealed the decline of augmentative beneficial insect releases as a management strategy.

Further pressure is being placed on citrus pest and disease management with the findings of the Strategic Agrochemical Review Process in 2022 (Hort Innovation project – MT21005), which identified that maintaining access to Group 4a chemistry for the medium-term is a significant concern. The IPDM practice survey identified group 4a insecticides were the products of choice to control key pests like Mealybugs, Fullers rose weevil, Kelly's citrus thrips, California red scale and Citrus gall wasp. A similar concern is emerging in Southeast Queensland, where the potential loss of mancozeb, currently under APVMA review, poses a risk to the management of citrus black spot and emperor brown spot, the region's two most significant pests or disease challenges. The survey also identified a heavy reliance on chemical control to manage Oriental spider mite in FNQ.

The pest ID and monitoring workshops and the district seasonal farm walks were an important opportunity of the IPDM extension program for grower and industry engagement. Data from the IPDM practice survey was again used to ensure the content of events was regionally relevant.

The project aimed to strengthen the sustainability and resilience of the Australian citrus industry by identifying barriers to effective pest and disease management and informing improvements in IPDM practices. It sought to reduce reliance on chemical controls, support industry adaptation to regulatory change, and guide future research and extension priorities.

The project was also responsible for managing the combined Project Reference Group (PRG) for Hort Innovation projects CT19009 – Integrated pest management of citrus gall wasp and Fuller's rose weevil, CT20009 – Integrated disease management of citrus black spot and 'Emperor' brown spot and CT19011 – Citrus industry IPDM extension program, to ensure cross project collaboration and that current industry needs were addressed by the citrus insect pest, citrus disease and IPDM extension projects collaboratively.

This NSW DPIRD delivered project was led by Andrew Creek. The NSW DPIRD team members were Alison Fattore, Dr Amanda Warren-Smith and Steven Falivene. The QDPI project team consisted of Emily Pattison, Stefano De Faveri and Ebony Faichney. The Agricultural Produce Commission team was Bronwyn Walsh and Rachelle Johnstone (WA DPIRD). Biological Services and Riverina IPM contributed expertise to the project.

IPDM is a priority of the Citrus Strategic Investment Plan 2022-2026. Outcome 1, Strategy 9 is 'Develop and optimise a whole-systems approach to integrated pest and disease management'. This project, along with related projects, contributed to the achievement of the KPI – Adoption of whole-systems IPDM strategies that reduce crop losses and enable sustainable management of pests and diseases.

Methodology

The IPDM extension program used many differing extension strategies and tools to improve grower's and citrus industry support personnel's knowledge of citrus pests, beneficials and diseases. As IPDM in Australia is usually overseen by professional crop scouts, consultants and chemical resellers, it was critical that the project target growers and all support personnel that contribute to making pest management decisions. The project targeted key Australian citrus growing regions (Riverland, Sunraysia, Riverina, Central Burnett, Far North Queensland and WA).

Each of the following contributed to the IPDM knowledge transfer and practice change:

Survey

The project began with regional IPDM surveys to identify key pests, current management practices, chemical use, awareness of biological and cultural controls, and knowledge gaps. While full industry saturation was not the goal, the surveys targeted a diverse cross-section of growers to capture regional variation. This process was critical for understanding the severity of local issues and ensuring project activities were appropriately tailored to each region's needs. Data from our IPDM practice survey was used to focus the published video content, fact sheet content and the webinar content. Evaluation surveys at individual events throughout the project were important to adjust delivery methods and to also monitor the impact of the extension work.

IPDM grower group

The Far North Queensland (FNQ) region favoured the establishment of a regionally specific Facebook group. The IPDM grower group was used to promote IPDM events and update IPDM demonstration site progress. Growers were encouraged to post pest related issues or comment on their IPDM experience.

Pest identification and monitoring workshops and seasonal farm walks

The Citrus industry IPDM extension program worked towards delivering ten events in each region over the project period. The first season of industry extension events was limited due to COVID-19 restrictions. The project team delivered workshops and seasonal farm walks focused on meeting regional priorities and drawing on interstate and local expertise to support the events. Event promotion varied between regions. The project team's regional contacts, rural supply store networks, citrus packing sheds and grower associations were used to promote events through flyers (email or printed at rural supply stores), grower SMS, e-newsletters and social media. Various event evaluation methods were utilised. Evaluation data was collected to ensure the appropriateness of the events as well as measure the impact. Data collection methods included paper evaluation surveys, dart boards, sticky dots on posters and online surveys.

Through the survey process, Central Burnett growers indicated a preference against participating in multiple field walks, citing time constraints and the delegation of pest and disease management to consultants. With approval from Hort Innovation project managers, a study tour and two demonstration videos were delivered in lieu of five regional events to better suit grower preferences and ensure effective knowledge transfer. The project team sought to be flexible and responsive to meet the needs of the target audience and accommodate regional preferences.

Regional participatory demonstration sites

Regional demonstration sites were identified as an effective tool to boost grower-learning and knowledge transfer by allowing interaction with IPDM approaches and results in a commercial setting. Sites were established in all regions except the Riverland. Most demonstration sites were used to host seasonal farm walks, allowing participants the opportunity to see the demonstration results, ask questions of the host grower and the IPDM experts attending the event.

The regional demonstration sites investigated sustainable pest management, based upon crop monitoring and using the least disruptive insecticide chemistry to natural enemies to manage pests. Many demonstration sites tested augmentative release of natural enemies. Some demonstration sites purposely managed key pests of concern without the use of 4a insecticides.

Australian Citrus News articles

The project team contributed four articles for the 'Australian Citrus News', published by Citrus Australia Limited, to extend IPDM knowledge and awareness. Eight articles were also published in the 'WA Grower' magazine and one edition of 'CitrusConnect', a NSW DPIRD citrus e-newsletter.

Printed field guide

A publication 'Pests, beneficials, diseases and disorders in citrus: a field identification guide' has been developed. The content was peer reviewed by the project team. Differing technical specialists reviewed each chapter. Images used were mostly NSW DPIRD images although some were sourced externally. Many lifecycles were sourced or adapted from prior NSW DPIRD publications and one third were drawn. The NSW DPIRD Development Officer – Information Delivery edited final text content and undertook the print design work.

PDF and printed fact sheets

Fact sheets were researched and written by various authors and were focused upon integrated management of the pest or disease. The factsheets aimed to complement events and regional participatory demonstration sites to boost grower learning. Data from the grower IPDM practice survey guided the fact sheet topics. The written content was peer reviewed and reviewed by a technical specialist on the subject. Seventy percent of the fact sheets were reviewed by practicing IPM consultants, to ensure the published content was practically accurate and adoptable by farmers. NSW DPIRD Development Officer – Information Delivery edited final text content and undertook the print design work. The fact sheets have a consistent format and design, with a Citrus industry IPDM extension program logo.

IPDM posters

To support grower learning and provide a lasting extension resource, the project developed pest identification posters tailored to regional priorities. The content of the posters was written in collaboration with the project leader and the authors. The content was peer reviewed by project collaborators and then by technical specialists. NSW DPIRD Development Officer – Information Delivery edited final text content and undertook the print design work for the southern posters. Additionally, QDPI staff produced a poster on the major pests of North Queensland citrus.

Webinars profile IPDM research

Webinars were used as an effective tool to engage a wider grower audience, especially those in remote areas or with limited availability, while also providing recorded resources for ongoing access. The webinar topics chosen were the high priority pests and diseases from the IPDM practice survey data. The webinars were a one-hour event, with two speakers on the program. There was an opportunity for questions and discussion. The webinars included polls and surveys to keep the audience engaged. The content was recorded and fully edited to publish the video with a transcript. Written consent to publish was obtained from all people who are shown in the video. In the final publication webinar participants are not shown and only the technical presentation was published. Final published webinars were long videos that could be navigated with chapter titles, so the viewer can skip to specific chapters.

Online video resources

Videos were used as an extension tool to increase accessibility, improve engagement, and provide growers with on-demand, visual learning resources. Video resources are short YouTube style videos that were filmed and edited by video producers. The video topics were generally highlighting a demonstration trial or providing information on a particular pest.

Videos produced by NSW DPIRD team members were published on the agency website. One of the QDPI contributed videos was produced in association with Citrus Australia and published on their Facebook page. The remaining two QDPI contributed videos will be published on the agency YouTube channel.

Results and discussion

Survey

The IPDM practices survey (Appendix 1), collected evidence of grower knowledge gaps and industry reliance on some chemicals. The adoption and use of crop monitoring and IPDM specialists varied between the regions nationally. The survey identified the importance of rural supply store horticulturists and in some cases, packer's grower services personnel in assisting growers with their pest and disease management decisions. Irregular supply of some key beneficial insects and availability of effective, multi-activity insecticide chemistry has seen a decrease in beneficial insect releases. Several growers commented, "class #1 fruit must be maximised to be profitable and chemicals achieve a better result". Fresh markets have almost zero tolerance for pests and citrus packers' expectations of growers reflect this.

The survey identified the priority pests and diseases of grower concern. Data was also captured on the chemistry, cultural and biological practices used to manage them. Survey participants rated their perceived level of control for each pest and disease they cited.

The project team shared data digitally with a selected group of Riverina survey participants using Microsoft Power BI interface. This allowed participants to compare their IPDM practices with other growers anonymously. Follow up calls were required to ensure the participating growers received the email and reviewed their data. Only two of the ten growers had viewed the data and said the results were interesting. Most growers had not looked and three cited difficulty

logging into the Departmental stored data. As a result, a PDF report was published on the NSW DPIRD website and growers were notified by articles and at IPDM extension events.

IPDM grower group

The active IPDM grower group in Far North Queensland has played a key role in facilitating the exchange of IPDM knowledge and experience among local citrus growers. Established as a closed Facebook group in March 2023, it was designed to create a safe and supportive space where members could comfortably ask questions and share insights. Since its inception, the group has grown to 55 active members and has seen over 30 posts in the 60 days to 30 May 2025. Content includes pest alerts and management advice from CT19011 project staff, updates from related demonstration trials, grower-led discussions and pest identification queries.

The success of a lemon IPDM demonstration site was reported and discussed within the Facebook group. Grower discussion and commentary contributed to the establishment of a second demonstration site investigating water rates with sulphur application. Growers were driving the learning process.

Pest identification and monitoring workshops and seasonal farm walks

The pest identification and monitoring workshops and seasonal farm walks delivered by the IPDM extension program engaged growers, orchard staff, new staff of IPM crop advisors, packer's grower services staff, rural supply store horticulturists and sometimes TAFE students. The events varied to meet regional needs (Appendix 2).

Effective spray application is an important aspect of IPDM. The extension program facilitated a workshop or an event on spray application in the FNQ, WA, Riverland and Sunraysia citrus production regions.

It was important that pest workshops had nationally respected entomologist specialists as guest speakers, for example, Dan Papacek (Bugs for Bugs) and Andrew Jessup (Janren Consulting). Workshops to increases grower knowledge of Queensland fruit fly in the Riverland and Sunraysia regions (Appendix 3), received an average score of 4/5 from participants. Dan Papacek also shared knowledge on Oriental spider mite management in Mareeba, FNQ. Extended video publications were published from the investment in interstate IPDM expertise. The published video titles are 'QFF with Dan Papacek' and 'Andrew Jessup discusses all things Queensland fruit fly'. This is accessible via on-demand video content with chapter titles on the NSW DPIRD YouTube channel.

Local IPDM expertise was also used as speakers at workshops and seasonal farm walks, that being a mix of experienced IPM consultants, state department extension officers, state department research scientists and their technical staff (for example, Riverina flyer in Appendix 4). The local expertise was important to further build trusted relationships to support IPDM adoption. Growers valued practical regional knowledge in the application of IPDM. The style and content of events varied between regions to address the knowledge gaps identified by the initial IPDM practice survey. Where appropriate and possible, company representatives of new products or technology to a region were encouraged to attend the event to address grower questions (for example, Corteva and AgNova in Appendices 3 and 4).

Many of the regional participatory demonstration sites were often used as sites for seasonal farm walks, so event participants could hear from and ask questions of the collaborating grower. Importantly other growers were able to see and discuss the results of the demonstration. If augmentative release of beneficial insects was a part of the demonstration site, a release was timed so participants could split into small groups and do the release. Grower to grower learning and removing the risk of IPDM adoption by seeing IPDM at work locally and in a commercial setting is beneficial for IPDM adoption.

Several event evaluation methods were used. Dart boards, sticky dots to answer questions and paper surveys worked well for event evaluations. At the Arcifa Bros event on 20th April 2023 in the Riverina (NSW), an evaluation was not undertaken on the day, so a brief online survey was sent via SMS the following day to 10 of the 15 event participants who had provided their contact details. Our experience was that a post event evaluation did not work, with only 2/10 attendees responding.

Growers evaluated the 'information supplied' (e.g. presentations) and printed content (e.g. IPDM fact sheets) used to support knowledge transfer at seasonal field walks as 'exceeding their expectations' (Appendix 4). Videos were published from the Citrus gall wasp, Arcifa Bros (NSW, Riverina) and the Hilltop Farming (FNQ, Mareeba) demonstration sites to extend the learning from some demonstration sites now and into the future.

Grower to grower communication worked well to extend IPDM knowledge to different regions. With detailed planning incorporated online meetings were used as part of seasonal farm walks in the Riverland region of SA and in Riverina, NSW. Initial survey data identified Queensland fruit fly as a priority pest of concern for Riverland growers. In 2023, the IPDM extension team facilitated an online session during a seasonal farm walk to share interstate citrus grower's experiences managing Queensland fruit fly. Riverland growers were able to ask the interstate growers their concerns and practical management techniques applied. The Loxton event evaluation data showed growers believed their knowledge had increased greatly and were motivated to try something new to manage Queensland fruit fly (Appendix 5). IPDM practice survey data showed Citrus gall wasp was the main pest of concern for Riverina growers. In 2022, Central Burnett, Moree, Gunnedah and a Sunraysia citrus grower shared their citrus gall wasp experiences with Riverina growers attending the seasonal field walks. Most event evaluation data indicated participant knowledge of citrus gall wasp improved and their confidence to manage the pest had also improved. The Leeton growers event evaluation indicated their confidence had improved enough to manage the Citrus gall wasp (Appendix 5).

Regional participatory demonstration sites

The IPDM extension program facilitated nine regional participatory demonstration sites around Australia that were used for information exchange and to explore alternative, sustainable management strategies for regional pests or diseases of concern (Appendix 6). The project was unsuccessful at outsourcing the establishment and management of a site in the Riverland. Additional demonstration sites were established in regions where project personnel resided. Videos were published to extend the outcomes from the southern demonstration sites of relevance to Riverland growers.

Sharing knowledge gained from demonstration sites also inspired conference publications. Emily Pattinson (QDPI) was a speaker at the 2024 Australian Citrus Congress and additionally published a poster about two FNQ demonstration sites (Appendix 7). NSW DPIRD published a poster at the 2024 Australian Citrus Congress about the Citrus gall wasp demonstration site (Appendix 8). Andrew Creek (NSW DPIRD) and Ebony Faichney (QDPI) published a poster and abstract for the Citrus Technical Forum in 2022.

Adoption of some sustainable pest management practices will require change in the availability of chemistry options to growers. For example, there are barriers to the alternative Citrus gall wasp management strategies proven in a Leeton demonstration site which will reduce adoption in the immediate future. Systemic chemical control is effective and is the cheapest management option. The parasitic wasp *Megastigmus brevivalus* is not commercially available. The wasp must be harvested from known, naturally established repositories. NSW DPIRD hosted an event in October 2023 at Yanco. The event had printed fact sheets and a handout. The presenters shared research trial results and gave an update on the Citrus gall wasp demonstration site. Evaluation showed 90% of the participating growers intended to manage citrus gall wasp with cultural control plus systemic neonicotinoid insecticides rather than cultural control combined with Surround® or biological control (i.e. parasitic wasp) (Appendix 9).

Australian Citrus News articles and other publications

The citrus Industry IPDM extension program published four articles in the 'Australian Citrus News' to extend IPDM knowledge and awareness (Appendix 10). The articles are listed as follows:

- ACN issue 2 2023 'Exploring integrated pest and disease management' by Rachelle Johnstone
- ACN issue 3 2024 'Innovative mite control in North Queensland citrus trials show promise' by Emily Pattinson
- ACN issue 4 2024 'There's a new era in mealybug control for North Queensland' by Emily Pattinson
- ACN issue 2 2025 'Sustainable management of California red scale: A modern IPM approach' by Dr Meena Thakur and Andrew Creek

WA DPIRD collaborator Rachelle Johnstone regularly published IPDM focused articles in the WA Grower magazine and effectively promoted IPDM extension, webinar events and many other publications of the citrus industry IPDM extension program (Table 1). The WA Grower is published by vegetables WA, WA Citrus, Pomewest and Stonefruit WA. It is a quarterly publication distributed to every citrus grower across all growing regions of WA, as well as other key stakeholders across the state and nationally. It is also available online *https://wagrower.vegetableswa.com.au/collections*

Table 1. IPDM focused citrus articles published by Rachelle Johnstone in the WA Grower magazine

DATE	PUBLICATION	ARTICLE
01-Jun-22	WA Grower - Winter 2022	Learning more about integrated pest and disease management
21-Sep-22	DPIRD Media Release	Fruitful discussion on citrus pest and disease identification
01-Dec-22	WA Grower - Summer 22/23	Citrus IPDM workshops focus on pest identification and monitoring
01-Mar-23	WA Grower – Autumn 2023	Autumn pest and disease management
01-Jul-23	WA Grower – Winter 2023	Wasp Watch - CGW monitoring and control
01-Jul-23	WA Grower – Winter 2023	Disease management - IPDM disease field walk summary
01-Dec-23	WA Grower - Summer 23/24	Get the goss on gall wasp - IPDM field walk
01-Oct-24	WA Grower - Winter 2024	Orchard management - IPDM field day
01-Mar-25	WA Grower – Autumn 2025	Pest management in lemons

Alison Fattore (NSW DPIRD) published a citrus IPDM focused article promoting the publications of the extension program in the 'CitrusConnect' November 2024 edition titled 'IPDM – a sustainable way to reduce chemical use and pest infestations in the orchard'. NSW DPIRD e-newsletter CitrusConnect-november-2024. MailChimp data indicates that 396 of the 740 e-newsletter recipients opened the email and 47 of those 396 people clicked an article for further reading.

Printed field guide

The project team has put a substantial effort into creating the content for 'Pests, beneficials, diseases and disorders in citrus: a field identification guide'. This was a significant undertaking and required greater than expected team member time. Much of the information required was not readily available, so many different sources had to be consulted. While it was intended to publish the guide by the end of 2023 the team believed the additional effort resulting in a thorough, detailed and accurate output was warranted and a significant achievement (Appendix 11). Copies of this guide will be made available for growers at rural supply stores, through pest consultants and project team members and their state agricultural agencies. The Citrus industry IPDM extension program intends to promote the publication and availability of the printed field guide through an Australian Citrus News article, the WA Grower magazine and in the CitrusConnect e-newsletter in the period July-September 2025. The guide will also be made available online.

PDF and printed fact sheets

The thirty 'priority pests' online PDF fact sheets published by the IPDM extension program cover the most important pest and diseases of grower concern, as identified by the IPDM practice survey. The fact sheets are written with a grower focus and have practical information that was reviewed by practicing crop consultants and specialists. Further information was often presented in QR code style. The 'Further information' section of these fact sheets has been a good way to promote important IPDM information for example, the 'Citrus gall wasp shiny app' that assists management of this pest. Prior to this fact sheet, very few growers would know about this application published from an earlier research project.

The fact sheets are an output from this project that will continue to exist after the extension program and support grower IPDM decision making into the future. The fact sheets are published on the NSW DPIRD citrus website within the IPDM extension program accordion.

https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/ipdm-extension-program

The fact sheets of Queensland grower concern will also be published on the QDPI website. Printed fact sheets assisted knowledge transfer at the IPDM workshops and seasonal farm walks. The fact sheets were popular items at events.

IPDM posters

- 300 printed copies each of 'Pests of southern citrus', 'Citrus diseases' and 'Natural enemies of citrus pests'

The above three posters are published on the NSW DPIRD citrus website within the IPDM extension program accordion.

https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/ipdm-extension-program

- 100 printed copies of 'Major pests of North Queensland citrus' (Appendix 12)

The posters have been popular items that growers and packers took away from seasonal farm walks, CAL regional forums and the 2025 Australian Citrus Congress.

Webinars profile IPDM research

The IPDM extension program organised, facilitated, recorded and published three webinars with a profiled researcher over the life of the project. Planning for the fourth webinar is in progress (Appendix 13). The participants completed a poll within the technical presentations to improve audience engagement. The participants asked questions of the presenter and some growers shared their experiences during the facilitated discussion time.

1. 07/04/2022 'Managing citrus diseases with copper in southern Australia', presenters were:

   Dr Nerida Donovan (Citrus Pathologist, NSW DPIRD) – 'Citrus diseases and rind blemishes'

   Rory Tomlinson (Regional Sales Manager, Tanuki Pty Ltd) – 'Using copper in citrus to prevent citrus disease development'

2. 11/10/2023 'Citrus gall wasp webinar', presenters were:
   Dr Jianhua Mo (Research Entomologist, NSW DPIRD) – 'Citrus gall wasp – life cycle, monitoring, predict emergence, controls and latest research'
   Cameron Stone (Research and Development, AgNova Technologies) – 'Surround® and Fruition® CGW indicator trap'
3. 30/01/2025 'Sustainably managing red scale', presenters were:
   Dr Meena Thakur (Research Entomologist, NSW DPIRD) – 'California red scale – pest description, life cycle, monitoring and degree days'
   Rob Weppler (Riverina IPM, Entomologist) – 'California red scale management, chemicals and natural enemies'
   Andrew Creek (Development Officer, NSW DPIRD) – 'IPDM demonstration site – red scale mating disruption'
4. 17/07/2025 'Citrus soil health and Phytophthora root rot', presenters are:
   Dr Tony Pattison (Principal nematologist, QDPI) Soil health, managing soil constraints and the benefit of biologically healthy soil'
   Dr Nerida Donovan (Citrus Pathologist, NSW DPIRD) – '*Phytophthora spp*., symptoms, cause and management'

Online video resources

The citrus industry IPDM extension program published eight IPDM focused videos over the project period. Seven videos are published on the NSW DPI citrus website, within the IPDM extension program accordion, and one from North Queensland, which was published in Citrus Australia media. Views of the published video content are detailed in Table 2.

Video 1. 'Mitey mites in Far North Queensland' is published on the Citrus Australia YouTube channel (https://www.youtube.com/watch?v=8JjA28TDqJA).

The other seven videos are published on the NSW DPIRD YouTube channel and are available from the NSW DPIRD citrus website IPDM extension accordion (https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/ipdm-extension-program):

Table 2. List of IPDM videos and webinars published with views and watch time data (May 2025).

IPDM videos	Views	Watch time (h)
1. Mitey mites in Far North Queensland	183	
2. Integrated pest management of Citricola scale	691	16.1
3. Andrew Jessop discusses all things Queensland fruit fly	322	42.8
4. QFF with Dan Papacek	125	5.6
5. Monitoring for citrus gall wasp	155	3.1
6. Citrus Gall Wasp demonstration site	475	15.6
7. The citrus industry IPDM demonstration site at Arcifa Bros.	198	6.7
8. Good bugs, great citrus: natural enemies in citrus	281	7.0
WEBINAR 1: Copper webinar	174	10.5
WEBINAR 2: Citrus Gall Wasp	194	16.4
WEBINAR 3: California red scale - managing it sustainably	148	5.4

The project has filmed content and is editing two short videos as substitute extension material for the Central Burnett region. The videos were determined to be more relevant and appropriate for growers than the intended 4x citrus pest and disease seasonal field walks workshops. One video will feature Citrus black spot and the outcomes of the IDM demonstration site in the Central Burnett. The second video will feature current best practice management for Emperor brown spot. These QDPI authored videos will be published on the Citrus Australia website to provide Central Burnett and coastal NSW citrus growers with accessible, on-demand video content for both Citrus black spot and Emperor brown spot.

Outputs

Table 3. Output summary

Output	Description	Detail
Survey of IPDM practices	An industry data set managed in Microsoft Power BI. Published report in .PDF format.	A report published on the NSW DPIRD citrus website, IPDM extension program accordion, titled 'Report - IPDM practice survey 2022.pdf'. https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/ipdm-extension-program The survey results were presented at IPDM extension events in 2022. The survey data guided CT19011 project activities to ensure regional needs were addressed.
IPDM grower groups	FNQ regionally specific Facebook group	
10 pest ID and monitoring workshops or seasonal farm walks per region	IPDM focused events	A combined total of 60 extension events were delivered. The IPDM event summary report (Appendix 14) shows the breadth of grower and crop advisor engagement. The attendance and evaluation data included in the events summary report shows the relevance of content delivered to growers and their improved confidence in managing citrus pests. Events were delivered in the Riverland (Renmark, Loxton and Waikerie), Sunraysia (Coomealla, Ellerslie, Nangiloc and Colignan), Riverina (Leeton and Griffith), Central Burnett (Mundubberra and Gayndah), Far North Queensland (Mareeba) and WA (Moora and Harvey).

8 regional participatory demonstration sites	Growers and crop advisors worked with IPDM extension program collaborators exploring different IPDM strategies	IPDM demonstration site report (Appendix 6). Seasonal farm walks held at demonstration sites were a highly successful way to improve grower knowledge of California red scale, Oriental spider mite, citrus gall wasp, Katydids and Citrus black spot and also of natural pest enemies like Cryptolaemus ladybird beetles, Aphytis parasitic wasps and Californicus predatory mites. For example, seasonal field walk participants on 23/03/2023 held at the Leeton, Citrus gall wasp demonstration site indicated their knowledge managing target pests had improved after the seasonal farm walk. Participants indicated they had greater confidence at identifying pests and beneficials and 50% of the participants indicated they intended to make a change within their business to improve gall wasp management (Appendix 14).
4 Australian Citrus News articles	Growers and crop advisors	(Appendix 10) ACN issue 2 2023 pp 12-13 'Exploring integrated pest and disease management' By Rachelle Johnstone ACN issue 3 2024 pp 16-17 'Innovative mite control in North Queensland citrus trials show promise' By Emily Pattinson ACN issue 4 2024 pp 26-27 'There's a new era in mealybug control for North Queensland' By Emily Pattinson ACN issue 2 2025 pp 22-23 'Sustainable management of California red scale: A modern IPM approach' By Dr Meena Thakur and Andrew Creek
Printed field guide	'Pests, beneficials, diseases and disorders in citrus: a field identification guide'	The field guide delivered has far greater content than the original publication proposed, "20 of the most common". The project team has worked to deliver a 130-page publication, A5 in page size, that includes 27 pests, 14 beneficials, 17 diseases and 15 disorders (Appendix 11). It is intended to promote the publication and availability of the printed field guide by an Australian Citrus News article and distribute by rural supply store horticulturist networks during July-September 2025.
Fact sheets	30 'priority pests/diseases'	The fact sheets are all published on the NSW DPIRD citrus website, IPDM extension program accordion. The publications were well received by industry and are available for perpetuity to assist growers with their pest management decisions. https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/ipdm-extension-program 10 important fact sheets were printed and used at the IPDM workshops and seasonal farm walks to assist knowledge transfer.
Posters	4 IPDM focus	The printed posters were well received at field events and workshops by citrus growers. The Grower Services Manager for Mildura Fruit Company (MFC) corresponded about the good information and quality of the posters. We shared the print files, so as MFC can print some smaller sized posters to display (Appendix 15). Some Riverina citrus packers took pest and disease poster copies for their growers. Printed copies remain with state department extension staff from the IPDM extension program at respective sites of NSW DPIRD, QDPI and WA DPIRD for distribution.
Webinars profile	3 webinars	The published webinars with IPDM researchers are available on the NSW

IPDM research	published	DPIRD citrus website, IPDM extension program accordion. Table 2 lists the webinars published with views and watch time data. At the conclusion of the California red scale webinar, 78% of participants gave a rating of 8/10 as usefulness of the webinar, with plenty of applicable information. A month after the webinar, a MFC grower services representative emailed, requesting the webinar recording (Appendix 16). A fourth webinar will be held on 17 July 2025 and published.
Videos	8 IPDM focused videos published	NSW DPIRD YouTube channel, with links on the 'IPDM-extension' accordion https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/ipdm-extension-program Citrus Australia YouTube channel https://www.youtube.com/watch?v=8JjA28TDqJA Table 2. Lists the IPDM videos published with views and watch time data.
Oral presentation	Presentation at 2024 Australian Citrus Congress	Emily Pattinson (QDPI), "An IPM approach to Oriental spider mite control for citrus in North Queensland"
Conference posters	Citrus technical forum 2022 2024 Australian Citrus Congress	Andrew Creek (NSW DPIRD) and Ebony Faichney (QDPI) 'National integrated pest and disease management extension program (CT19011)' (Appendix 17). Emily Pattinson (QDPI) 'An IPM Approach to Controlling Oriental Spider Mite (Eutetranychusorientalis) in North Queensland Citrus' (Appendix 7). Andrew Creek (NSW DPIRD) 'Citrus gall wasp demonstration site' (Appendix 8).

Outcomes

Table 4. Outcome summary

IPDM is a priority of the Citrus Strategic Investment Plan 2022-2026. This project has contributed to Outcome 1, Strategy 9, 'Develop and optimise a whole-systems approach to integrated pest and disease management' and the KPI – Adoption of whole-systems IPDM strategies that reduce crop losses and enable sustainable management of pests and diseases. It has also contributed to Outcome 3, Strategy 1, 'Deliver communication and extension programs to create positive change in the areas of biosecurity preparedness, varieties that meet consumer demand, sustainable production, pest and disease management, and export protocols and markets'.

Through the survey undertaken at the commencement of the project, information on baseline pest and disease management practices at a regional scale is available and a deeper understanding of priority pests and diseases of concern and regional differences has been developed.

Outcome	**Alignment to fund outcome, strategy and KPI**	**Description**	**Evidence**
Increased grower and crop adviser knowledge of citrus pests and diseases and beneficials	Outcome 1: The Australian citrus industry has increased profitability, efficiency, and sustainability by protecting	This project significantly increased awareness and knowledge through targeted extension materials and events.	Event participants indicated their knowledge 'improved with new information' and for some people, 'increased greatly'

	the production base through innovative research and development (R&D), biosecurity preparedness and responsiveness, sustainable best management practices (BMPs) and superior varieties. Strategy 9. Develop and optimise a whole-systems approach to integrated pest and disease management (IPDM).	The WA DPIRD end of project evaluation survey showed 60% of growers surveyed had a significant improvement in their ability to identify citrus pests and diseases.	(Appendix 14). There was good industry participation at FNQ events. (Appendix 18 - QDPI M&E report). WA DPIRD project evaluation survey (Appendix 14 pp.89). Legacy project documents such as fact sheet and the guide will continue to be available as reference documents for the Australian citrus industry.
Increased grower and crop adviser knowledge of IPDM		Knowledge of IPDM principles was strengthened through multiple activities and the tangible outputs delivered by the project. The WA DPIRD end of project evaluation survey showed 20% of the growers surveyed had a very significant improvement in their IPDM knowledge.	The eight regional participatory demonstration offered first-hand learning opportunities. In FNQ, post-event evaluations showed that 55% of participants gained new IPDM knowledge, and 66% reported increased confidence in applying IPDM strategies (Appendix 18 - QDPI M&E report). WA DPIRD project evaluation survey (Appendix 14 pp.89). Event reports and event evaluation data. (Appendix 14).
Increased adoption of IPDM to manage pests and diseases in citrus	Outcome 3: The Australian citrus industry has enhanced adoption of R&D through effective communication and extension initiatives. Strategy 1. Deliver communication and extension programs to create positive change in pest and disease management.	The extension program offered an extensive opportunity for grower and crop advisors to improve IPDM knowledge, skills and aspirations and provide practical and commercially valid information to support adoption of integrated approaches to manage citrus pests and diseases. Our extension program was multifaceted. There were IPDM demonstration sites, seasonal farm walks and pest workshops. These	In FNQ, the adoption of Cryptolaemus as a biological control for Spherical mealybug increased. Four growers adopted the practice all reported successful outcomes and intent to continue. (Appendix 18 - QDPI M&E report). The WA growers whom hosted a demonstration site on their property both indicated the activity was very beneficial to them, in understanding what pests were in their orchard. Both

		activities were supported with printed fact sheets and posters. Online publications such as videos, fact sheets and webinars. IPDM focused magazine articles supported the information exchange. A FNQ regional IPDM face book group also assisted grower adoption of IPDM.	growers have adopted IPDM practices including pest monitoring to assist guiding their pest management decisions (Appendix 6). Adoption is an individual business decision and there are many reasons a grower may adopt or not adopt. This project, through a multi-faceted extension program addressed key preferred learning styles and has been responsive to regional differences. Trialability is a key barrier to IPDM adoption and the demonstration sites have provided practical information in a commercial setting.
Increased appeal of Australian fruit to export markets due to reduced chemical use		Most of the IPDM demonstration sites offered growers and pest and disease management decision makers opportunity to see alternative pest and disease management strategies with reduced chemical inputs.	The WA growers with demonstration sites have seen a reduction in sprays (Appendix 6). The FNQ lemon demonstration site at Hilltop Farming reduced the number of miticide applications by 80% (Appendix 7). The Dareton, NSW IPDM demonstration site that tested mating disruption tabs for California red scale management had only one selective insecticide applied in the 2024-25 season. The growers conventional treated side of the block had four pesticides applied to achieve comparable export quality navel oranges (Appendix 6).
The Australian citrus industry is better equipped to continue production with the future loss of some chemical options and	Outcome 1: The Australian citrus industry has increased profitability, efficiency, and sustainability by protecting	Grower participation at seasonal farm walks, IPDM workshops and at IPDM demonstration sites have increased grower	Demonstration sites showed California red scale, citrus gall wasp and light brown apple moth can be adequately

IPDM is adaptative to future needs and threats.	the production base through innovative research and development (R&D), biosecurity preparedness and responsiveness, sustainable best management practices (BMPs) and superior varieties. Strategy 9. Develop and optimise a whole-systems approach to integrated pest and disease management (IPDM).	knowledge of sustainable pest management options. The published resources like 30 'priority pest' fact sheets, 8 IPDM videos and 4 webinar presentations of the extension program support further knowledge gain. The printed field guide will ensure growers are better equipped to identify pests and diseases and apply management strategies at the most effective stage of the pest or disease life cycle.	managed without neonicotinoid group chemistry (Appendix 6). A publication 'Pests, beneficials, diseases and disorders in citrus: a field identification guide' (Appendix 11), and other project publications will continue to be available to the Australian citrus industry. The project activities, particularly the workshops, seasonal farm walks and demonstration sites aimed to increase confidence in IPDM and how to incorporate cultural, biological and chemical options in an integrated and sustainable crop protection program. Improved knowledge and skills will contribute to industry resilience and adaptability.

Monitoring and evaluation

Table 5. Key Evaluation Questions

Key Evaluation Question	Project performance	Continuous improvement opportunities
Effectiveness		
To what extent has the project achieved its expected outcomes?	Event evaluation data (Appendix 14), indicates a perceived increase of knowledge of citrus pests and diseases and their management by the event participants. The WA team undertook end of project farm visits of adoption of key growers who had participated in events over the last 4 years. All surveyed had adopted a new pest management technique since participating in the IPDM activities (Appendix 14 pp.89).	Growers may have greater awareness and knowledge of citrus pests and diseases, however further encouragement by demonstration sites is a way to increase adoption of sustainable pest management strategies to reduce chemical use. The baseline data generated in the IPDM survey at the start of the project provided a deep understanding at a regional scale. Another survey could be undertaken in about 2028. The resourcing for design and analysis of surveys should not be underestimated if the survey

		is to provide meaningful information and evidence for R&D priorities.
Relevance		
How relevant was the project to the needs of intended beneficiaries?	Grower organisations and citrus packers collaborated repeatedly with the project leader throughout the extension programs 4-year duration. The grower organisations and citrus packers provided publication advice and regional support to find suitable sites for IPDM demonstrations and appropriate orchards for seasonal farm walks. This involvement helped to ensure the project was relevant to intended beneficiaries.	It was found the combined PRG process did not work for the project team in this case. PRG members are extremely busy people. The focus diseases of research in northern production areas were not of relevance to southern production focused PRG members, and similarly, the pest project research focus was on southern citrus pests of concern. A 1.5-hour meeting duration is an excessive time commitment from busy people. The extension program was the third project presentation at each meeting agenda. There was limited discussion and feedback. PRG meeting participation declined as the projects progressed. For example, 27/03/2024 there were 4 of the 8 industry PRG members in attendance. During 2022, two PRG members (from differing regions) resigned due to inability to commit.
Process appropriateness		
How well have intended beneficiaries been engaged in the project?	There has been extensive engagement with citrus growers, rural supply store horticulturists, citrus packers and professional IPDM crop consultants through the 4 webinars and 60 events and 8 demonstration sites facilitated nationally by this project.	Improved engagement with Australian Citrus News would increase industry awareness of project outputs. Greater engagement with state department or agency communications teams would also increase industry awareness of project outputs.
To what extent was the engagement processes appropriate to the target audience of the project?	Citrus growers, rural supply store horticulturists, citrus packers and professional IPDM crop consultants continued to engage with the project and attend events over the four-year period of the project. The IPDM survey and ongoing engagement with growers resulted in alternative extension activities being proposed for FNQ.	Future extension projects should have fewer deliverables and focus greater resources on increasing awareness of project achievements. Flexibility in deliverables should be built into the project, especially when there is an in-depth survey at project commencement. Surveys designed with a social researcher and deep 'why' questions should be used more widely as a tool for prioritising R&D and extension needs and strategies. For example, the survey found that a specific pest was the

		highest pest of concern in a region, but deeper questioning identified that while it was the highest pest of concern, growers felt they had suitable management options. However, there were other pests that they did not feel confident to control.
Efficiency		
What efforts did the project make to improve efficiency?	Engagement with some interstate IPDM expertise was recorded and published. This enables future resource use and future knowledge sharing.	Copies of the printed fact sheets, posters and the field guide remain with respective state departments involved in CT19011. These are available upon request for industry organisations and future extension initiatives. The survey enabled activities to be better targeted at a regional scale, improving efficiency in the application of project resources.

Recommendations

The project has developed key IPDM resources that will have an enduring legacy through their availability on DPIRD, QDPI and CAL websites. Information on insect pests, mites, beneficials and disease are available to growers, IPDM specialists and other farm advisors.

It is recommended that work continues to identify the lowest impact insecticide chemistry for seasonal katydid control. If conclusive efficacy data is obtained, product label changes should be pursued. Industry has switched to methomyl, since the ½ rate chlorpyrifos can no longer be used due to export MRLs and potential product registration changes. This can lead to secondary pests. The IPDM extension program identified some potential alternative options at demonstration sites but full efficacy and residue data needs to be generated.

One of the IPDM extension program's demonstration sites has shown California red scale mating disruption combined with augmented release of Aphytis to be a potential sustainable alternative to neonicotinoid insecticide chemistry. It is recommended that additional demonstration sites in other regions are established to further assess the technology.

Regional on-farm participatory demonstration sites have proven to be a very effective tool to increase grower knowledge and facilitate the adoption of IPDM practices. Quality printed resources with practical content are valued by grower and crop advisors. This should be considered in the design of appropriate extension strategies in future R&D projects.

Demonstrations encouraging sustainable pest management practices should be supported. Fifteen years ago the ½ rate chlorpyrifos + oil and augmented Aphytis wasp release was the main pest management strategy in southern production regions. Aphytis wasp production is potentially commercially unviable for biological product suppliers due to reduced demand as many current insecticide products can control a range of pests. Changes to product registrations may leave growers seeking alternative pest management strategies for insect pests and specific biological products may not necessarily be available.

There are limited citrus crop consultants servicing WA citrus growers. There is limited monitoring by growers and key farm personnel as orchards always tend to have other tasks or issues that demand immediate attention. Building and maintaining IPDM capacity and capability is going to be critical for widespread adoption of IPDM in the Australian citrus industry.

Refereed scientific publications

Whole book

Fattore A, Creek A, Donovan N, Thakur M, Weppler R, Pattison E, Falivene S and Johnstone R (2025) Pests, beneficials, diseases and disorders in citrus: a field identification guide. NSW Department of Primary Industries and Regional Development, Orange.

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Appendices

1. Appendix 1 IPDM practices survey
2. Appendix 2 IPDM events list
3. Appendix 3 Interstate IPDM expertise **CONFIDENTIAL**
4. Appendix 4 Local IPDM expertise **CONFIDENTIAL**
5. Appendix 5 Grower to Grower knowledge share **CONFIDENTIAL**
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7. Appendix 7 Poster QDPI Australian Citrus Congress
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10. Appendix 10 Australian Citrus News articles **CONFIDENTIAL**
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IPDM for the citrus industry

This project has been funded by Hort Innovation using the citrus research and development funds from the Australian Government.
For more information on the fund and the strategic levy investment, visit horticulture.com.au

Citrus Industry IPDM Extension Program

CT19011 – Report on the Citrus IPDM practice survey, 2022

To obtain benchmark data on the integrated pest and disease management (IPDM) practices in the Australian citrus industry, stakeholders were surveyed in 2022. The survey data collected helped to guide the activities and publications for the Citrus Industry IPDM Extension Program to meet on-farm needs.

This report is separated into summaries from NSW DPI, QDAF and DPIRD collaborators, reflecting the data obtained from their respective regions.

Authors:

Andrew Creek | Development Officer, NSW Department of Primary Industries (NSW DPI)

Emily Pattinson| Horticulturist, Queensland Department of Agriculture and Fisheries (QDAF)

Rachelle Johnstone | Research Scientist, Department of Primary Industries and Regional Development (DPIRD), Bunbury WA

Acknowledgements

Dr Katrina Sinclair | Research Scientist, NSW Department of Primary Industries
Matt Adkins | Leader Industry Adoption, NSW Department of Primary Industries
Ebony Faichney |Development Horticulturist (Plant Protection), QDAF

Contents

Summary

The survey was undertaken from April to July 2022. Data saturation was achieved in the Riverina, and strong trends were identified in other regions. A total of 110 participants were interviewed nationally. The median orchard area of participants was 60 ha. There was a good representation of a typical family-owned and managed citrus orchard while also gathering data from some larger, corporate-type orchards.

The survey identified pests and diseases of grower concern and participants also rated their perceived level of control. The chemistry, cultural and biological practices used to manage them were recorded. The use of crop monitoring and IPDM specialists varied between regions. Rural supply store horticulturists were also important decision-making people for pest management.

Irregular supply of some key beneficial insects and availability of effective, multi-activity insecticide chemistry has resulted in decreased beneficial insect releases. Field days and websites were the most frequent sources cited for additional pest or disease information.

Survey results

Participants

The survey collected data from 110 participants. Most (88%) participants identified themselves as the 'grower' (Table 1 and Figure 1). Almost all (98%) participants worked full-time in the citrus industry (Figure 1). The Australian citrus industry has mostly experienced owners and orchard managers, with many people having likely grown up in the industry.

Table 1. Roles and experience of the IPDM survey participants.

Participant role	Proportion of respondents (%)	Experience (years)
grower/orchard owner/orchard manager	75	28
grower/orchard manager	9	19
orchard manager	9	28
grower/orchard owner	4	23

The 52 Riverina participants surveyed had an average of 33 years of citrus experience, while the 24 Sunraysia participants had an average of 23 years of experience. The size of the orchard managed by the participants varied from 4 to 2,200 hectares (ha). Only 4 respondents represented orchards larger than 500 ha. The median orchard area was 60 ha, so many family-owned and operated orchardists were interviewed (Figure 1).

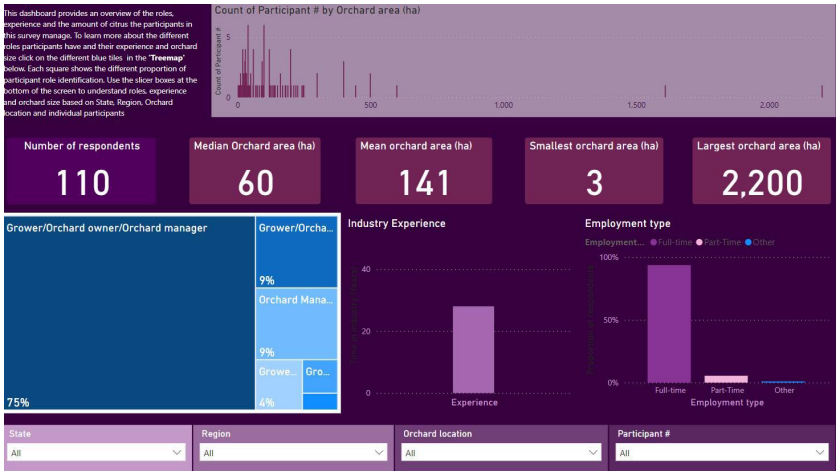


Figure 1. A screen shot of the survey participant dashboard.

Australia wide, the IPDM practice survey covered 15,678 ha, 61% of the industry by area that Citrus Australia Limited reported in the 2018 Australian citrus tree census. Riverina survey participants collectively manage 5,651 ha of citrus orchard (Table 2). The data from other regions involved more than half of the regional planted area (Table 2).

Table 2. The number of IPDM survey participants per region compared to Citrus Australia Limited (CAL) regional area data from the 2018 Australian citrus tree census.

Region	Participants (n)	IPDM surveyed area (ha)	CAL survey area* (ha)
Riverina	52	5,651	7,648
Sunraysia	24	3,981	5,342
Riverland	11	2,822	5,600
Queensland	16	2,753	4,592
Western Australia	7	471	1,022

The survey participants were chosen to reflect the varietal mix of each region. For example, in the Riverina, most growers have navel orange or Valencia orange as their main variety. In this region, the data collected was representative of the region, with most participants surveyed having either Valencia orange (38%) or navel orange (46%) as their focus crop. Mandarin-focused growers represented 7% of the Riverina survey participants, which is comparable to the Citrus Australia regional plantings data of 5% (Table 3).

Table 3. Number (and proportion) of participants surveyed for each focus variety compared to Citrus Australia Limited (CAL) Riverina regional data from the 2018 Australian citrus tree census.

Variety group	Number of participants for each focus variety	Variety group as a percentage of Riverina citrus plantings (CAL 2018)
Valencia and common	20 (38%)	53%
Navel orange	24 (46%)	39%
Mandarin	4 (7%)	5%
Lemon and lime	3 (<1%)	2%
Blood orange	1 (<1%)	
Grapefruit	0	1%

Figure 2. A screen shot of the market focus for pest and disease management of navel orange growing participants of the IPDM practice survey nationally.

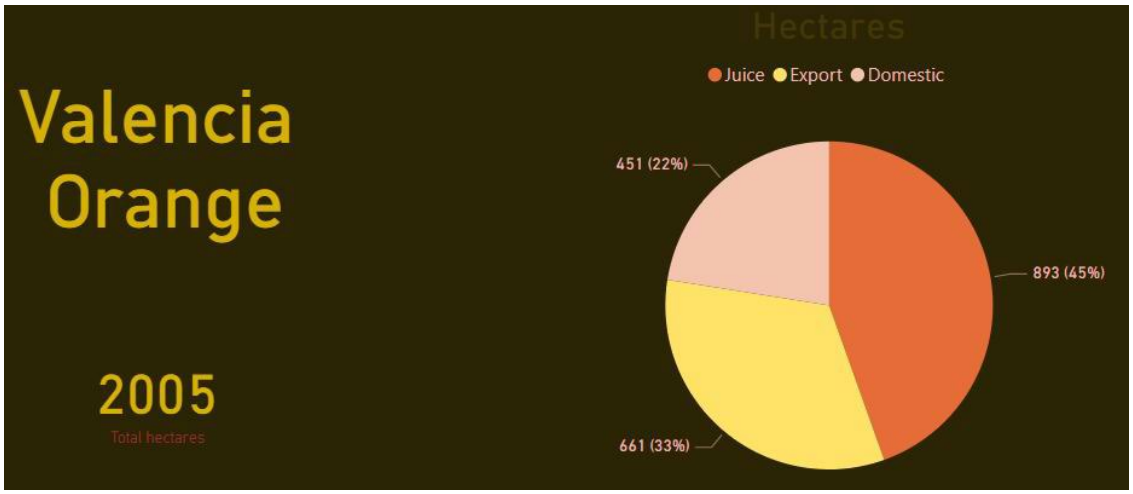


Figure 2. A screen shot of the market focus for pest and disease management of both Valencia orange growing participants of the IPDM practice survey nationally.

The market focus for pest and disease management varied between both varieties and states for the same variety (Table 4). An area of 6,907 hectares of national navel orange plantings was represented (Figure 2). Most (96%) of the navel orange production growers had an export focus for pest and disease management. Valencia orange producers had 33% of the area managed for an export market focus, 22% had a domestic pest management focus, and almost half (45%) were managed for juice processing. Contracted juice fruit has a greater tolerance for blemish and some insect pests than export navel orange production. A Valencia orange grower in the Riverland will likely have a lower tolerance to insect pests like Katydid and Red scale, as they are export focused. In contrast, a contracted juice Valencia orange grower in the Riverina has a higher tolerance for fruit blemishes and pests of quarantine concern (Table 4). This data means the IPDM extension program must consider the differing needs and production constraints of event participants in the different regions nationally.

Table 4. The market focus for pest and disease management decisions for Valencia orange production in differing production regions nationally.

Region	Export (%)	Domestic (%)	Juice (%)
Riverina	25	24	51
Sunraysia	63	9	28
Riverland	85	1	14
Queensland	0	100	0
Western Australia	57	43	0

Knowledge of pests and disease

Participants were asked to rate their knowledge of pests and diseases specific to their region. Responses varied for different pests (Figure 3). A 'degree of concern' was calculated, which the IPDM extension team will use to focus their efforts on the pests and diseases affecting participants (Table 5).

Citrus black core rot has a low degree of concern. Even though 30% of survey participants had no knowledge of the disease, only 5 of the 110 survey participants listed black core rot as a concern. Consequently, limited IPDM extension program resources should be spent on citrus black core rot. Queensland fruit fly, red scale, citrus gall wasp and oriental spider mites are pest examples that require extension efforts. Phytophthora root rot is a disease that extension efforts can also justify resources on (Table 5).

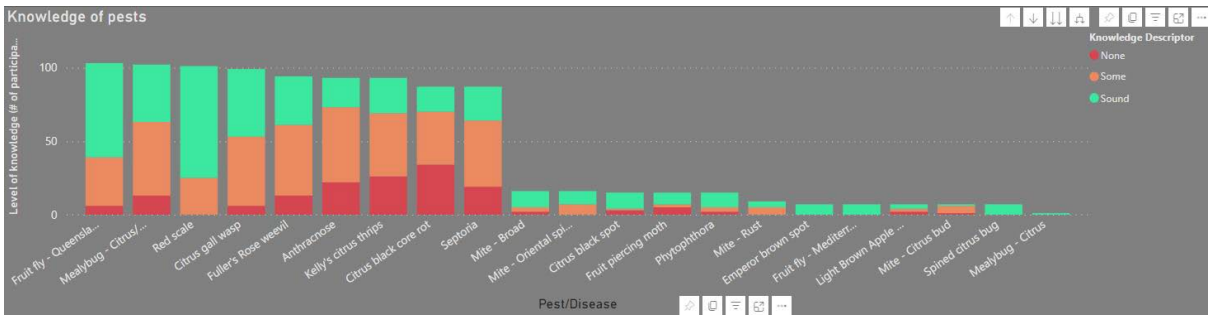


Figure 3. Participant knowledge of pests and diseases.

Table 5. 'Degree of concern' indicates how many participants ranked a particular pest or disease in their top 3 pests of concern against how many people were asked about their knowledge of this pest.

Pest	Degree of concern	Disease	Degree of concern
Red scale	68	Phytophthora	25
Citrus gall wasp	55	Citrus black spot	10
Queensland fruit fly	34	Anthracnose	9
Mealybug/citrus	19	Emperor brown spot	6
Light brown apple moth	16	Septoria	6
Oriental spider mite	10	Black core rot	5

Tri-state – Riverina, Sunraysia and Riverland regions

Andrew Creek, NSW Department of Primary Industries

Pests and diseases of concern

Survey participants were asked, 'Over the past 5 years, what have been the 3 main diseases of concern?'. Most tri-state participants did not list any diseases of concern, which somewhat reflects growing citrus in the dry, southern tri-state regions, where a seasonally applied autumn copper spray of good coverage is sufficient to manage citrus diseases currently in the region. Phytophthora root rot was the greater disease concern, followed by Anthracnose and Septoria. Sudden death was listed by 2 of the 52 Riverina survey participants, reflecting the use of Tri22 rootstock compared to the Riverland and Sunraysia.

The tri-state growers were generally quick to nominate 3 pests of concern. Red Scale was listed in each region, yet the level of control was adequate to good.

Riverina

Citrus gall wasp was cited by 42 of the 52 respondents in the Riverina. Alarmingly, 33% of these growers reported poor control, 48% indicated 'adequate control – but could be better ', and only 17% had good control (Figure 4). Citrus gall wasp, red scale and Queensland fruit fly were the 3 main pests of concern in the Riverina (Figure 4). Only half of the Riverina participants that listed light brown apple moth and Anthracnose indicated good control. Riverina growers mostly reported poor and adequate control for elephant weevil. Leaf minor and mealybugs were also pests that concerned Riverina growers.

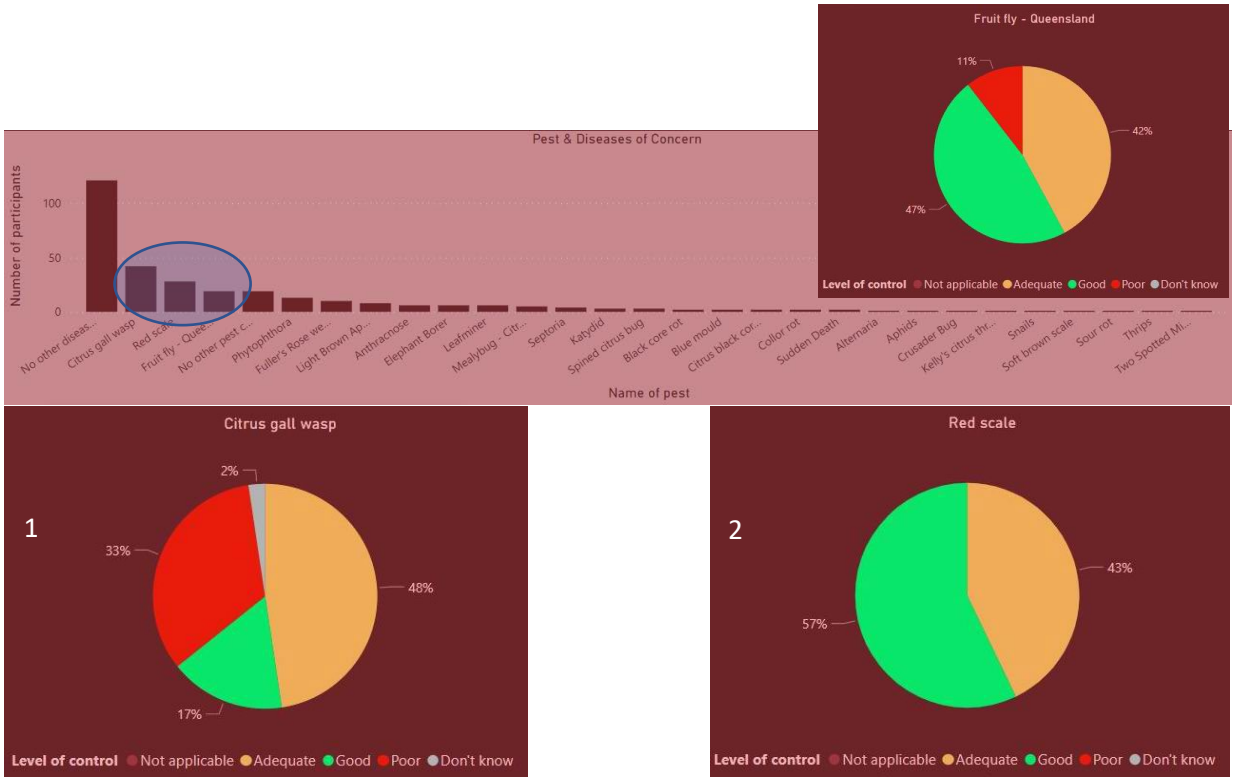


Figure 4. Riverina pests and diseases of concern and the IPDM survey participants' rated level of control.

1 – poor control (unacceptable amount of fruit rejects)
2 – adequate control (okay levels of fruit rejects but could be better)
3 – good control (acceptable amount of rejects)
4 – don't know

Sunraysia

Red scale, Queensland fruit fly, Mealybugs and Light brown apple moth were the pests of concern over the last 5 years for Sunraysia growers (Figure 5). The Sunraysia survey participants generally cited good or adequate control of their nominated pests. Only 16% nominated Citrus gall wasp as a pest of concern, much less than the 80% of Riverina survey participants. Twelve per cent of Sunraysia survey participants listed snails as a concern, and the level of field control being achieved was considered adequate to poor.

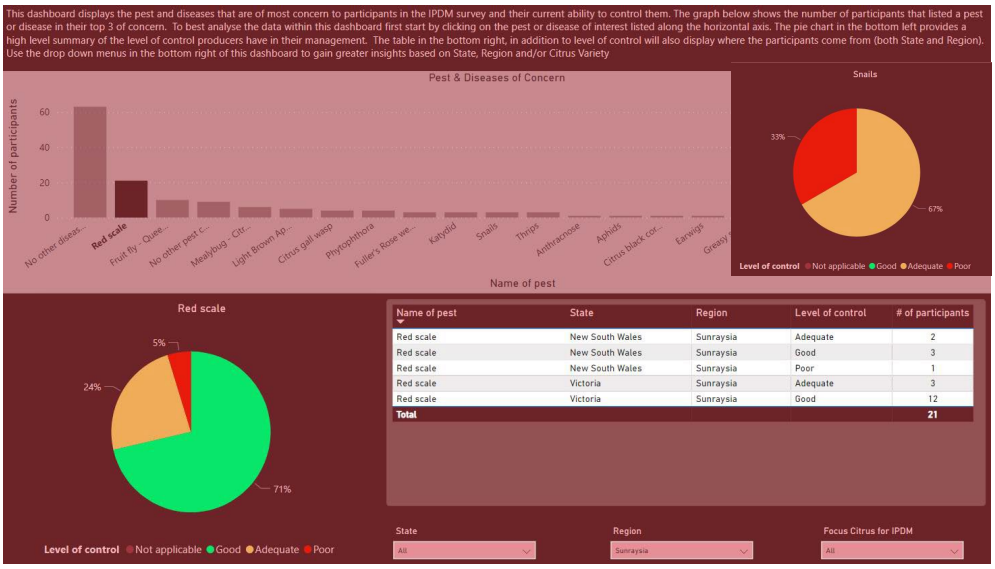


Figure 5. Sunraysia pests and diseases of concern and the rated level of control for Red scale and snails.

Riverland

Citrus gall wasp, red scale and mealybug were the most common pests of concern over the past 5 years for the Riverland growers surveyed (Figure 6). Recent management practices must be working, as 78% of the people who nominated citrus gall wasp indicated good control. Red scale control was considered adequate but growers mentioned a desire for improvement. The South Australian Riverland region has been experiencing Queensland fruit fly outbreaks. Two of 11 respondents indicated Queensland fruit fly was a pest of concern over the past 5 years, with a poor to adequate level of control. Earwigs were an increasing insect pest in the region.

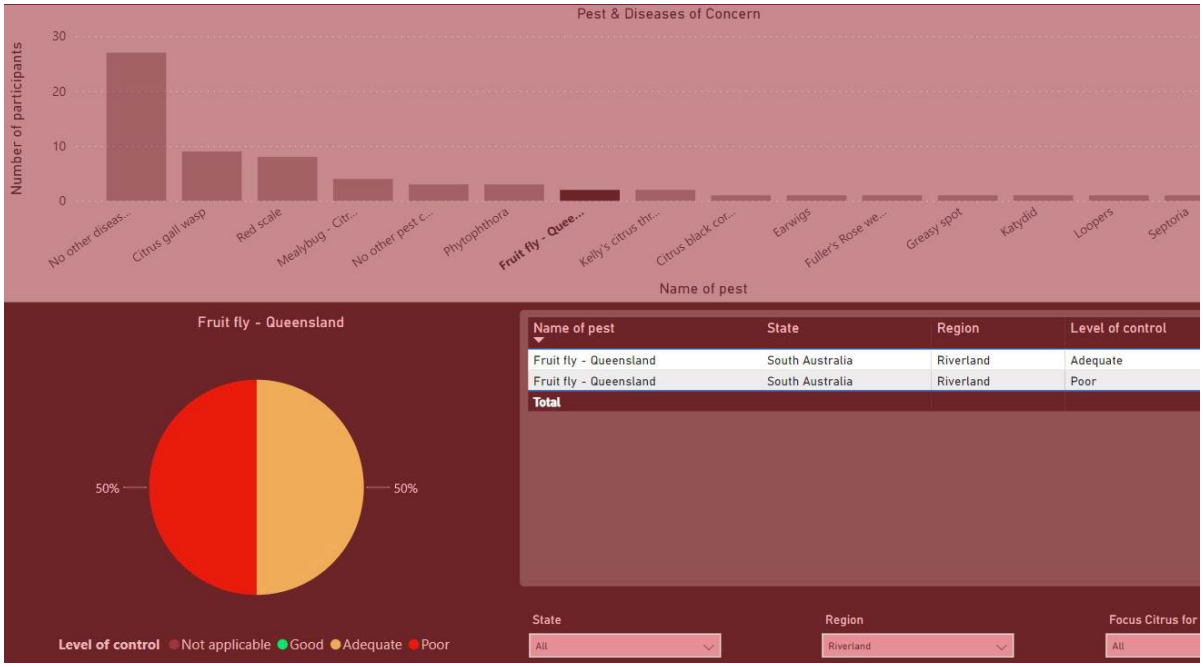


Figure 6. Riverland pests and diseases of concern and the rated level of control for Queensland fruit fly.

Biological and cultural control practices

Most survey participants currently bait spray to control Queensland fruit fly; a few in the Riverina and Sunraysia chose to cover spray.

Decaying fruit is generally not removed from under the tree canopy. Some Queensland mandarin growers removed fallen fruit and a few mixed businesses in Sunraysia that have almond orchard sweepers also did.

Most growers try to minimise dust within the orchard. It is difficult to manage dust during summer in the dry, western production regions of Sunraysia and Riverland. During discussion, participants indicated speed limit signage was used primarily to improve orchard safety, however, reduced dust was a secondary benefit of signage.

Most navel orange blocks were monitored to a protocol for pests (Figure 7), but Valencia blocks were not (Figure 7). This is understandable, considering 51% of the Riverina Valencia orange was managed for pests with a juice market as focus and returns have been low (Table 4).

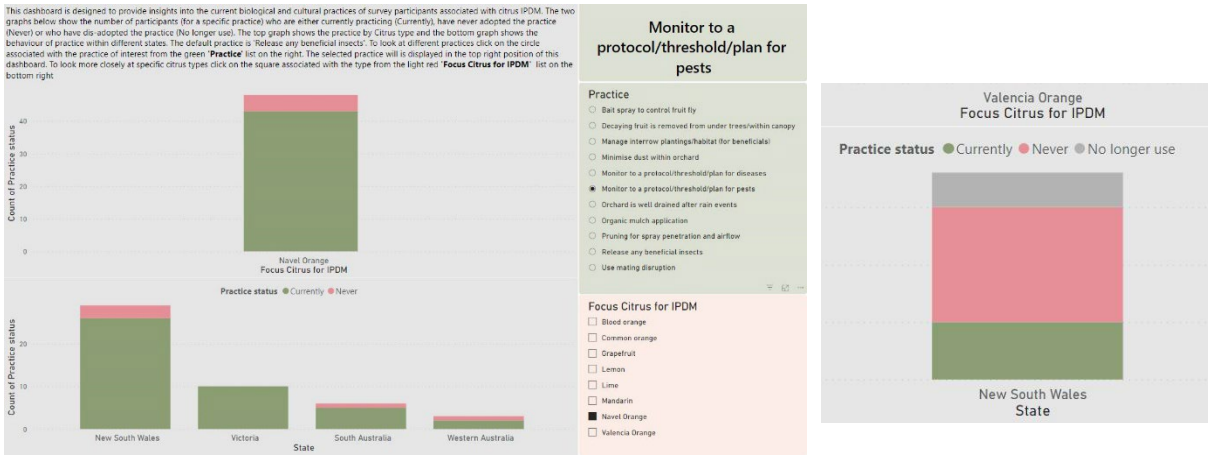
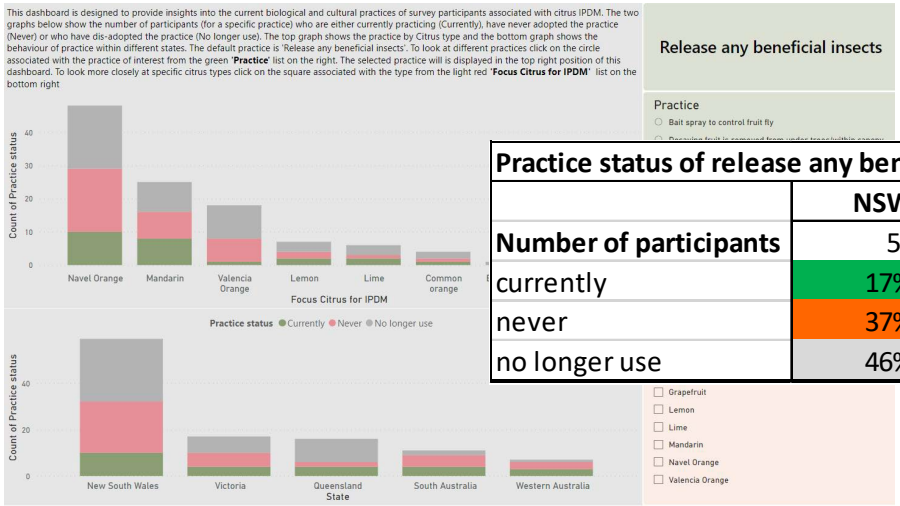


Figure 7. Comparison of navel orange and Valencia orange responses to 'monitoring to a protocol/threshold/plan for pests'.

Survey participants reported navel orange, mandarin and Valencia orange orchards were well drained after rain. Most participants indicated organic mulch was never applied under the tree, while 30% indicated they applied organic mulch under the tree. Some Riverina survey participants reported using composted cattle feedlot manure or chicken shed litter. A Sunraysia participant indicated they 'no longer use' organic mulch due to rising production costs and freight for manure. One Riverina participant discussed spreading straw mulch under the tree with machinery, but due to the increasing cost of freight for bales and the large volume of straw required, they 'no longer use 'straw organic mulch application.

Pruning regulates crop load and helps manage canopy height. We asked about pruning in the context of pest and disease management. All (100%) mandarin, lemon, grapefruit and blood orange growers and 97% of navel orange growers prune for spray penetration and airflow as part of pest and disease management. A third of the Valencia orange and Common orange varietal focus survey participants 'never' prune for spray penetration and airflow.

An equal proportion of respondents (40%) from all citrus focus varieties' no longer use 'or 'have never used' beneficial insects as part of their pest management; 20% indicated they 'currently 'release beneficial insects. Responses were similar for all states (Figure 8).



Practice status of release any beneficial insects			
	NSW	VIC	SA
Number of participants	59	17	11
currently	17%	24%	18%
never	37%	35%	45%
no longer use	46%	41%	36%

Figure 8. The practice status of beneficial insect release as part of pest management for differing citrus varieties and comparison of differing states.

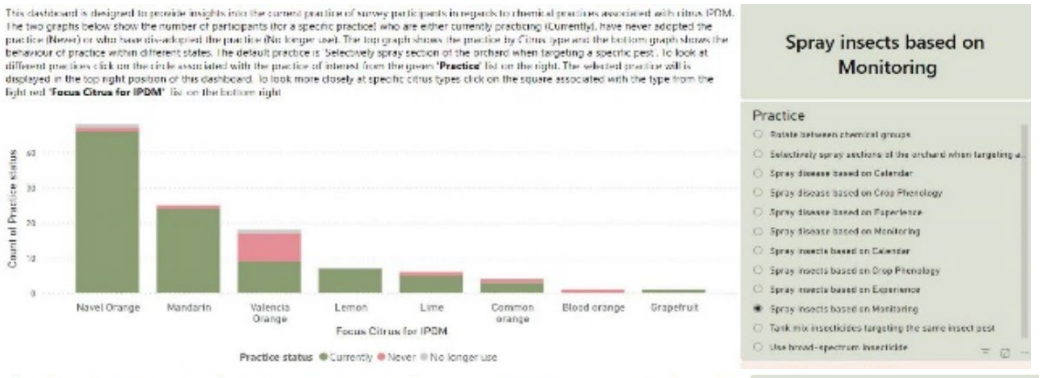
Some tri-state survey participants were questioned about why they 'no longer use 'beneficial insect release as part of their pest and disease management. The responses varied. Many said the systemic chemicals provide good control. Another respondent said, 'the packing shed requirements for minimal blemish are so tight, with the chemicals I use, there is no point releasing beneficial insects'. The cost of beneficials was another reason participants stopped using them. *Aphytis* spp. was the most reported beneficial insect that participants purchased in the past and have since stopped using. Availability of *Aphytis melinus* was minimal in 2021–22 and there was no commercial supply in the 2022–23 season. *Aphytis lingnanensis* was available.

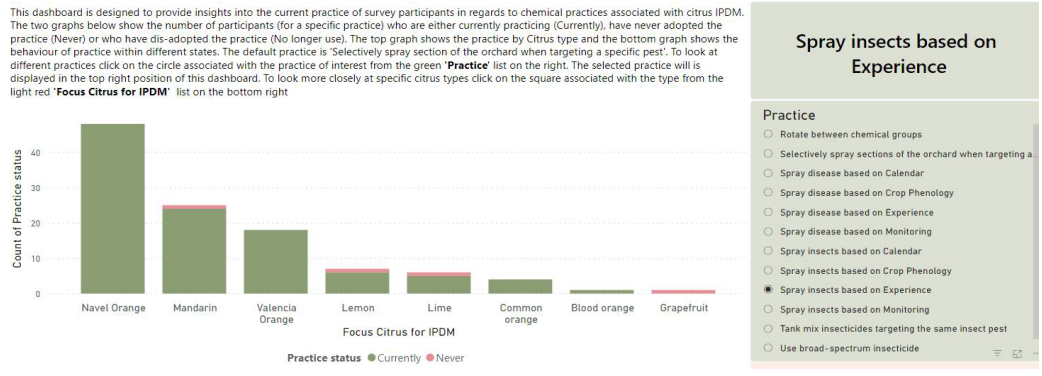
Mating disruption is rarely used as part of pest management, with most survey participants answering, 'never use '. Some (12%) mandarin survey participants indicated they 'no longer 'use mating disruption. One of these participants was questioned further and had used light brown apple moth mating disruption ties and found they were costly to purchase and dispense the ties. Fifteen per cent of navel orange participants reported currently using mating disruption as part of their pest management. Two participants clarified they were currently testing red scale mating disruption.

Spray practices

Monitoring data and grower experience were equally important factors when deciding to spray insecticides (Figure 9). Monitoring data was less important for Valencia participants, with most being contracted juice growers in NSW. Ten per cent of the 110 survey participants indicated they 'no longer' spray insects based on the calendar, and the majority (65%) 'never' spray insects based on the calendar.

However, seasonal pest patterns still influence some growers' decisions to spray. The arid, dry inland production regions historically grew Valencia and navel oranges. Usually, they managed pests and diseases with a ½ rate chlorpyrifos tank mixed with horticultural mineral oil in mid-November and an autumn copper spray. Almost 80% of survey respondents were from the tri-state production regions, and the survey data reflects that, with calendar or season timing of sprays being important for some. Valencia orange and common orange growers did not spray for diseases based on monitoring; an autumn coper spray provides adequate control. Most survey participants relied on experience and calendar-timed sprays to manage citrus diseases. Monitoring for diseases was important in the Central Burnett and Far North Queensland growing regions.





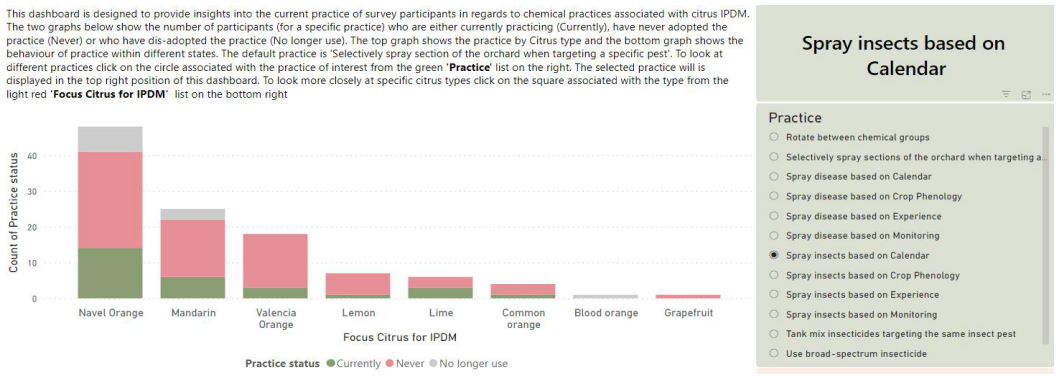


Figure 9. The practice status of 'monitoring', 'experience' and 'calendar' as influencing factors on chemical control spray decisions for pest management of differing citrus varieties.

Chemical rotation

Most (93%) IPDM survey participants currently rotate between chemical groups. The 'never' rotate between chemical group responses were relatively few and from processing orange and lime production. All citrus categories, except limes, indicated they 'never' tank mix insecticides targeting the same insect pest.

Survey participants were asked, 'Do you selectively spray sections of the orchard when targeting a specific pest 'to understand whether people have incorporated a 'hot spot' approach to their spraying. Most (92%) of the Navel orange-focused survey participants selectively sprayed sections of the orchard (Figure 10). Results were similar for mandarin, Valencia orange and lemon, with few growers 'never' selectively spraying.

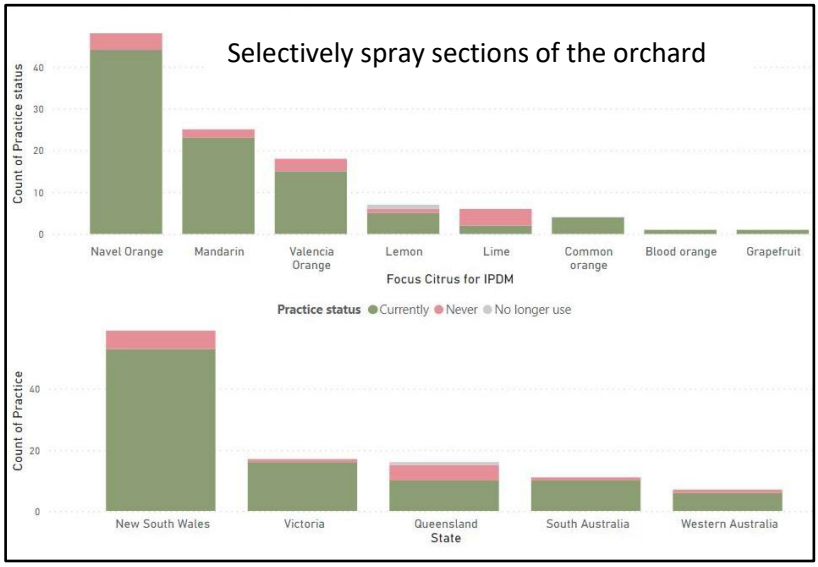
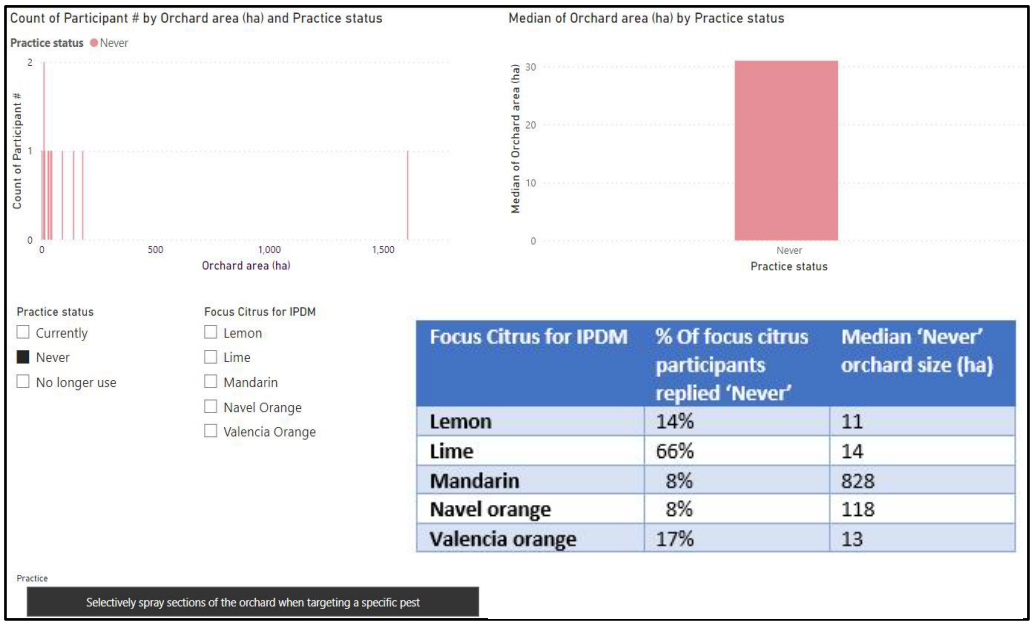


Figure 10. Dashboard showing data on the practice of 'selectively spray sections of the orchard when targeting a specific pest' for differing citrus varieties and state comparison data.

The survey data showed those individuals who selected 'never' for selectively spraying sections of the orchard when targeting a specific pest were mostly from smaller orchards (Figure 11).



Focus Citrus for IPDM	% Of focus citrus participants replied 'Never'	Median 'Never' orchard size (ha)
Lemon	14%	11
Lime	66%	14
Mandarin	8%	828
Navel orange	8%	118
Valencia orange	17%	13

Figure 11. Dashboard showing the median orchard size of orchards from which respondents indicated they 'never' selectively spray sections of the orchard when targeting a specific pest for differing citrus focus varieties.

Those who responded with 'never' were from a new orchard development and not currently cropping. In young orchards, insect pest pressure is reduced compared to a block of mature citrus trees. Hence, pests like soft scale and Citrus leaf miner were likely to be managed similarly across an entire new orchard.

Responses were mixed for the question, 'Do you use broad-spectrum insecticides?' with 70% of survey participants using broad-spectrum insecticides. Broad-spectrum insecticide chemistry is the only registered chemical control option for some insect pests, for example, Katydid, a common insect pest in the southern states. Interestingly 22% of navel orange, 36% of mandarin, 33% of Valencia orange and 33% of lemon participants indicated they either 'Never use' or 'No longer use broad-spectrum insecticide (Figure 12).

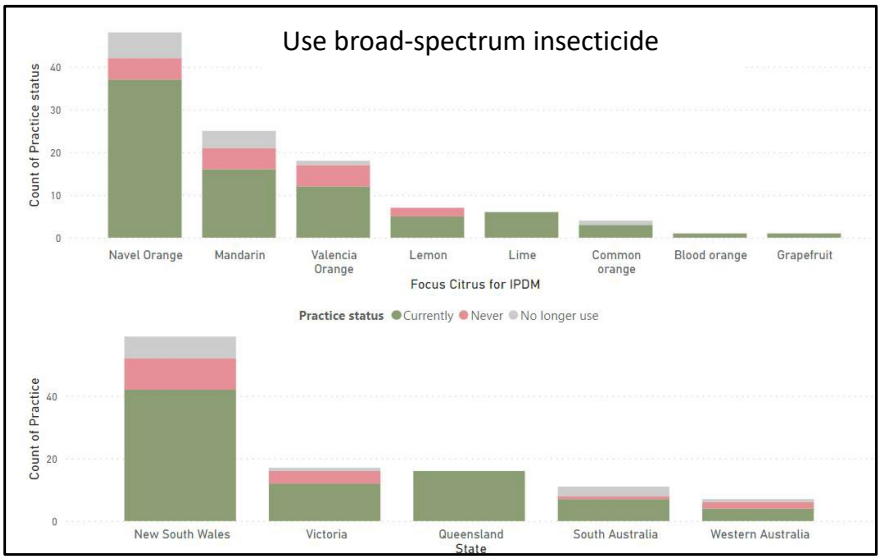


Figure 12. The practice status of 'Use broad-spectrum insecticide' for differing citrus varieties and the practice status compared between states.

Even though 70% of growers indicated they use broad-spectrum insecticide chemistry, they currently also use softer chemistry options (Figure 13).

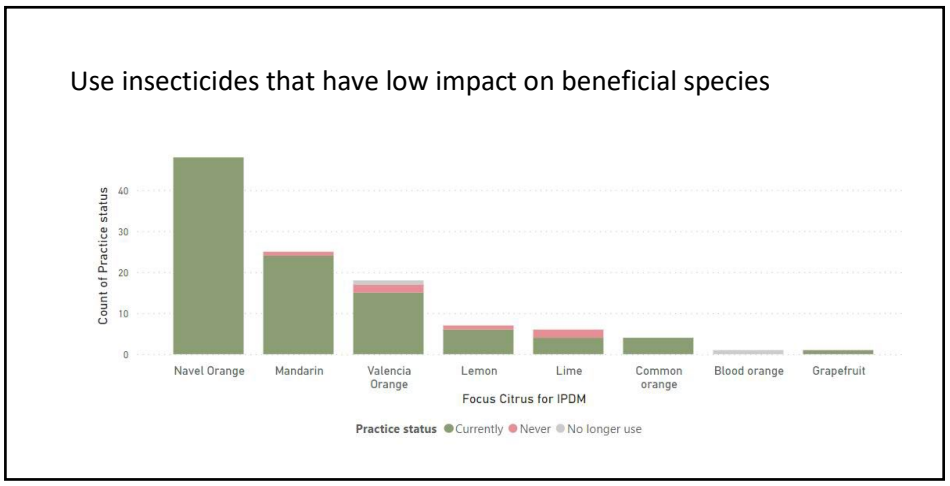


Figure 13. The practice status of 'Use insecticides that have low effect on beneficial species" for differing citrus varieties.

Recent chemistry use data show an intention to use 'softer' insecticide chemistry to preserve natural beneficials rather than actual industry practice. There may also be a lack of industry knowledge on the effects of differing insecticide chemistry on natural beneficials in the orchard. For example, 100% of Navel orange varietal focus participants indicated they use insecticides that have a low effect on beneficial species (Figure 14). However, if we tally the softer insecticide chemistry used by Navel orange growers for lepidopteran pests (i.e. the sum of BT, methoxyfenozide, spinetoram and tebufenozide (Figure 16), compared to the medium-high effect on beneficials chemistry (carbaryl, chlorpyrifos, cyantraniliprole, methomyl, and acetamiprid + pyriproxyfen), it is soft chemistry 18% vs 89% for the broader spectrum chemistry.

Even if we disregard the cyantraniliprole, as an application of this product in export navels was more likely for Fuller's rose weevil, and the acetamiprid + pyriproxyfen for red scale was the more likely target pest, it is soft chemistry 18% vs 66% for the broader spectrum chemistry. Perhaps 66% of navel growers each had Katydid as a pest that required control, and broader spectrum chemistry is the only control option available.

Decision making people

Survey participants indicated 'Personal experience' is most important for pest and disease decision-making. Pest scouts or pest and disease experts were most widely used in SE Queensland, Sunraysia and the Riverland. Ninety per cent of Sunraysia participants used a pest scout, whereas in the Riverina, 53% of growers surveyed used a pest scout (Figure 14). Rural supply store horticulturists are important decision-makers for Riverina, Sunraysia and Riverland growers. Government officers, neighbours and friends are rarely used in pest and disease decision-making.

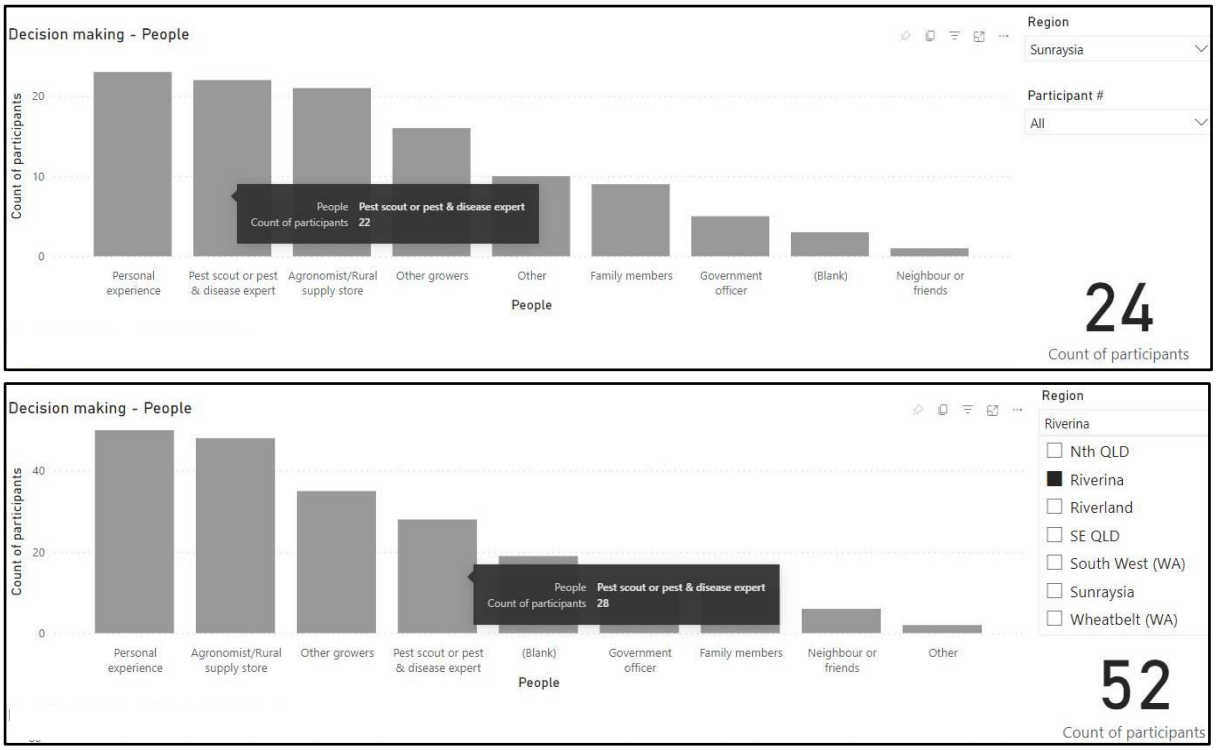


Figure 14. Pest scout or pest and disease experts were used more widely in Sunraysia than the Riverina. Agronomists and rural supply store horticulturalists are equally important decision makers.

A relationship with a good pest scout and or a rural supply store horticulturist is extremely important to citrus growers. Question 11 of the survey asked, 'Where else do you seek information to help make a pest and disease management decision?' Many times, the participant's response reflected how busy Australian citrus growers are. 'I do what the pest scout says' or 'I am too busy, that is why I have a pest scout and 'I do whatever my agronomist tells me'.

Not all participants answered question 11 and perhaps indicated their preference for information generally. Sixty two per cent of participants indicated field days were a good additional information source to help make pest and disease management decisions. Fifty four per cent of participants indicated websites were an important information source. One participant mentioned, 'a quick Google search or web sites was a quick way to seek information'. Thirty one per cent of the participants surveyed indicated magazine articles, 20% newsletters and only 4% indicated webinars as an additional information source.

Recent chemistry use

Survey participants reported chemical use for pest and disease management for a representative focus variety block in their orchards. Based on their effect on beneficial insects, a score was placed on the different chemistries used by respondents to help us identify potential growers for IPDM demonstration sites. A score of 10, 5 or 1 was used respectively for high, medium and low impact. Insecticide use varies between navel orange growers, and some did not apply an insecticide at all (Figure 15).

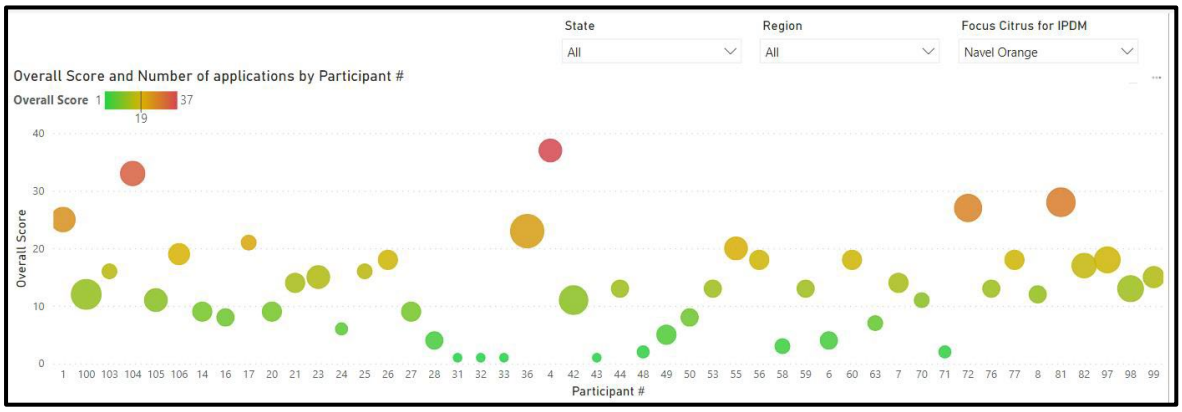


Figure 15. IPDM score based upon chemistry use for the navel orange focus survey participants.

The tri-state chemical use results are summarised in Figures 16, 17 and 18. The data shows the tri-state region extensively uses copper fungicides, spirotetramat and noenicitinoid insecticides. In April 2018, the European Union (EU) voted to restrict the use of 3 neonicotinoid compounds (imidacloprid, clothianidin, and thiamethoxam) to use in greenhouses only to limit environmental risks. The APVMA is currently assessing whether the Australian registered neonicotinoid products continue to meet the safety and labelling criteria in accordance with the Agvet Code.

Spirotetramat (e.g. Movento®) has recently come off patent in Australia. Lower-cost, generic products are likely to become common, and their use will increase. Some insect and mite pests readily develop resistance to chemical products that are applied regularly or used in a manner that is not according to label directions.

Methomyl and chlorpyrifos are used where softer insecticide chemistry options are not available to manage some insect pests. There was greater chlorpyrifos use in Valencia oranges compared to navel oranges, as they have a greater domestic and juice processing market focus. The USA ban on chlorpyrifos residue has restricted the use of chlorpyrifos products in navel oranges. Methomyl use was greater than chlorpyrifos in navel oranges.

Navel orange (Riverina, Sunraysia and Riverland)

Average 2.1 fungicides applied
Average 2.4 insecticides applied
Average 0 miticides applied
Average 0.3 bait spray for QLD fruit fly

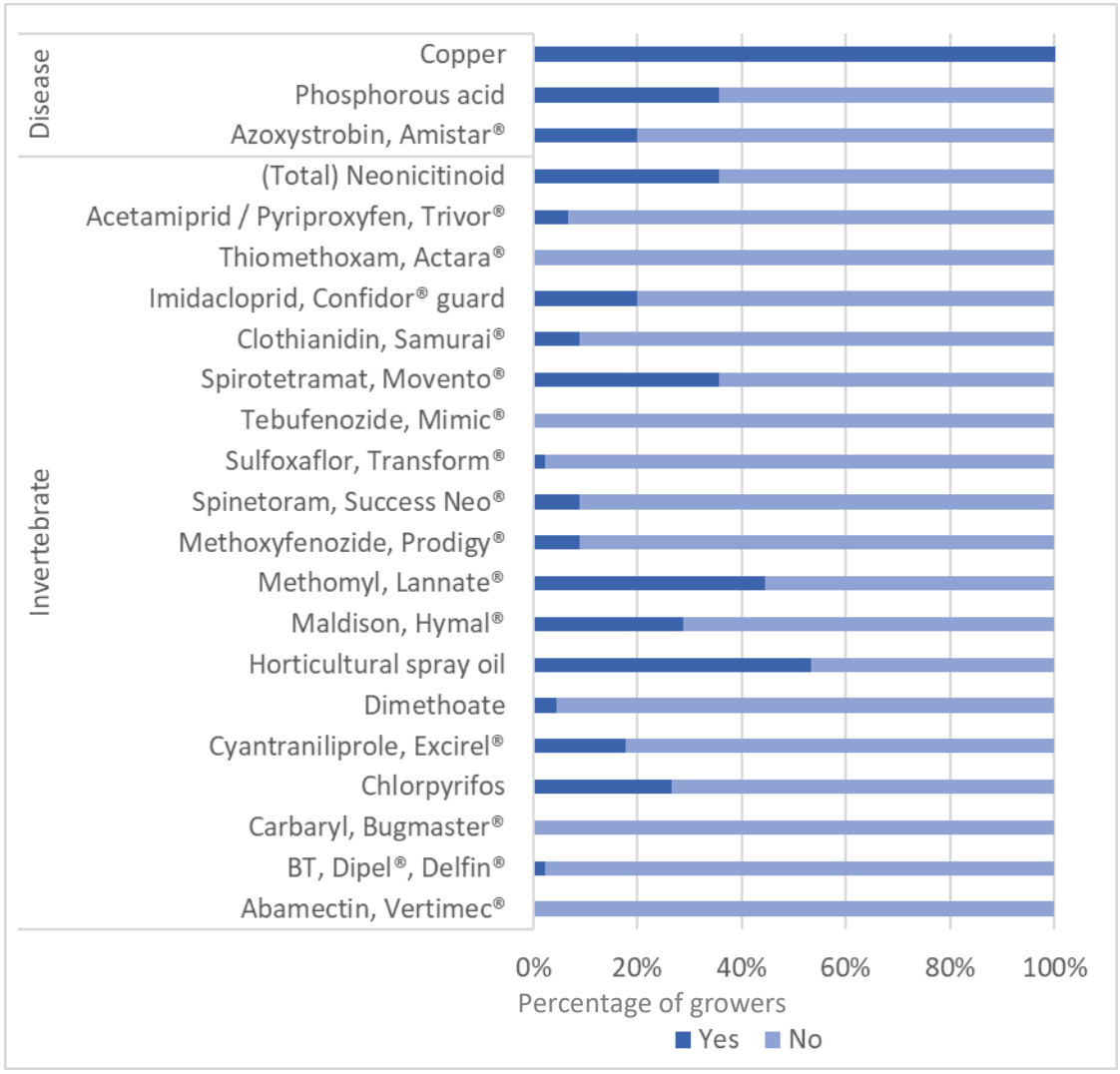


Figure 16. Chemicals used in the 2021–22 season for the 45 **navel orange** focus variety IPDM practice survey participants from the Riverina, Sunraysia and Riverland regions. Each participant reported chemical use for a representative block on their orchard.

Valencia and Common oranges (Riverina, Sunraysia and Riverland)

Average 1.6 fungicides applied
Average 0.9 insecticides
Average 0 miticides applied
Average 0.8 bait spray for QLD fruit fly

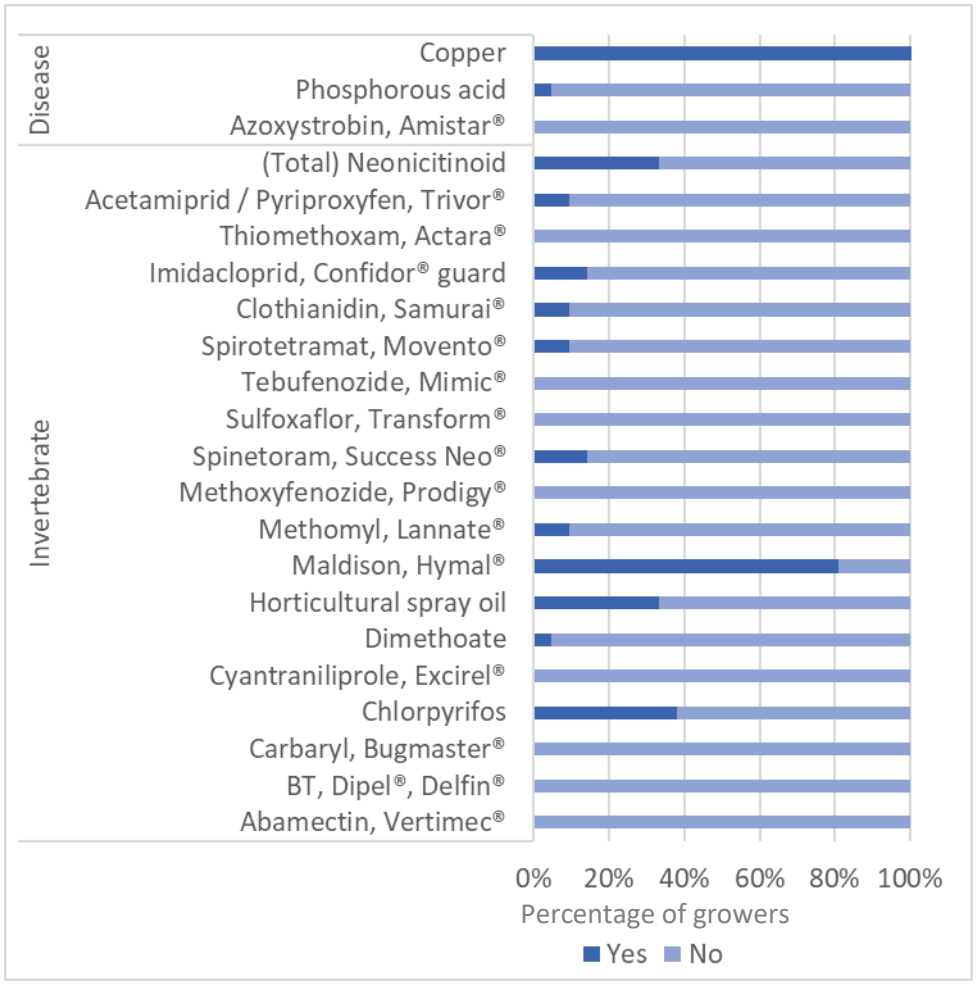


Figure 17. Chemicals used in the 2021–22 season for the 21 **Valencia and Common orange** focus variety IPDM practice survey participants from the Riverina, Sunraysia and Riverland regions. Each participant reported chemical use for a representative block on their orchard.

Mandarin (Riverina, Sunraysia and Riverland)

Average 1.6 fungicides applied
Average 1.9 insecticides applied
Average 0.1 miticides applied
Average 0 bait spray for QLD fruit fly

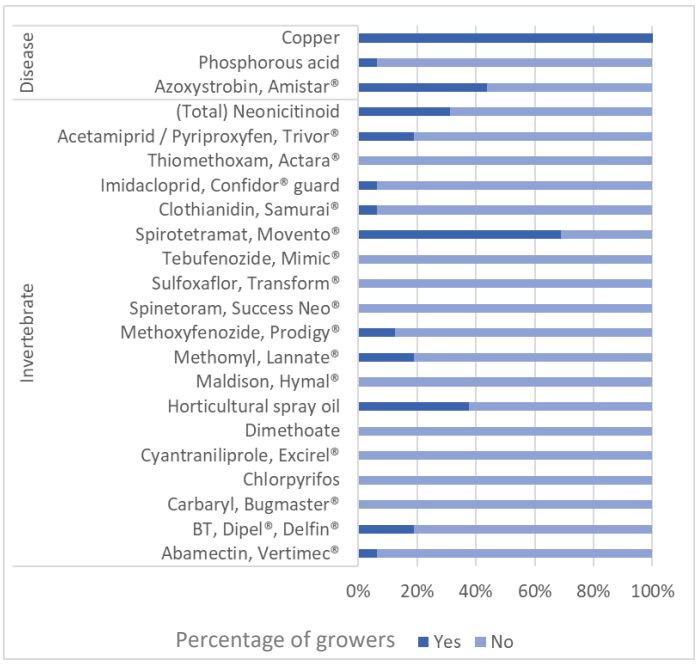


Figure 18. Chemicals used in the 2021-22 season for the 16 – mandarin focus variety IPDM practice survey participants from the Riverina, Sunraysia and Riverland regions. Each participant reported chemical use for a representative block on their orchard.

Chemistry use was higher for grapefruit, limes and lemons than Navel, Valencia and Common oranges. Grapefruit, limes and lemons are predominantly grown in Queensland, where a warmer climate increases the diversity of pests and also the number of pest generations annually. The increased number of wet days, higher humidity and heat greatly increase citrus disease pressure. SE Queensland mandarin growers use more fungicides than southern mandarin production (Figure 19).

Mandarin (SE Queensland)

Average 14.2 fungicides applied
Average 3.2 insecticides applied
Average 2.2 miticides applied
Average 6.0 bait spray for QLD fruit fly

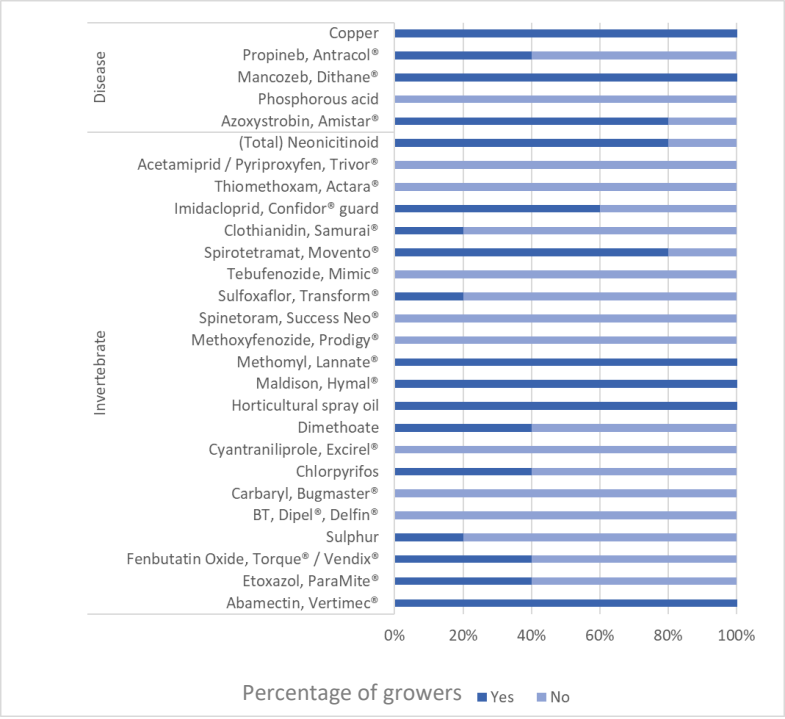


Figure 19. Chemicals used in the 2021-22 season for the 5 – mandarin focus variety IPDM practice survey participants from the Central Burnett region. Each participant reported chemical use for a representative block on their orchard.

North Queensland

Emily Pattison, Queensland Department of Agriculture and Fisheries, Mareeba

Queensland citrus growers were given a survey designed to determine pest and disease concerns. In north Queensland there were 9 survey respondents; one grapefruit grower, one lemon grower, six lime growers and one mandarin grower. This was representative of the north Queensland citrus growers according to a regional industry profile conducted in 2018 by the Queensland Department of Agriculture and Fisheries.

The farm size of north Queensland survey respondents ranged from 3 ha to 1610 ha, with a median of 40 ha. The experience of survey respondents in the citrus industry averaged 21.7 years.

The survey identified oriental spider mites as the number one pest or disease issue for citrus growers in north Queensland (Figure 20). Seven out of the 9 growers surveyed identified it as a pest of concern; of that 7, 6 growers reported that they currently achieve poor pest control. The next most concerning pests were fruit spotting bug, mealybug, and broad mite, which were only pests of concern for three growers.

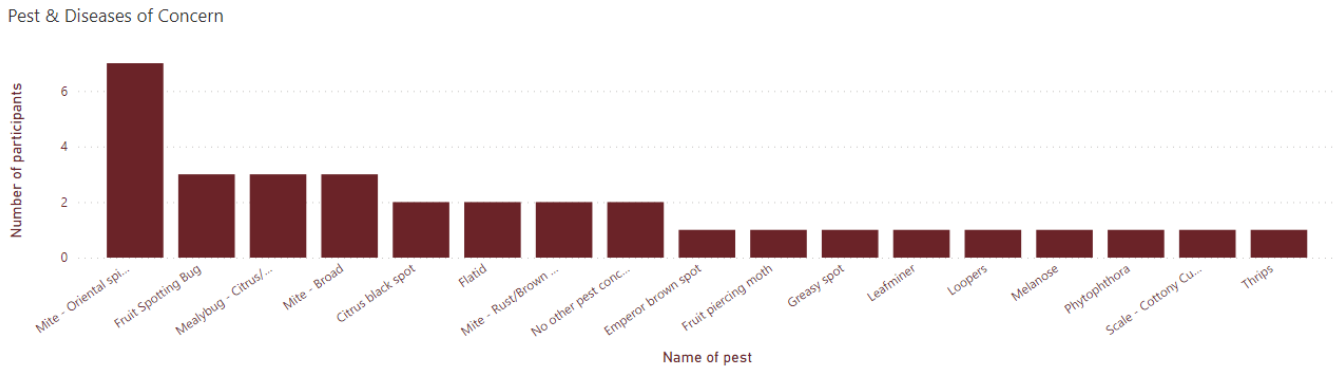


Figure 20. Pests or diseases of concern as rated by north Queensland Citrus growers.

The survey respondents indicated a very chemically reliant approach to controlling pests in the region, with an average of 35 pesticides and fungicides applied annually by each grower. Additionally, growers tended to favour disruptive, broad-spectrum chemistries such as methomyl (Lannate®) and chlorpyrifos (Lorsban®) over softer options (Table 6). There was also a high use of miticides, which reflects the seriousness of the oriental spider mite issue and the poor control achieved.

Table 6. The top 5 insecticides used in North Queensland citrus expressed as an average number of applications per grower each year.

Chemical	Average applications/Year
Methomyl (Lannate®)	8
Sulfur	8
Abamectin	7
Horticultural oils	6
Chlorpyrifos (Lorsban®)	3

Only one grower surveyed indicated they did not monitor for pests and diseases, but there were still 3 growers still practising calendar spraying for pests. All but 2 growers rotated between chemical groups to manage resistance, however, three growers tank-mixed different insecticide products to target the same pest.

The incidence of growers releasing beneficial insects was low, with only 4 currently releasing any and 3 that had in the past but no longer used them. Similarly, there were only 3 growers that managed inter-row plantings to retain the beneficial insects. Pruning for spray penetration and airflow was the most common cultural practice used (by 8 growers) in the region.

The survey results indicated that the area is experiencing substantial pest issues, particularly from oriental spider mites, and that the current method relies heavily on chemicals for control. While there is awareness of IPM best practices, there has been only moderate uptake.

Southeast Queensland

Seven citrus growers responded to the survey in the Southeast Queensland region; six mandarin growers and one lemon grower. The average farm size in this region was comparatively larger than in north Queensland, with the smallest orchard being 24 ha and the largest being 200 ha, with a median orchard size of 126 ha.

The biggest pest and disease issue for growers in the Southeast region was citrus black spot disease, which all growers rated as a disease concern (Figure 21). Despite it being rated a pest of concern by so many growers, only one grower reported they were not achieving adequate control of the disease (Figure 22). This was followed by emperor brown spot, which was considered a disease of concern by five growers. For Southeast citrus growers, red scale was considered the pest of most concern, rated by four growers.

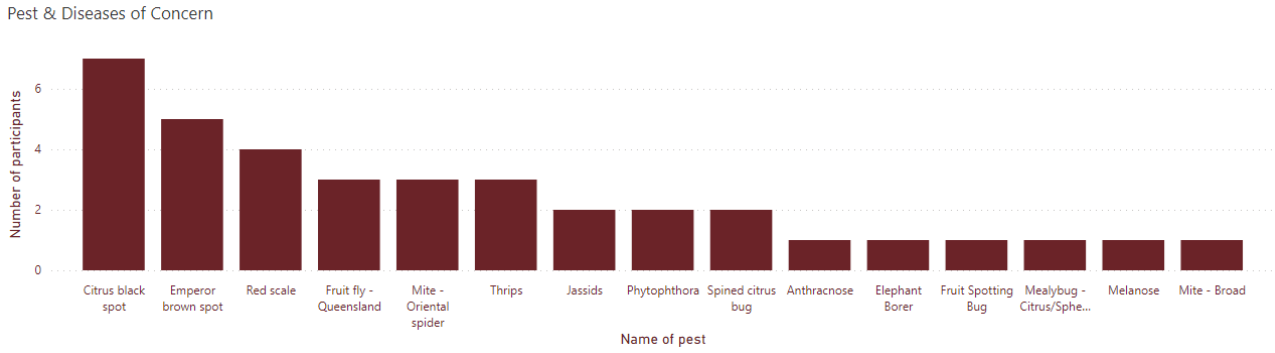


Figure 21. Pests or diseases of concern as rated by Southeast Queensland citrus growers.

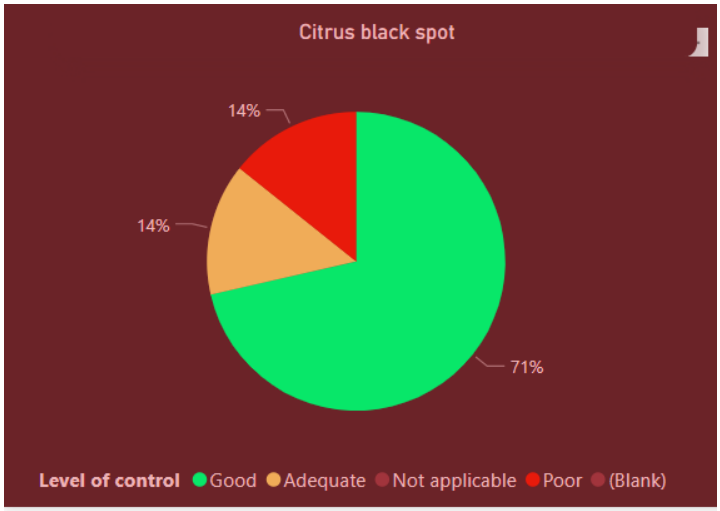


Figure 22. The level of control of citrus black spot as considered by the growers who rated it a pest of concern.

Chemical use in Southeast Queensland reflected the disease issue identified in the survey, with fungicide use dominating insecticide use (Table 7). Growers were applying an average of 14 fungicides a year with mancozeb, copper and azoxystrobin being the most popular, and 10 applications of pesticides, five of which were maldison to control Queensland fruit fly. Despite the number of maldison sprays used each year, only 3 growers rated fruit fly as a pest of concern. Two of these growers reported good control and one reported adequate control, suggesting that fruit fly control systems that integrate maldison are very effective.

Table 7. The top 5 insecticides used in Southeast Queensland citrus expressed as an average number of applications per grower each year.

Chemical	Average applications/year
Mancozeb (Dithane®)	9.4
Maldison	4.7
Copper	3.5
Horticultural oils	1.8
Methomyl (Lannate®)	1.8

Generally, good spray practices were being undertaken in Southeast Queensland. All respondents rotated between chemical groups, selectively sprayed an orchard area to target a pest and never tank-mix insecticide products to target the same pest. All 7 growers sprayed for disease based on monitoring; however, 5 growers supplemented this with calendar spraying. In terms of insect pests, only 2 growers used calendar spraying.

Southeast citrus growers demonstrated good knowledge and use of cultural and biological practices for pest and disease control. All growers monitored to a threshold for pests and diseases, minimised dust in the orchard, pruned for airflow and spray penetrations and used a bait spray for fruit fly control. Six out of the 7 growers manage inter-row plantings to encourage beneficial insects. It was interesting that all 7 growers had released beneficial insects in the past, but had not continued this.

The survey showed that citrus growers in Southeast Queensland have more issues with disease than insect pests; however, they were achieving good control of the issue. Despite that, their knowledge and implementation of IPM practices were high.

Western Australia

Western Australian orchards in the southwest region (Harvey, Manjimup) and the wheatbelt region (Moora, Gingin) were included in the survey. While only 7 surveys were completed, this included most of the largest producers as well as some smaller producers. These businesses captured a total of 471.5 hectares of production, which is close to 50% of the total production area in the state. Most participants were growing for the domestic market (86%). For the total production area of those surveyed, 45% was being grown with pest and disease management based on an export market focus.

Varieties

The main varieties grown by surveyed Western Australian growers were navel orange, mandarin and lemons (71.4% of participants), followed by Valencia orange (42.9%) and some also growing lime (28.6%), grapefruit (28.6%) and common orange (14.3%) (Figure 23.).

Navel orange was the most common variety grown by total area (Figure 24), with 228.7 hectares for the participants (56% of the total production area). Mandarins were the second highest area with 109.6 ha (27% of the total area).

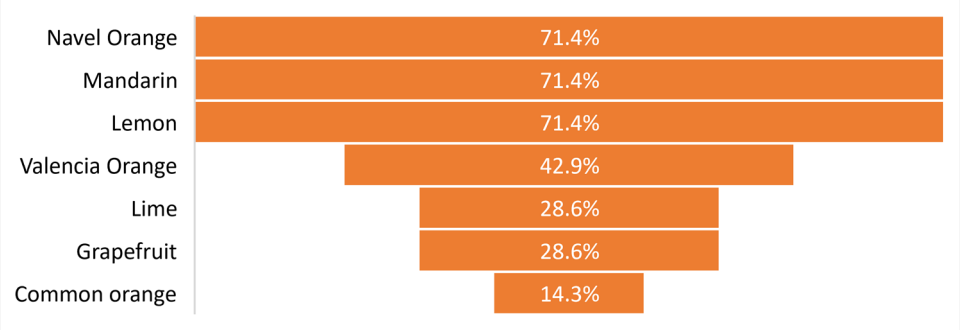


Figure 23. Percentage of survey participants growing each variety.

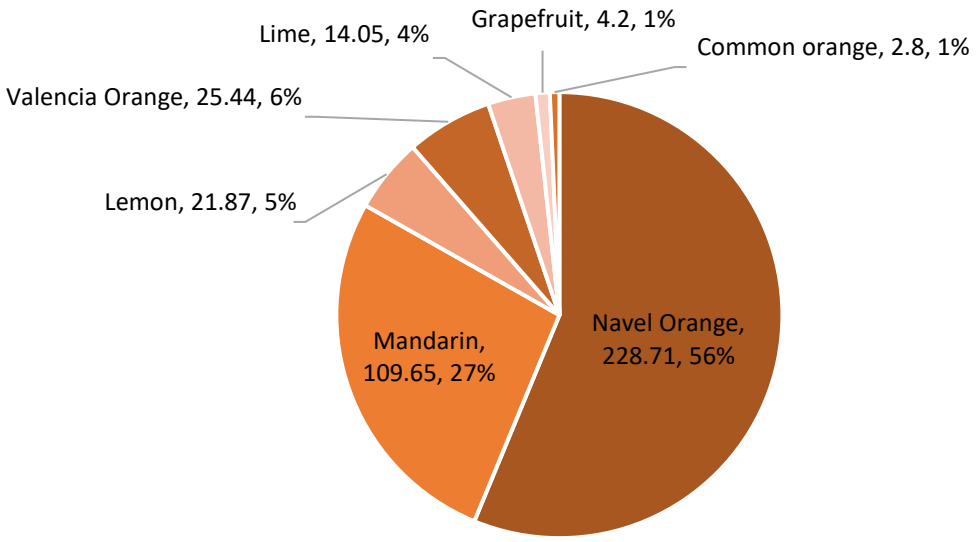


Figure 24. Total area (hectares) of each variety grown by survey participants in WA.

Pests and diseases of concern

All participants listed red scale as a pest of concern. Light brown apple moth was an issue for 40% of participants, but only in the wheatbelt growing region (Figure 25). Thrips were also an issue for 40% of participants in both regions. Mealybug was a problem for 30% of participants, all in the southwest

region. Other pests of concern were citrus bud mite (southwest only), aphids, pink wax scale and cottony cushion scale.

Seventy per cent of participants reported good control of red scale, with the remaining 30% having an adequate level of control (Figure 26). All participants who listed LBAM, aphids, pink wax scale and cottony cushion scale as pests of concern reported a good level of control of these pests. Only 30% had good control of thrips with 70% having adequate control. Participants with Kelly's citrus thrips, citrus bud mite and mealybug felt they had an adequate level of control of these pests.

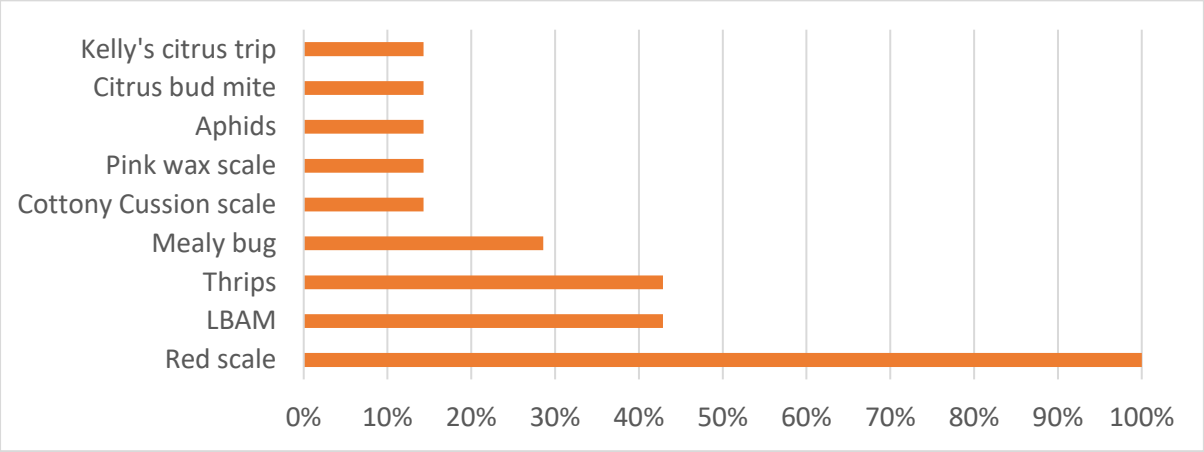


Figure 25. Main pests of concern for WA participants over the last 5 years.

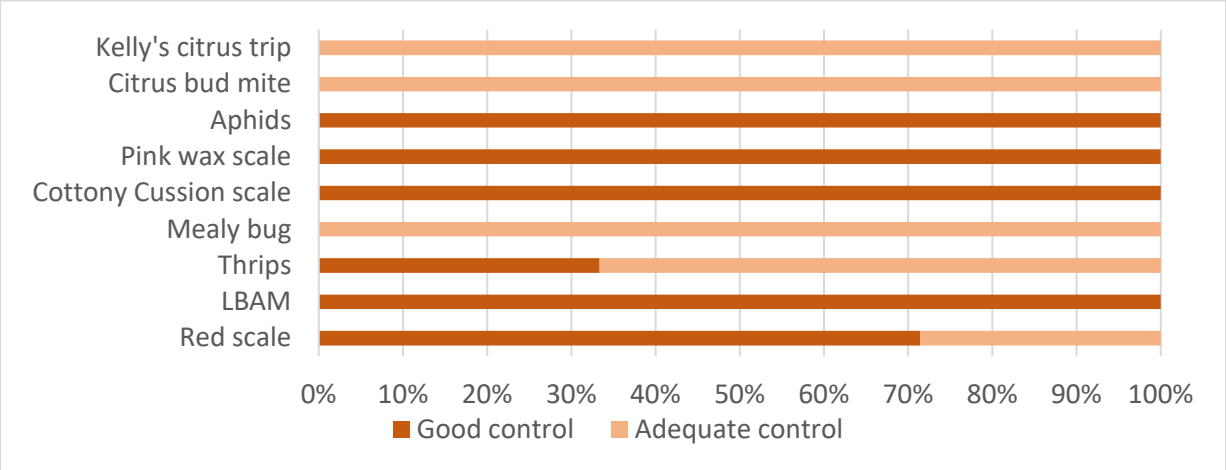


Figure 26. Level of control of the main pests of concern for WA participants.

Diseases were not as much of an issue for WA orchards in the last 5 years (Figure 27). For 28% of participants, phytophthora was a disease of concern, but they had good control (Figure 28.). Anthracnose and citrus black spot were an issue for 145 of the orchards surveyed and a poor level of control of these diseases was reported. Botrytis and Alternaria brown spot were a concern for 14% of participants who had an adequate level of control of the disease. Black core rot and sooty mould had good control for the 14% of participants who had an issue with this disease in the last 5 years.

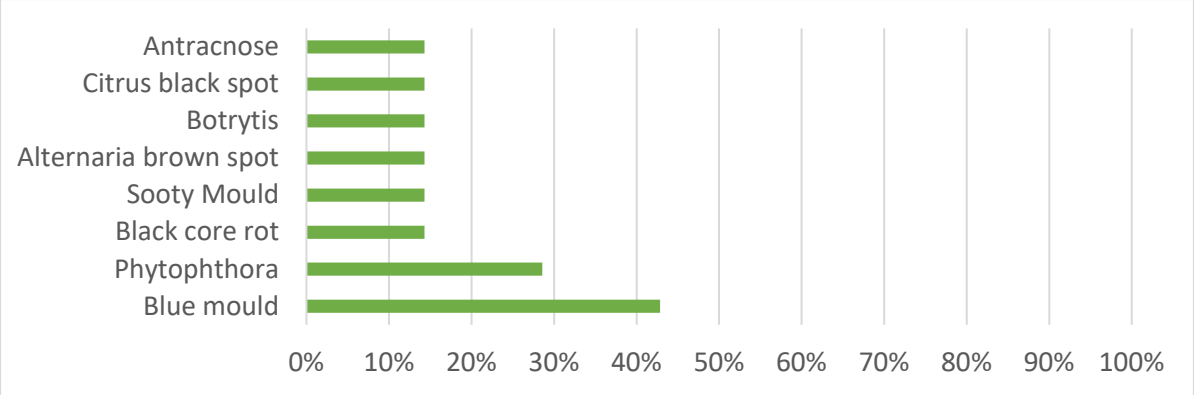


Figure 27. Main diseases of concern for WA participants.

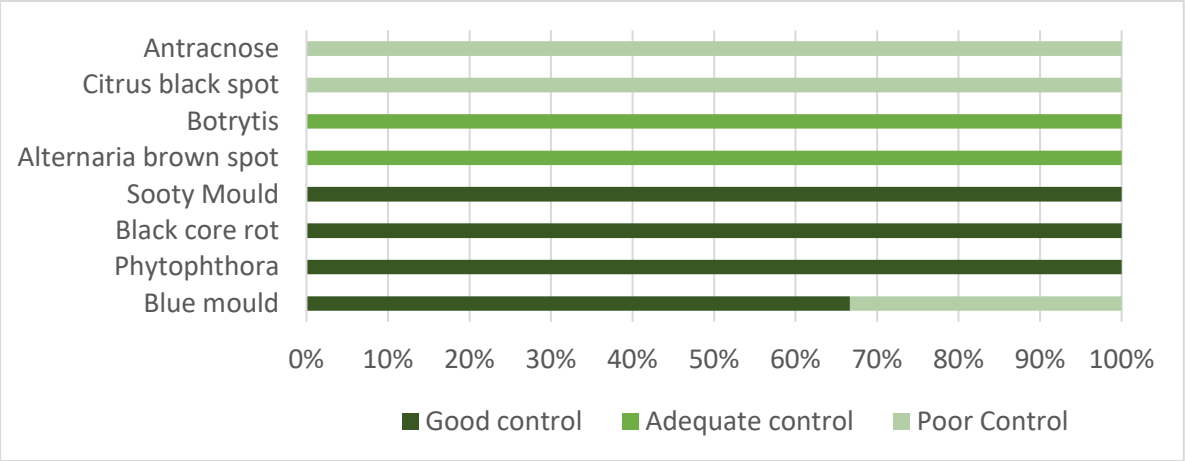


Figure 28. Level of control of the main diseases of concern for WA participants.

Knowledge of pests and disease

Knowledge of pests and diseases was quite varied for the survey group (Figure 29). All participants had a sound knowledge of red scale and Mediterranean fruit fly. Participants were less confident of their knowledge of Fuller's rose weevil, LBAM, citrus bud mite, Anthracnose, mealybug and citrus gall wasp (noting that citrus gall wasp is not yet an issue for WA orchards).

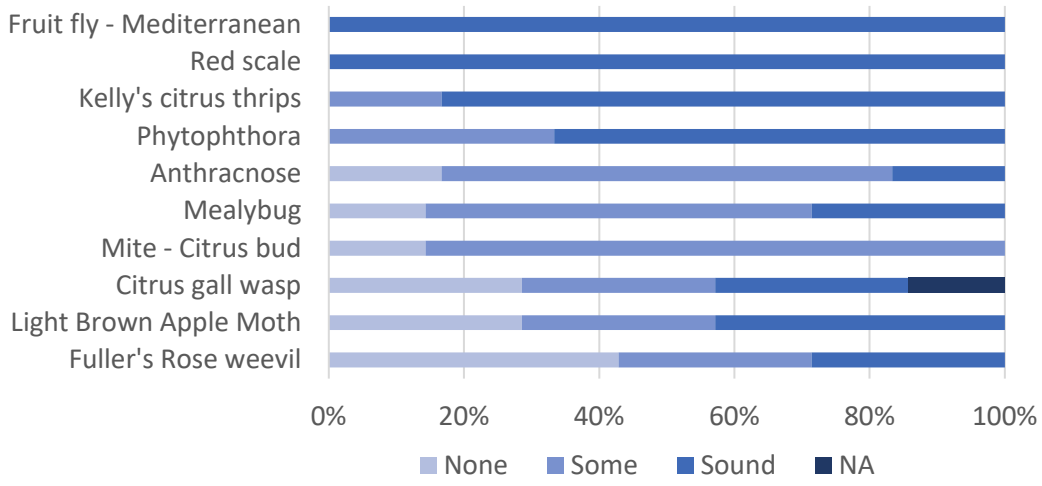


Figure 29. Participants' level of knowledge of pests and diseases.

Biological and cultural practices

All participants prune trees for spray penetration and airflow (Figure 30). Only 57% remove decaying fruit from the orchard and 71% bait spray to control fruit fly. No orchards are currently using mating disruption. Only 43% are releasing beneficial insects and 14% manage the inter-row for beneficials. Seventy-one per cent of participants said they monitored to a protocol for pests and 57% monitored to a protocol for diseases.

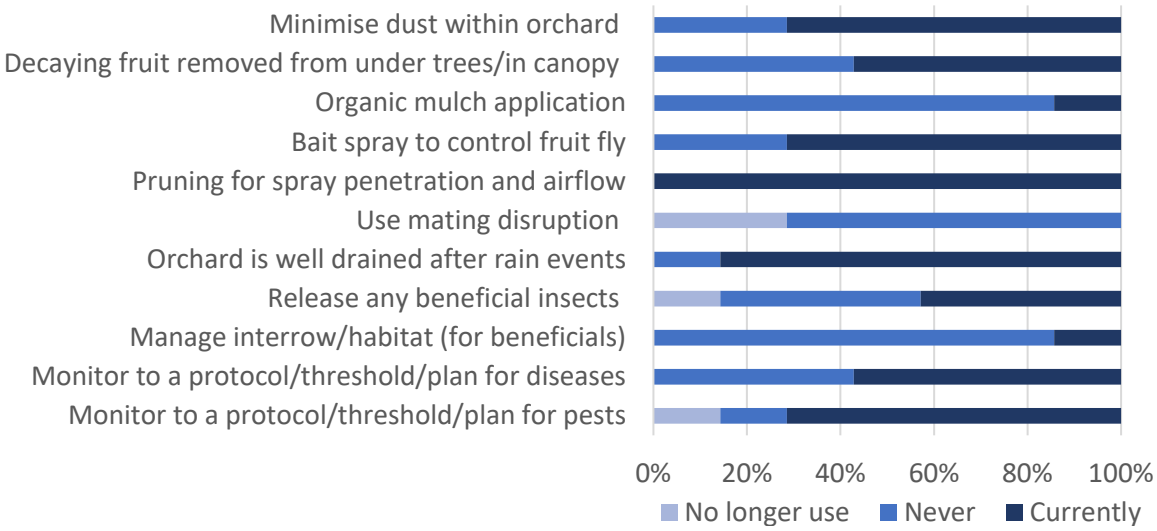


Figure 30. Percentage of WA participants currently using IPDM practices.

Spray practices

Decision-making for spraying for pests and diseases was based on both monitoring and experience for all participants (Figure 31). However, 57% spray on a calendar for pests and 71% for disease. Most orchards selectively spray for pests and rotate between chemical groups (86%). All participants indicated they use insecticides with a low effect on beneficials, however, 57% use broad-spectrum insecticides.

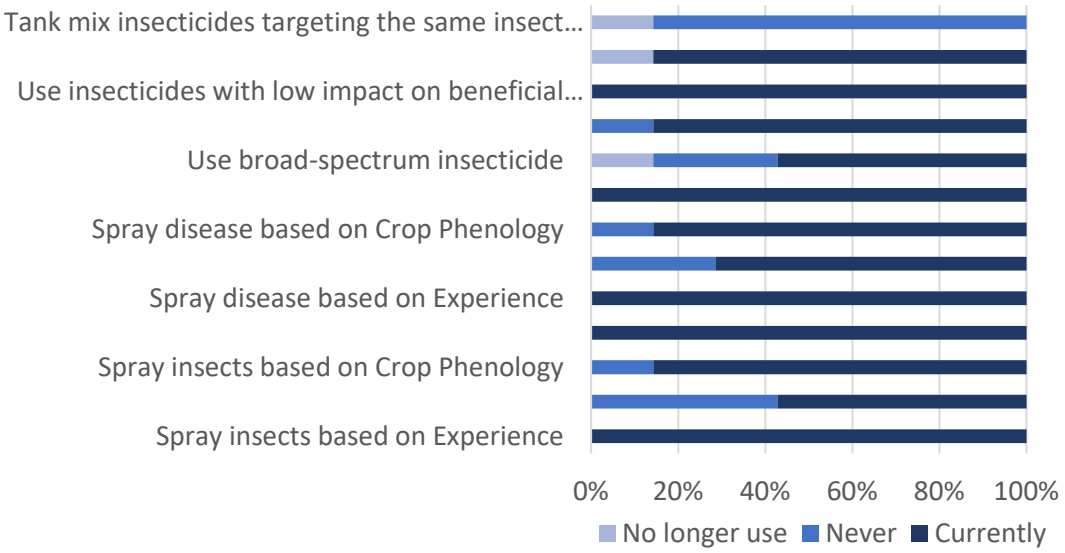


Figure 31. Percentage of WA participants currently using IPDM practices related to spraying.

Recent chemistry use

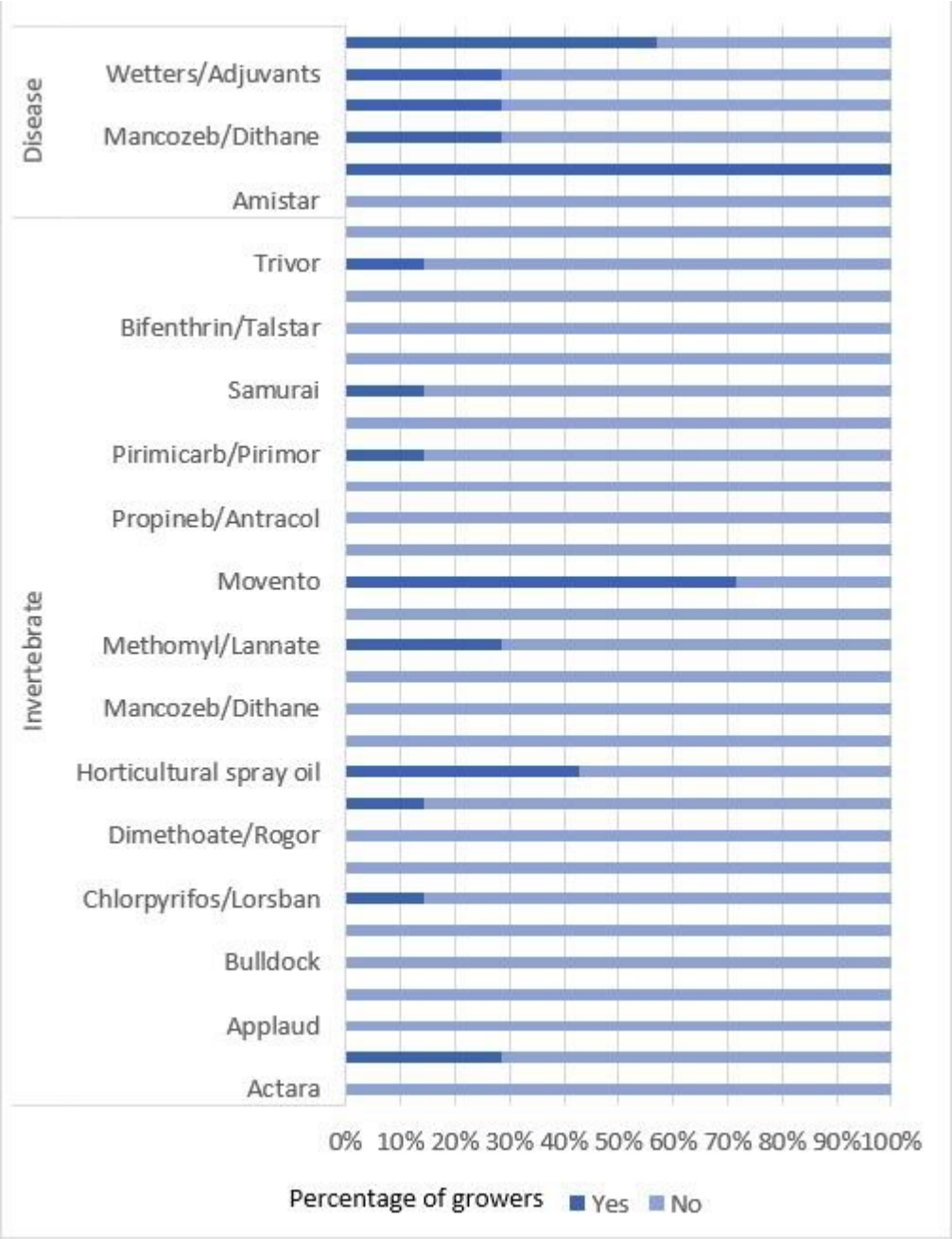


Figure 32. Chemicals used in the 2021–22 season for the 7 IPDM practice survey participants from Western Australia. Each participant reported chemical use for a representative block on their orchard, based upon their focus citrus variety.

Appendix 1

Tri-state survey tool

Interviewer Instruction - Citrus insect pest and disease management survey

Pest and disease management is one of the most critical practices for citrus growers to achieve short- and long-term goals for their business. Protecting the crop each year is made more difficult by the ever-increasing demands by consumers and communities for high-quality citrus that is produced with reduced impact on the environment, as well as a greater emphasis on food safety. This Hort Innovation project (CT19011) is a 4-year project aimed at understanding how the citrus industry is currently managing pests and diseases. Outcomes will include a roadmap for practice change to best meet your business needs while also meeting the broader requirements of domestic and global supply chains and societies' expectations of modern agriculture. Your participation in this survey will help inform us of the types of practice currently needed to manage pests and diseases and the changes that are important to you. It will also make sure the information provided in our workshops, fact sheets and video tutorials meet your needs and help you to implement the right pest and disease management practices for your business.

Feel free to adapt the above paragraph to whatever narrative feels most comfortable to you. It is offered as a guide to the high level objectives of CT19011 and the reasons why we are conducting the survey

Population sample

Survey a range and diversity of citrus growers. Crop – most participants should have the common regional crop/variety. Select some participants that produce the 2nd or 3rd most planted variety in the region and focus the survey upon this crop/variety. Try to ensure the population sampled proportionately reflects the markets of the regions produce (export, domestic, contracted juice) type growers.

IPDM for the citrus industry

This project has been funded by Hort Innovation using the citrus research and development funds from the Australian Government.
For more information on the fund and the strategic levy investment, visit horticulture.com.au

Interview consent form

Citrus Industry IPDM extension program CT19011
Survey of IPDM practices

Consent for interview to be used as data in reports and publications:

By providing my signature below, I hereby give my consent that the responses given could be included in presentations, reports and publications produced from this survey.

I give my consent on the strict understanding that I will not be named/identified.

I have been given the opportunity to ask questions about the survey and received satisfactory answers.

I understand that I am free to withdraw my participation in the survey or choose not to answer a question at any time.

Signed by: ……

Name: ……

Date: ……

Citrus Industry IPDM extension program CT19011 - Contact details:

Project leader:

Andrew Creek, Development Officer

NSW Department of Primary Industries

M: 0428 934 952 E: andrew.creek@dpi.nsw.gov.au

Local State Department IPDM extension project officer:

Ebony Faichney

Development Horticulturist (Plant Protection)

Department of Agriculture and Fisheries

M: 0491 212 948 E: ebony.faichney@daf.qld.gov.au

Survey Instrument

Citrus insect pest and disease management survey

Background information/participant details (Q1 – Q7)

Q1 Participant name (the interviewee): _

Q2 Participant occupation (tick)

- ☐ grower
- ☐ orchard owner
- ☐ orchard manager
- ☐ pest scout
- ☐ agri-consultant
- ☐ other……

Q3 Employment type (tick)

- ☐ full-time
- ☐ part-time
- ☐ casual
- ☐ other……

Q4 How long have you worked in the citrus industry (years or months):

_____

Q5 Orchard location/s (nearest town): _

Q6 What is the total area of your orchard/s(hectares or acres is fine please record which)?

NOTES:

Q7. What is the varietal mix in your orchard?

Citrus Australia has industry data on varietal mix by region. This question digs a little deeper into understanding which markets a grower is focussed on. This question is designed to understand whether a grower is export focussed or not as this has implications to the complexity of pest and diseases management, i.e. KCT export growers have quarantine pests of concern to manage and perhaps a lower tolerance to fruit damage. Willingness to change or compromise on management options may therefore be reduced.

Citrus type	Percentage of your total growing area	Which market is your pest and disease management focus on Export, Domestic or Juice (circle)
Navel Orange		Export Domestic Juice
Valencia Orange		Export Domestic Juice
Common orange		Export Domestic Juice
Blood orange		Export Domestic Juice
Mandarin		Export Domestic Juice
Lemon		Export Domestic Juice
Lime		Export Domestic Juice
Grapefruit		Export Domestic Juice
Pummelo		Export Domestic Juice
List others:		
		Export Domestic Juice
		Export Domestic Juice
		Export Domestic Juice

Assessment of pests and diseases and level of control (Q8 – Q11)

In this section we would like to understand the pests and diseases that effect your business and how you manage them in your orchard.

Either allow the grower to choose a citrus group OR you select based on the info collected in Q7 with consideration of the current surveyed population in your region proportionately reflecting the diversity of varieties grown and markets supplied. Use the selected citrus group for this question when considering all further questions.

Citrus variety: ……

Q8 Over the past 5 years, what have been 3 main diseases of concern?

1._____	poor control	adequate	good control	don't know
2._____	poor control	adequate	good control	don't know
3._____	poor control	adequate	good control	don't know

Rate your current level of control for each of these diseases on the scale of 1 to 4 with:

1 - poor control (unacceptable amount of fruit rejects)

2 – adequate control (okay levels of fruit rejects but could be better)

3 – good control (acceptable amount of rejects)

4 – don't know

Q9 Over the past 5 years, what have been 3 main pests of concern?

1._____	poor control	adequate	good control	don't know
2._____	poor control	adequate	good control	don't know
3._____	poor control	adequate	good control	don't know

Rate your current level of control for each of these pests on the scale of 1 to 4 with:

1 - poor control (unacceptable amount of fruit rejects)

2 – adequate control (okay levels of fruit rejects but could be better)

3 – good control (acceptable amount of rejects)

4 – don't know

NOTES:

Q10 Which of the following do you use as part of pest and disease decision making (tick all that apply):

- ☐ advice from a pest scout or pest and disease expert
- ☐ government officer (NSW DPI/LLS, DPIRD, QDAF etc)
- ☐ advice from my agronomist/rural supply store
- ☐ my own personal experience
- ☐ advice from family members
- ☐ advice from my neighbour or friends (informal networks)
- ☐ Advice from other growers (formal networks)
- ☐ other……..

Q11 Where else do you seek information to help make pest and disease management decisions:

- ☐ magazine articles
- ☐ workshops
- ☐ field days
- ☐ fact sheets
- ☐ websites
- ☐ newsletters
- ☐ webinars
- ☐ other:

NOTES:

In this section (Q12 – Q14) we would like to understand in greater detail your pest and disease practice by focussing on a specific citrus variety

Citrus variety: ……

Q12 Which of the following practices do you currently use, have used or have never used as part of your pest and disease management?

The practices in the table below are designed to cover biological and cultural components of IPDM. Chemical control will be covered in Q13.

We have condensed the number of questions within this table here to consider high-level cultural and biological practices. Within each of these high-level practices there could be several sub-practices eg. different types of slashing fits within "Manage interrow planting/habitat (for beneficials)". But to capture each sub-practice is too exhaustive. With this survey we aim to start high-level and then dig down into the detail at a later time, in a later survey.

Practice	Currently	No longer use	Never
Monitor to a protocol/threshold/plan for pests			
Monitor to a protocol/threshold/plan for diseases			
Manage inter-row plantings/habitat (for beneficials)			
Release any beneficial insects			
Orchard is well drained after rain			
Use mating disruption			
Pruning for spray penetration and airflow			
Bait spray to control fruit fly			
Organic mulch is applied under the tree			
Decaying fruit is removed from under trees/within canopy			
Minimise dust within orchard			

NOTES:

Q13 When you use chemical controls for pest management, do you currently use, have used or have never used, the following practices

For the 'Decision Making' section in the table below it is fine for decisions regarding when to spray for insect or disease pests to be based on multiple approaches eg. Experience and Calendar. If it works you can try and record the specific pest/s against the decision eg. CGW spraying is based on monitoring but it is not necessary. It is a topic that we can survey more in-depth at a later point. Understanding in the first instance that they take different approaches is valuable enough.

Decision Making	Currently	No longer use	Never
Spray insect pests based on……			
Experience			
Calendar			
Crop phenological stage			
Monitoring			
Spray disease pests based on……			
Experience			
Calendar			
Crop phenological stage			
Monitoring			
Other practices			
Use broad-spectrum insecticide			
*Do you selectively spray sections of the orchard when targeting a specific pest			
Use insecticides that have low impact on beneficial species			
#Rotate between chemical groups			
Tank mix insecticides targeting the same insect pest (i.e. double up for a specific pest)			

*This question looks to understand whether people have incorporated a 'hot spot' approach to their spraying. They may not do it for all pests but if they do it for at least one pest then record as currently doing it.

#Rotate between chemical group means using different chemical groups, not brands. Make sure you clarify with participants if they say they are currently rotating chemicals as to what they are rotating.

NOTES:

Q14 Indicate a citrus category grown on the orchard. What chemicals were used to manage pests and diseases this season for a representative block on the orchard?

- ☐ Orange
- ☐ Mandarin
- ☐ Lemon
- ☐ Lime
- ☐ Grapefruit
- ☐ Pummelo

Circle the chemistry used to manage pests and diseases for season 2021/22. Indicate the number of sprays applied in a typical growing season.

In the example below, a copper fungicide was applied 2 times and Amistar® once. Unmarked chemistry / products are considered not applied. Dithane, phosphorus acid and WETCIT® were not applied to the example block.

e.g.

Amistar®	Copper x2	Mancozeb/Dithane®
Phosphorus acid	Wetters/Adjuvants x4	WETCIT®

FUNGICIDES / Adjuvants

Amistar®	Copper	Mancozeb/Dithane®
Phosphorus acid	Wetters/Adjuvants	WETCIT®

INSECTICIDES / miticides

Actara®	Exirel®	Mancozeb/Dithane®
Abamectin/Vertimec	Horticultural spray oil	Propineb / Antracol®
Applaud®	Imidacloprid / Confidor®	Paramite®
BT / Dipel®, Delfin®	Horticultural spray oil	Pirimicarb / Pirimor®
-	Maldison / Hy-mal®	Proclaim®
Carbaryl / Bugmaster®	Methoxyfenozide / Prodigy®	Samurai ®
Chlorpyrifos/Lorsban®	Methomyl / Lannate®	Spinetoram / Success Neo ®
Imidacloprid / Confidor®	Methoxyfenozide / Prodigy®	Bifenthrin / Talstar®
Dimethoate / Rogor®	Mimic®	Sulfoxaflor / Transform®
Exirel®	Movento®	Trivor®
Horticultural spray oil	Natural Pyrethrin / Pyganic®	Torque®/Vendex®

Other, please indicate _____

NOTES:

Knowledge of pests and diseases

Q15 Tick the most appropriate box for the participant's knowledge of each pest/disease

NB. The tables are regional specific. Retain only the table relevant to the region you are focussing on i.e. delete all other tables

Riverina, Sunraysia and Riverland

Knowledge	Citrus gall wasp	Red scale	Fuller's rose weevil	Kelly's citrus thrips	Citrus mealy bug	Queensland fruit fly	Septoria	Anthracnose	Citrus black core rot
None									
Some									
Sound (sufficient to act)									
Not applicable									

You the interviewer on the back of the following prompts make a subjective assessment on whether the interviewee has the following knowledge:

Some (101): They're aware of what a pest looks like or they have heard of a particular pest or disease and they know when it occurs (i.e. approx. time of the season when they are likely to be around)

Sound (active management practices): In addition to the above they can identify its damage to the tree or fruit, articulate a trigger point for action (either climactic conditions to look out for, damage or population thresholds etc.) and can judge if their practices are having an effect/working

NOTES:

Q 16 Do you have any other comments about any of the topics covered in the survey?

_____

_____

_____

_____

_____

We appreciate the time you have spent answering the questions.

The findings of this citrus IPDM survey will be in a report to Horticulture Innovation. A summary article will be published in the subscription e-newsletter, "Citrus Connect". The full report will be made available on the NSW DPI website.

Please indicate below if you prefer to have a copy emailed directly to you.

Email:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

The Citrus Industry IPDM extension program is forming regional IPDM grower groups.

The groups:

- meet 3 times each season for field walk type events focused upon regionally specific integrated pest and disease management.
- Group members contribute to the design of a local IPDM demonstration site.
- Regionally specific face book groups will be established and managed by departmental officers to discuss and answer pest and disease related issues group members may post.

Please indicate if you would like to be part of our local IPDM grower group.

☐ Yes
☐ No

CT19001 - A minimum of ten pest ID and monitoring workshops or seasonal farm walks per region

Region		Date	Description
Central Burnett			
	1	1/03/2022	Visit to 11 growers to introduce project and conduct surveys
	2	26/10/2022	Citrus Regional Forum, Gayndah - Tamil presenting experimental ideas and concepts
	3	24/10/2023	Citrus Regional Forum, Mundubbera - Field walk to look at disease demo site
	4	5/03/2024	Visit to disease demo site as part of the Australian Citrus Congress, Bundaberg
	5	25/10/2024	Mandarin and pest farm walk, Mundubbera - run by Steven Falivene,
	6	18/03/2025	Study tour, Riverina, central Burnett growers were given the opportunity to see demo sites in the southern regions including a major pest, gall wasp.
FNQ			
	1	24/03/2022	Field walk, Mareeba, extending some previous demo work looking at cultural practices and their affect on citrus mites
	2	28/03/2023	Citrus regional forum - presentation of trial plans
	3	5/04/2023	Field walk, Mareeba, presenting results of mite release demo
	4	21/06/2023	Citrus agronomist group - Inaugral meeting
	5	27/09/2023	Citrus agronomist group - secondary meeting
	6	27/03/2024	Citrus agronomist group - post wet season meeting
	7	18/07/2024	Nutrien Horticulture day - presentation of Cryptolaemus work and promotion of printed factsheets
	8	2/10/2024	Citrus regional forum - presenting spray volume work
	9	17/10/2024	Spray workshop for agronomists
	10	14/03/2025	Field walk - second mite demo
WA			
	1	Mar-22	Field walks cancelled due to COVID restrictions in WA at the time
	2	20/09/2022	Bindoon - Pest identification and orchard monitoring workshop
	3	4/10/2022	Harvey - Pest identification and orchard monitoring workshop
	4	28/03/2023	Burekup - Disease management field walk– Guest speaker Nerida Donovan (NSW DPI)
	5	29/03/2023	Gingin - Disease management field walk – Guest speaker Nerida Donovan (NSW DPI)
	6	4/10/2023	Bindoon - CGW monitoring and management workshop
	7	5/10/2023	Harvey - CGW monitoring and management workshop
	8	8/05/2024	Dandaragan - Spray application and drone demonstration field walk
	9	19/11/2024	Bindoon - Stall with IPDM factsheets, posters etc. at Citrus Australia regional forum
	10	25/02/2025	Pest management workshop/field walk - CGW management (Meena Thurker NSW DPIRD), IPDM demonstration site - presentation of monitoring results, lessons learned (Rachelle & demo site growers)
Riverina			
	1	15/03/2022	Seasonal field walk, Griffith - citrus gall wasp and california red scale, IPDM expertise - Rob Weppler, Judith Peddler and Zeshan Ali (Riverina IPM)
	2	15/03/2022	Seasonal field walk, Leeton - citrus gall wasp and california red scale, IPDM expertise - Rob Weppler and Zeshan Ali (Riverina IPM)
	3	13/09/2022	Workshop style event, Griffith - Queensland fruit fly, IPDM expertise Andrew Jessup (Janren consulting), Rob Weppler (Riverina IPM)
	4	19/10/2022	Leeton, indoor presentations and also field walk, growers experienced with citrus gall wasp management speaking to Riverina growers. IPDM expertise Dr Jianhua Mo (NSW DPI) and Mal Wallace (CitriCare)
	5	19/10/2022	Griffith, indoor presentation and also field walk, growers experienced with citrus gall wasp management speaking to Riverina growers. IPDM expertise Dr Jianhua Mo (NSW DPI) and Mal Wallace (CitriCare)
	6	20/11/2022	Riverina CAL regional forum, IPDM focused citrus gall wasp presentation.Dr Jianhua Mo and Andrew Creek (NSW DPI)
	7	23/03/2023	Leeton, seasonal farm walk at the citrus gall wasp IPDM demonstration site, IPDM expertise Scott Munro (NSW DPI) and Rob Weppler (Riverina IPM)
	8	20/04/2023	Widgelli, IPDM demonstration site, seasonal pest managemnet at IPDM demonstration site, IPDM expertise Dr Jianhua Mo (NSW DPI), Zeshan Ali and Rob Weppler (Riverina IPM)
	9	4/10/2023	Information broker group meeting - Rural supply store horticulturists. Seasonal pests - mealybugs and citrus gall wasp discussed. IPDM extension program publications.
	10	13/10/2023	Yanco, NSW DPI seasonal fram walk focused upon citrus gall wasp. IPDM expertise Scott Munro and Andrew Creek (NSW DPI)
	11	25/03/2024	Yoogali, IPDM demonstration site, seasonal pest managemnet at IPDM demonstration site - Katydid and LBAM. IPDM expertise Zeshan Ali and Rob Weppler (Riverina IPM)
	12	22/10/2024	Riverina CAL regional forum, local demonstration site progress, IPDM extension program publications. Natural enemies in citrus - IPDM expertise Dr Meena Thakur and Andrew Creek (NSW DPI)
	13	20/03/2025	CAL Australian Citrus Congress, IPDM demonstration site outcomes, IPDM extension program publications. Natural enemies in citrus orchards - IPDM expertise Emily Pattinson (QDAFF), Dr Meena Thakur, Scott Munro and Andrew Creek (NSW DPIRD)
Sunraysia			
	1	22/03/2022	Ellerslie seasonal farm walk - citrus gall wasp, California red Scale. IPDM expertise Lachlan Mannes (Maness Entomology) and James Altmann (Biological Services)
	2	22/03/2022	Iraak seasonal farm walk - citrus gall wasp, California red Scale. IPDM expertise Lachlan Mannes (Maness Entomology) and James Altmann (Biological Services)
	3	16/08/2022	Dareton, Queensland fruit fly presentations and orchard demonstration. IPDM expertise Andrew Jessup (Janren Consulting) and Dan Papacek (Bugs for Bugs)
	4	18/04/2023	Dareton IPDM demonstration site, seasonal farm walk - California red scale and seasonal pests. IPDM expertise Megan Bennett (Maness Entomology)
	5	19/04/2023	Iraak, seasonal farm walk - California red scale and seasonal pests. IPDM expertise Lachlan Mannes (Maness Entomology)
	6	13/09/2023	Dareton, A collaborative NSW DPI & Sunraysia Citrus Growers inc. event - 'Dareton citrus field day'. CAL, Hort Innovation and MFC guest speakers. NSW DPI research project updates. "Citrus IPDM extension program" - Andrew Creek
	7	17/09/2024	Sunraysia CAL regional forum, Steven Falivene (NSW DPIRD) update forum participants on IPDM extension program demonstration sites, activity and the publications.
	8	15/10/2024	Dareton, 'NSW DPIRD farmwalk and BBQ lunch'. Part of the program delivered was a IPDM extension program session. Andrew Creek focused presentation upon natural enemies and two demonstration sites.
	9	28/02/2025	Dareton, seasonal farm walk - IPDM demonstration site, California red scale. IPDM expertise Lachlan Mannes (Maness Entomology) and James Altmann (Biological Services)
	10	26/02/2025	Dareton, Citrus spray application workshop. Don Thorpe (Horticulture Spraying Specialists) and facilitated by Stvene Falivene (NSW DPIRD)
	11	2/04/2025	Dareton, 1/2 day workshop - Pest 6 major and their natural enemies. IPDM expertise Andrew Jessup (Janren Consulting), Dr Meena Thakur, Steven Falivene and Andrew Creek (NSW DPIRD)

Region		Date	Description
Riverland			
	1	23/03/2022	Waikerie seasonal farm walk, IPDM expertise Craig Swanbury (Fruit Doctors) and James Altmann (Biological Services)
	2	23/03/2022	Loxton seasonal farm walk, IPDM expertise Craig Swanbury (Fruit Doctors) and James Altmann (Biological Services)
	3	17/08/2022	Waikerie, Queensland fruit fly presentations and orchard demonstration. IPDM expertise Andrew Jessup (Janren Consulting), Dan Papacek (Bugs for Bugs) and James Altmann (Biological Services)
	4	17/08/2022	Loxton, Queensland fruit fly presentations and orchard demonstration. IPDM expertise Andrew Jessup (Janren Consulting), Dan Papacek (Bugs for Bugs) and James Altmann (Biological Services)
	5	27/04/2023	Waikerie, Queensland fruit fly - a QLD and a NSW grower discuss Qfly management and Q&A session via zoom. Seasonal farm walk - seasonal pests. IPDM expertise Craig Swanbury (Fruit Doctors) and James Altmann (Biological Services)
	6	27/04/2023	Loxton, Queensland fruit fly - a QLD and a NSW grower discuss Qfly management and Q&A session via zoom. Seasonal farm walk - seasonal pests. IPDM expertise Craig Swanbury (Fruit Doctors) and James Altmann (Biological Services)
	7	19/09/2024	Renmark, CAL Riverland regional forum, IPDM extension program publications, Seasonal pests and two spotted mite management. IPDM expertise Steven Falivene (NSW DPIRD)
	8	27/02/2025	Loxton, seasonal farm walk, IPDM expertise Craig Swanbury (Fruit Doctors) and James Altmann (Biological Services). IPDM extension program publications Steven Falivene (NSW DPIRD)
	9	28/03/2025	Waikerie, Citrus spray application workshop. Don Thorpe (Horticulture Spraying Specialists) and facilitated by Stvene Falivene (NSW DPIRD)
	10	3/04/2025	Loxton, 1/2 day workshop - Pest 6 major and their natural enemies. IPDM expertise Andrew Jessup (Janren Consulting), Dr Meena Thakur, Steven Falivene and Andrew Creek (NSW DPIRD)

IPDM for the citrus industry

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Citrus Industry IPDM Extension Program (CT19011)

Regional participatory demonstration sites report

To assist IPDM knowledge transfer and the adoption of sustainable pest and disease management practices, the citrus industry IPDM extension managed regional participatory demonstration sites in Australia covering the Riverina, Sunraysia, Central Burnett, FNQ and WA production regions. Demonstration sites varied in focus and style between the regions to meet the differing regional needs of citrus growers. Typically, the demonstration sites compared something that had already been proven by replication or was testing something new and was exploratory. The intention was to demonstrate best practice pest and disease management. Designs were mostly half blocks, or sections of a block, rather than whole row or single tree treatments.

Contents

Riverina regional on-farm demonstration sites

Citrus gall wasp management

Region: Riverina, NSW

Collaborating grower:

(2021-2023) - Ray Durkin, Farm 312, Stringer Rd, Corbie Hill, NSW

(2023-2024) - Jessie Singh, Farm 312, Stringer Rd, Corbie Hill, NSW

Background

The chosen block for the demonstration site was 14 rows (1.4 ha) of large, mature Keenan Valencia orange on Tri22 rootstock planted at 22 ft x 22 ft (6.7 m x 6.7 m). The block is contracted for juice production with 45 year old trees in 2022 at the commencement of the demonstration. The block had a severe infestation of citrus gall wasp. The trees were heavily galled and were very low yielding.

The whole orchard, except this Valencia orange block, had been treated annually with systemic insecticides to manage citrus gall wasp. Past chemical pest control records of the orchard were 2017 Movento®, 2018 Confidor®, 2019 Samurai®, 2020 Confidor® and 2021 Samurai®. The chemistry managed orchard pests adequately and there were very low levels of galling throughout most of the orchard.

Aim

1. Manage citrus gall wasp in the 4 western rows of the block (Figure 1), without the use of neonicotinoid (group 4A) insecticide products, for example, Samurai® Systemic Insecticide or Confidor® Guard Soil Insecticide, imidacloprid active type products.
2. Establish a repository of the citrus gall wasp natural enemy, the parasitic wasp *Megastigmus brevivalvus*.

Figure 1. Location of the demonstration site on Farm 312. The 14 rows of the demonstration site are bounded by the red square, whilst the blue shaded area marks the trees that are not being treated with neonicotinoids. *Megastigmus brevivalvus* were established in the orange shaded row.

Method

Treatments were:

1. Surround® applied 5 Kg / 100L + DuWett® at 2000 L water per ha and then a second application 10 to 14 days later at a rate of Surround® 2.5 Kg / 100L + DuWett® at 2000 L water per ha.
2. Either Samurai® Systemic Insecticide or Confidor® Guard Soil Insecticide alternated by year.
3. Parasitic wasp release Megastigmus brevivalvus.

The initial intent was to heavily hedge the rows assigned to Surround® treatment in August/September 2022. In the heavily infested situation of these Valencia orange trees, such cultural control as heavily hedge prior to adult wasp emergence would reduce the citrus gall wasp pressure for the coming season. An unseasonally wet spring prevented heavy hedge of the rows in 2022. The Surround® treated rows were not heavily hedged until early spring 2023. Normal light hedge, to manage tree canopy for harvest and maintain tractor access was applied as required across the whole site. Tree skirting was undertaken after the completion of citrus gall wasp emergence.

Taps were installed into the drip tube irrigating the 4 rows assigned for Surround® and the row assigned with the parasite release treatment (Figure 1). These taps were turned off to exclude the neonicotinoid (group 4A) insecticide products used on the orchard.

The Surround® treated, and the conventional annual neonicotinoid (group 4A) insecticide product treated rows were each monitored for both pest and beneficial insects by Riverina IPM for the 2022-23, 2023-24 and 2024-25 seasons. The need to apply any additional pest management was based upon the monitoring data. The demonstration site was monitored and actively managed until April 2025.

Results

A Fruition® citrus gall wasp trap was hung at the start of citrus gall wasp adult wasp emergence for a two-month period each season. The Fruition® citrus gall wasp trap showed high pressure in 2022. By the end of the demonstration site duration, the citrus gall wasp pressure was low and similar for both the Surround® and the systemic neonicotinoid insecticide treatment (Figure 2). The gall size has reduced in the parasitoid release trees and they have a crop of oranges for 2024-25 season.

Figure 2. (Left) Fruition® citrus gall wasp trap indicated high pressure and large gall size in 2022. (Right) Fruition® traps collected in December 2024 indicated low citrus gall wasp pressure.

Season 2022-23

Citrus gall wasp emergence commenced in the Valencia block after the first week of November in 2022. The spring was looking wet, so in consultation with the grower, we planned to apply Surround® three times over the adult wasp emergence period at rate of Surround® 2.5 Kg / 100L + DuWett® at 2000 L water per ha. Surround® was applied on 11/11/2022 and another, 14 days later 25/11/2022 (Figure 3). A 40 mm rain event occurred within a few days after the first Surround® application. The coverage of Surround® appeared to remain, however, due to further rain events and an extended emergence period, a third Surround® application was applied on 15/12/2022.

Figure 3. (Left) a comparison of Surround® sprayed and unsprayed spring flush shoots. (Centre) a close view of Surround® coverage in the spring flush. (Right) Surround® application with the orchard sprayer.

On 19/12/2022 *Megastigmus brevivalvus* were released in the single eastern row. An orange net bag of 5 or 6, cigar sized galls was hung in every second tree. Brown wasps were walking on and emerging from the galls purchased form Biological Services (Figure 4).

Figure 4. (Left) orange net bags were used to hang parasitised galls in every second tree (Centre and Right) *Megastigmus brevivalvus* female wasps are a small honey-coloured wasp that lays their egg inside the citrus gall wasp egg.

By January 2023 monitoring data indicated higher mealybug and red scale pressure in the 4 rows treated with Surround® compared to the Samurai® treated rows. After consultation with the collaborating grower, we decided the pest pressure was not high enough for chemical intervention, we chose to release green lacewing larvae (Figure 5), and Cryptolaemus ladybird beetles (Figure 6), for assistance with scale and mealybug control. Releases were on the 30/01/2023 and 24/02/2023. The combined release was n=12,000 lacewing eggs and n=800 Cryptolaemus ladybird beetle larvae and n=200 Cryptolaemus ladybird beetle adults over the 90 surround treated trees.

Figure 5. Sixty beneficial release boxes (left) were hung in branches of the Surround® treated rows to release the lacewing larvae (right), that developed in the carrier medium (rice hulls) and a small quantity of sterilised moth eggs for the larvae to feed on.

Figure 6. Both Cryptolaemus ladybird beetle adults (left) and larvae (centre) were released. Beetle bags were used to assist larvae establishment to mealybug hot spots (right).

During summer, early signs of galls could be seen in the Surround® treated rows, between the trees, where spray coverage was difficult. The collaborating grower made plans with a hedge contractor. The double-sided hedge machine hedges the north and south side of the trees, by driving in and reversing out. This removed the spring growth that had reduced Surround® coverage and reduced gall wasp pressure in the 2023 spring emergence. The hedge contractor cancelled the job. It is often difficult to get hedging contractors when required on time.

Crop monitoring data from April to May indicated the mealybug releases undertaken were not successful in reducing pest pressure in the Surround® treated rows. Data from 5/04/2022 showed that the Surround® treated rows had 11% mealybug compared to 1% mealybug in the Samurai® Systemic Insecticide treated rows. California red scale pressure was comparative, with surprisingly high Aphytis parasitism in the Surround® treated rows. Prior research has shown a direct increase of California red scale pressure when Surround® was applied. It must be noted this demonstration site is not replicated and orchard situations vary.

At this demonstration site, autumn monitoring data displayed low 2-spotted mite pressure in the Samurai® Systemic Insecticide treated rows and zero pressure in the Surround® treated. Aphytis parasitism, predatory Haplothrips and predatory mites were natural enemies seen in Autumn, whilst monitoring the Surround® treated rows. The Samurai® Systemic Insecticide treated rows had a comparative level of predatory mites.

Trees heavily infested with citrus gall wasp can recover in the first year of chemical treatment. In 2022-23 season, the systemic insecticide treated trees cropped. The Surround® treated trees had some fruit, whilst the row with *Megastigmus brevivalvus* did not crop (Figure 7).

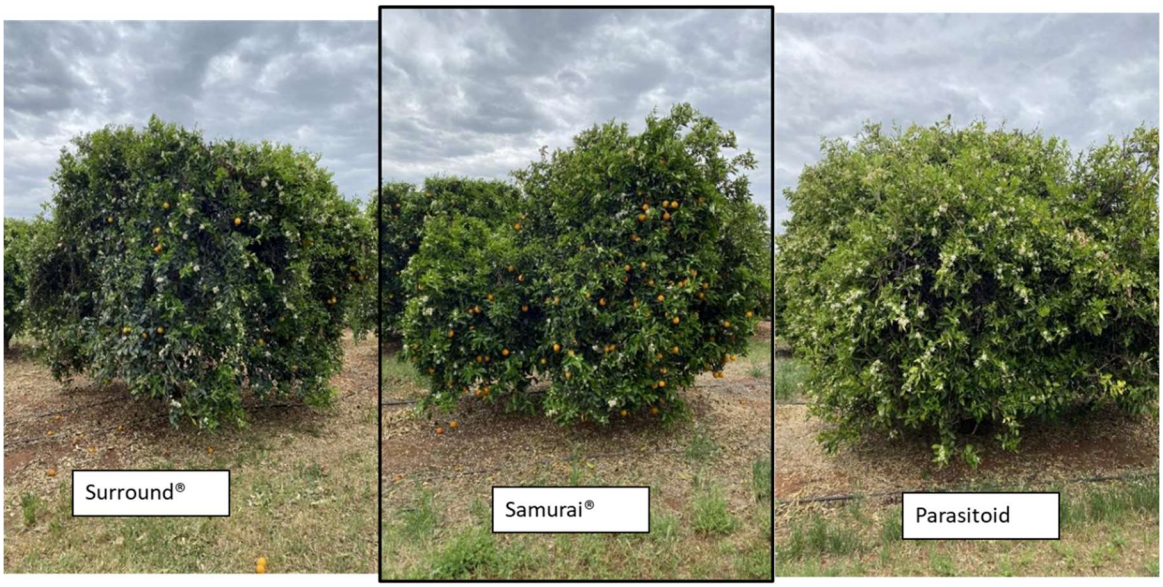


Figure 7. Images of the demonstration site trees (October 2023), showing the comparative flowering and Valencia orange cropping between treatments.

Branch samples clearly showed that the Samurai® Systemic Insecticide had high efficacy against citrus gall wasp, as the prior season spring flush was not galled (Figure 8). The 2022 spring flush of the parasitoid release rows was heavily galled, as the biological control in this demonstration has one generation per year. It will take multiple seasons for the parasitic wasp population to build and the gall size to reduce. Spring 2022 was the first augmented release of the *Megastigmus brevivalvus* at high levels.

Figure 8. (Left) A Samurai® treated branch sample with no current season galls. Prior season galls are encircled. (Right) A branch sample from the parasitoid release row with large prior season galls (encircled), and current season galls up to 20 cm long.

Season 2023-24

The tops of all trees in the Valencia block were mechanically hedged 4/09/2023, prior to citrus gall wasp emergence. The parasitoid release rows were only topped. The Surround® treated rows were additionally hedged between the trees (Figure 9), with the hedge machine driving over the drip tube, to remove the galled growth, where spray coverage was difficult to originally obtain. The prunings were raked into the inter-row and mulched to assist drying.

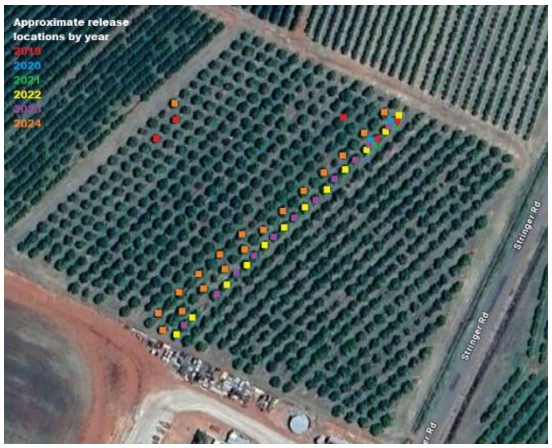
(Right) Figure 9. At least 1-1.5 m of canopy was mechanically hedged from the north and southern side of the Surround® treated trees to reduce citrus gall wasp pressure.

The first application of Surround® was applied on 20/10/2023 and a second application was applied on 03/11/2023. In the 2023 spring, two applications were considered enough to deter the citrus gall wasps from egg laying as there was not excessive rainfall (Figure 10).

Figure 10. (Left) Orchard airblast sprayer applying the Surround®. (Right) Surround® covered trees.

The first augmentative release of *Megastigmus brevivalvus* for 2023-24 season of the IPDM demonstration site was completed on 10/11/2023, in the single 'parasite release' row in the east (Figure 1 and Figure 10). One styrofoam box of galls was distributed in 15 orange net bags, hanging the bags in every second tree. This was applied in the trees that never had bags with parasitised galls hung in 2022. The parasitised galls were sourced from South Australia and cost $250.00 per box + $63.00 postage and handling.

CT19009 had released some parasitised galls on seven random trees in the Valencia block over the period 2019-2021 (Figure 11). Project CT19009 collaborated with the IPDM extension program and technical staff collected a random sample of galls prior to wasp emergence from the 'parasite release' row in the east.



(Right) Figure 11. Release locations of *Megastigmus brevivalvus* by year at the IPDM demonstration site.

Data indicated the successful establishment of *Megastigmus brevivalvus* from the release on 19/12/2022, with an increase of parasitism from <1% in prior seasons to 19% parasitism in the current 2023 season (Table 1).

Table 1. Percentages of wasp parasitism for the gall sampled years, just prior to citrus gall wasp (CGW) emergence (stored at room temperature).

Year	CGW No.	Parasitic Wasp No.	TOTAL Wasp No.	% Parasitism	Notes
2020	2000	12	2012	0.6	Galls collected from both PW release areas.
2021	13625	94	13719	0.7	Galls collected from both PW release areas.
2022					Data not collected.
2023	12077	2884	14961	19.3	Galls collected from eastern release row only.
2024	3430	736	4166	17.7	Galls collected from eastern release row only.

Due to the establishment success of *Megastigmus brevivalvus* from the 2022 parasitoid release in this IPDM demonstration, a second repository was commenced at the Yanco Agricultural Institute (YAI). GPS coordinates 34°37'01.7"S 146°25'13.8"E

Orange net bags full of parasitised galls were hung in trees on the 16/11/2023. The parasitised galls were sourced from Biological Services in South Australia. Further releases at the Yanco site were also implemented the following year on 07/11/2024 (Figure 12).

Insecticide products that kill the citrus gall wasp have not been used in the Valencia orange block with the *Megastigmus brevivalvus* repository.

(Right) Figure 12. YAI parasitic wasp release rows

Mid-summer monitoring data indicated high levels of California red scale (RS) in both the Surround® (28% RS) and Nuprid 350® SC soil insecticide (24% RS) treated rows. The Surround® rows, for the second season displayed increasing mealybug levels. Chemical intervention was not undertaken on any treatment as the target market was contracted juice fruit. The pest levels were not high enough to impact tree health. Autumn monitoring data indicated 26% mealybug in the Surround® treated rows. The numbers of live red scale had dropped in both treatments and most of the scale appeared dead or parasitised. The Surround® treated rows had higher Aphytis parasitism than the Nuprid 350® product treated rows. The pest consultant commented, "I think Surround® probably disrupts the biological control of both red scale and mealybugs, but it is good to be seeing Aphytis." Monitoring data from late April, showed the systemic soil insecticide treated rows had two-spotted mites present, for the second season.

On 8/04/2024 the tops of the trees and the tree skirts were mechanically pruned in the demonstration site Valencia orange block.

Season 2024-25

Early September NSW DPIRD staff meet with Mr Jessie Singh, (the new owner of Farm 312), to plan the demonstration site management for the coming season. Quite understandably, it was difficult to convince him that the sickly, non-cropping trees of the eastern parasite release are in a slow process of recovery. After a couple orchard visits, the plan was to continue the citrus gall wasp demonstration site by expanding the parasite release by another two rows, apply the Surround® treatment to the 4 rows and apply Samurai® systemic insecticide to the remainder of the Valencia block after harvest.

On 07/11/2024 the first release *Megastigmus brevivalvus* was undertaken at the demonstration site, in the rows next to the 2022 and 2023 eastern release row (Figure 10). James Altmann (Biological Services), who sourced the parasitised galls reported, "75% parasitism of the material sent." James owns commercial citrus blocks in South Australia and has 90% parasitism. Galls are small and hard to find. James assesses percentage parasitism with two sample gall times during emergence, since sticks dry out and parasites fail to emerge through the hardened galls. James also commented, "Parasitism has merit, it just needs patience and belief that there is a sustainable solution". No second release was undertaken at the Stringer Rd demonstration site in the 2024-25 season.

In 2024, the Surround® application to the western 4 rows was:

12/10/2024, 5 kg Surround® + DuWett (2000 L/ha)

30/10/2024, 2.5 kg Surround® + DuWett (2000 L/ha)

After attending IPDM extension events, Vince Iannelli was willing to try *Megastigmus brevivalvus* on 3 rows of Valencia oranges (0.3 ha) as a sustainable way to manage citrus gall wasp. Most of the block will be managed conventionally for citrus gall wasp and other pests. This Valencia orange block on Mckay Rd, Merungle Hill, NSW were low producing and severely infested with citrus gall wasp a few years ago. The trees were heavily hedged and insecticides are used to prevent re-infestation by citrus gall wasp. The GPS coordinates of this trial are 34°36'15.2"S 146°25'56.2"E.

Records of this 3-row trial establishment are below:

22/11/2024 release 1, *Megastigmus brevivalvus* (source galls Biological Services, Loxton)

29/11/2024 release 2, *Megastigmus brevivalvus* (source galls collected from Durkin demonstration)

6/12/2024 release 3, Megastigmus brevivalvus (source galls collected Stringer Rd)

6/12/2024 2 cups of Aphytis released into 3 rows of *M. brevivalvus* release area.

16/01/2025 2 cups of Aphytis released into 3 rows of *M. brevivalvus* release area.

Monitoring data in early December indicated red scale pressure was high (RS 24%) (Figure 13), early in the season in the 4 rows treated with Surround®. Mealybugs at 28%, were also high pressure similar to the prior autumn levels. After three years of consecutive use on this site, Surround® was showing signs of impacting upon the activity of natural enemies of both red scale and mealybugs. A spray of Movento® 40 mL/100L + Hasten® 50mL /100L was applied 21/12/2024 to the Surround® treated rows.

Figure 13. A Surround® treated leaf with California red scale.

On the 16/01/2025, two cups (20,000 wasps) of *Aphytis melinus* were released into the now, three rows of Citrus gall wasp parasite release, in the east of the Valencia orange block demonstration site. This augmentative release was applied as a preventative pest control, as we did not want to see pest issues in the expanding, untreated orchard section.

Autumn monitoring data indicated good red scale (4%) and mealybug (7%) control in rows 1-4 (Surround® 2x in spring + Movento® in summer) treated rows. The other rows treated with Samurai® Systemic Insecticide had similarly adequate pest control being red scale (18%) and mealybug (1%). Aphytis parasitism was active in the Samurai® treated rows. Predatory mites were active in both treatments. Two-spotted mites were not noted or at levels of concern in the Samurai® treated rows during the 2024-25 season.

On 26/03/2025 Samurai® Systemic Insecticide was applied to all Valencia orange rows in the demonstration block, except the 4 Surround® treated rows in the west and the original parasitic wasp row. We can assume the expansion of the parasitic wasp repository beyond the single eastern will be impacted as the Samurai® Systemic Insecticide will kill the citrus gall wasp. Killing the host (Citrus gall wasp) will also kill the parasitic wasp (*Megastigmus brevivalvus*).

At the end of the demonstration site period, the Surround® treated trees were cropping normally (Figure 14). The systemic noenicotinoid insecticide trees were also cropping normally and were the most cost-efficient

management of citrus gall wasp (Figure 15). Without heavily hedging, the biological control *Megastigmus brevivalvus* trees took years to return to production. The trees now have much greater vigour than 2022, the gall size has reduced and a Valencia orange crop is set for the 2024-25 season (Figure 16).

Figure 14. (Left) Surround® treated tree from the demonstration site on 31/03/2025. (Right) A closer image of crop load, immature, green coloured 2024-25 season Valencia oranges.

Figure 15. (Left) Samurai® Systemic Insecticide treated tree from the demonstration site on 31/03/2025. (Right) A closer image of crop load and tree health.

Figure 16. (Left) A parasite release treated tree from the demonstration site on 31/03/2025. (Right) A closer image of crop load and tree health.

Outputs and outcomes

Seasonal field walks 23/03/2023 and Central Burnett study tour 18/03/2025.

Poster - 2024 Australian Citrus Congress 'Citrus gall wasp demonstration site'

Video 'Citrus gall wasp demonstration site' published on the NSW DPIRD YouTube channel and are available from the NSW DPIRD citrus website IPDM extension accordion
https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/content/ipdm-extension-program

Grower adoption

NSW DPIRD site management are supporting the establishment of *Megastigmus brevivalvus* at the Yanco Agricultural Institute, by augmentative release and selectively using insecticide chemistry within the orchard.

Iannelli Oranges are establishing a trial of *Megastigmus brevivalvus* within one of their Valencia orange blocks.

At a seasonal field walk at Yanco on 13/10/2023 one participant indicated they will use Surround® to manage citrus gall wasp that season (Appendix 9 – Final report CT19001)

Key learnings from growers:

- Heavy hedging and the application of Surround® to deter citrus gall wasp egg lay has given comparable control to systemic soil applied insecticides.
- Surround® likely disrupts the biological control of both red scale and mealybugs.
- Sourcing parasitised galls is difficult. The *Megastigmus brevivalvus* wasps are currently not commercially available from suppliers of biological control agents.

Acknowledgements: Ray Durkin and Jessie Singh.

Katydid and Light brown apple moth (LBAM)

Region: Riverina

Collaborating grower:

Mario Marin, Farm 229, Pavese Rd, Yoogali, NSW

Background

The chosen orchard for the demonstration site is a 15 Ha development of navel oranges planted in spring 2017 (Figure 17). Blocks 11, 12 and 14 are each 4.5 Ha blocks of Lane Late navel oranges on Tri22 rootstock planted at 22 ft x 11 ft (6.7 m x 3.3 m). Crop monitoring data in October 2023 indicated high Katydid pressure and moderate Light brown apple moth (LBAM) pressure. The LBAM and Katydid would require chemical intervention. Previous seasons the grower used ½ rate Chlorpyrifos + Horticultural mineral oil to manage the spring insect pests, however changes to export requirements regarding orchard chemical product use meant Chlorpyrifos is no longer an option to manage seasonal pests like California red scale. Adequate LBAM and katydid control was an added benefit of the spring Chlorpyrifos application. At the time, Chlorpyrifos was also under review with the APVMA. The citrus strategic agrochemical review process final report in 2022 listed Chlorpyrifos as a chemical active of critical concern for the citrus industry of retaining access in the short term. This demonstration was established to compare differing insecticide treatments for LBAM control.

Aim

Find the most cost-efficient alternative to manage spring seasonal pests. Another aim was to observe the impact of a spring application of differing LBAM registered products and a California red scale registered product on seasonal pests and beneficials.

Figure 17. Location of the demonstration site on Farm 229

Method

Each block was monitored regularly for pests and beneficials by Riverina IPM Pty Ltd. Individual block crop monitoring data was used to make pest management decisions. This demonstration site ran for two consecutive seasons. Data from crop monitoring reports and harvest bin assessment data was used to assess the impacts of the different treatments applied in season 2023-24. Fifty centimetre, cubed, fruit frame count data was collected for each treatment to assess % Katydid and % LBAM damage. Twenty random trees were sampled. Frame counts were taken from both the eastern and western side of each tree. Bin assessments of fruit damage are planned for harvest.

The following summaries of insecticide applications for each season, in most cases, excludes surfactants. Full chemical application records are available from NSW DPIRD to Hort Innovation or chemical companies upon request.

Insecticide application records 2024-2025 season

Block 11
27/10/2023 Lannate® 200 mL/100 L @ 2500 L/ha (California red scale)
10/02/2024 Trivor® 40 mL/100 L @ 2500 L/ha (mealybugs)
16/02/2024 Exirel® 75 mL/100 L @ 2500 L/ha (Fuller's Rose weevil (FRW))

Block 12
27/10/2023 Trivor® 40 mL/100 L @ 2500 L/ha (LBAM)
16/02/2024 Exirel® 75 mL/100 L @ 2500 L/ha (FRW)

Block 14
27/10/2024 Exirel® 75 mL/100 L @ 2500 L/ha (LBAM)
16/02/2024 Exirel® 75 mL/100 L @ 2500 L/ha (FRW)
05/04/2024 Movento® 30 mL/100 L + Hasten 50 mL/100 L @ 4000 L/ha (California red scale)

Insecticide application records 2024-2025 season
Block 11
18/11/2024 Lannate® 200 mL/100 L @ 3000 L/ha (LBAM)

Block 12
19/11/2024 Trivor® 40 mL/100 L @ 3000 L/ha (LBAM)

Block 14
20/11/2024 Exirel® 75 mL per 100 L @ 3000 L/ha (LBAM)
15/04/2025 Movento® 40ml/100 L + Expedient oil 50 mL/100 L @ 3500 L/ha (California red scale)

Results

2024-2025 season

The regular crop monitoring data and bin checks at harvest indicated the Trivor® and Exirel® treatments for LBAM in late October 2023 gave comparable LBAM control. The block 11- Lannate® application for California red scale late October 2023, gave similarly, adequate LBAM control. Each spring applied product had <1% LBAM damage in the harvest bin check data.

The respective product application each gave similar and adequate spring katydid control as an added benefit to the respective products target pest application. Each spring applied product had <1% katydid damage in the harvest bin check data.

Consecutive summer monitoring data showed the percentage of mealybugs increased for the block sprayed with Lannate®, to high levels. An application of Trivor® was made on block 11 to manage the mealybugs. The February-24 application of Exirel® was applied due to the detection of FRW eggs in one block. All blocks received the Exirel® application, as the orchard is a single unit on the KCT registration. No FRW were detected in February after Exirel sprays had been applied in all 3 blocks.

Late January-24 monitoring reports were showing moderate levels of two-spotted mite in block 11. Two

spotted mites were not noted in the monitoring data from Block 12 and 14. Predatory mite activity was similar in all treatments.

Early April monitoring data indicated a moderate to high level of California red scale in block 14- Exirel®, spring application. This is understandable as Exirel® does not have a California red scale registration. Whereas block 11- Lannate® and block 12- Trivor® managed the first generation of red scale to an acceptable level of control by end of season. Block 11- Lannate® additionally had Trivor® applied in February for mealybugs. Trivor® also has efficacy and a registration for California red scale, so it is no surprise block 11 was the best for California red scale in our bin checks.

May-24 crop data showed similarly low two-spotted mite in all blocks and comparable predatory mite activity.

2024-2025 season

Crop monitoring data from the end of October showed moderate Helicoverpa pressure. Moderate numbers of katydids were detected in block 12. The other two blocks had low levels of katydid. Very few LBAM were seen in the blocks. The monitoring data indicated no chemical spray was required at that time. Crop monitoring data 14-days later showed katydids in all three blocks and some signs of fruitlet damage. LBAM presence was still low. The treatments of this demonstration site were applied almost one month later than the season prior. This highlights regular pest monitoring is important as pest development varies from season to season. Following a calendar spray application in mid-October for example, could have seen resources wasted and poor seasonal pest control.

Early summer mealybugs were moderate to high in block 11- Lannate® and block 14- Exirel®. Block 14 also had high California red scale early in the season, so Movento® was applied in this block.

March and April monitoring data showed low levels of two-spotted mite in block 11. Mealybugs were moderate in block 11 as there was no applied chemical intervention. There was comparable predatory mite activity in all blocks. California red scale levels were comparative across all blocks.

The data is not replicated and bin assessment at harvest in August 2025 will assess a far greater number of orange fruits. Preliminary frame count data (Table 2), shows acceptable Katydid control for all treatments. LBAM presence was low in spring 2024 at this orchard.

Table 2. % Katydid and % LBAM fruit damage data from the demonstration site, 3/04/2025.

Farm / Block	Number of of Fruit	% Katydid damage	% lbam damage
Marin Block 14	212	0.0%	0.0%
Marin Block 12	219	2.7%	0.0%
Marin Block 11	219	2.3%	0.0%

Outputs and outcomes

The seasonal farm walk on 25/03/2024 increased grower awareness of the importance of crop monitoring to understand the development and seasonality of insect pests. In some seasons, the cheapest chemical option, such as broad-spectrum insecticide chemistry, can lead to a need for further pest management sprays.

Key learnings from growers:

- Seasonal timing for LBAM and Katydid varies from year to year.
- Every season and orchard are different – regular monitoring provides the confidence to make the decision to spray or wait.
- Exirel® does not control red scale, Trivor® does control red scale, Lannate® (Methomyl) gives some control.
- Methomyl increased Long tailed mealy bug levels both seasons in this demonstration site.
- Block 12- Trivor® managed the first generation of red scale to an acceptable level of control by the end of season for an export quality focused – maximum pack out grower.

Acknowledgements: Mario and John Marin

Light brown apple moth (LBAM) and Katydid control in spring

Region: Riverina

Collaborating grower:

Vito Mancini, Red Belly citrus, Mallinson Rd, Lake Wyangan, NSW

Background

The chosen block for the explorative demonstration was a 2.3 ha Washington navel block (Figure 18). The trees are over 40 years old, in good health and cropping well. The block has a history of LBAM and Katydid pressure in spring. FMC were advised of the explorative demonstration.

Figure 18. Location of the LBAM demonstration site on Farm 229

Aim

Assess spring LBAM and Katydid control with insecticide chemistry that has lower impact on natural enemies of citrus pests than registered broad spectrum insecticide products.

Method

The chosen block was monitored by am IPDM expert prior to the LBAM application. The insecticide treatments were applied on 05/11/2024 with an orchard sprayer.

1. 50 mL/100 L Exirel® @ 4000 L/ha
2. 75 mL/100 L Exirel® @ 4000 L/ha

California red scale monitoring data was collected on 7/04/2025 by a crop scout. Fruit frame count data was collected for each treatment to assess % Katydid and % LBAM damage. Twenty random trees were sampled. Frame counts were taken from both the east and west side of each tree. Bin assessments of fruit damage are planned for harvest.

The Washington navel block was sprayed with Movento® 40 mL/100 L + Hasten 50 mL/100 L @ 4000 L/ha in late March to manage California red scale.

Results

Crop monitoring data on the 30/10/2024 showed moderate LBAM pressure and high Katydid levels in both blocks. Equal Katydid fruitlet damage was present in both the north and south blocks. Green lacewings were seen in both blocks.

The frame count data indicated that both rates of Exirel® have given adequate LBAM and Katydid control, with 0% LBAM damage and 1.1% Katydid and 0.8% Katydid for 50 mL and 75 mL respectively (Table 3). NB. This is not replicated research and only demonstration. The bin count data at harvest will give further fruit assessment data.

Table 3. % Katydid and % LBAM fruit damage data from the exploratory demonstration site, data collected on 7/04/2025.

Farm / Block	Number of of Fruit	% Katydid damage	% lbam damage
F1817 Exirel 50 mL	266	1.1%	0.0%
F1817 Exirel 75 mL	254	0.8%	0.0%
Kubank VM Redbelly	304	3.9%	0.0%
Kubank AM Redbelly	351	5.1%	1.4%

The collaborating grower also grew Arnold blood oranges at another local orchard at Kubank. In November 2024, two neighboring orchards were sprayed with differing insecticides to manage spring seasonal insect pests. The orchard 'Kubank VM Redbelly' had 75 mL/100 L Exirel® @ 4000 L/ha in November, whilst 'Kubank AM Redbelly' was sprayed with 50 mL + 1 L summer spray oil @ 4000 L/ha in November. This is ½ rate Chlorpyrifos + oil as according to product label for California red scale. The collaborating grower had observed 'Kubank AM Redbelly' had less Katydid and LBAM damage.

Data collected by an experienced IPDM scout in April supports the grower's observations (Table 3). Interestingly, from the data collected by the crop scout, both the Exirel® and the Chlorpyrifos spring treated orchards had 23% Red scale. The monitoring data showed high California red scale parasitism levels in the Exirel® treated orchard, whilst the Chlorpyrifos treated orchard had a low level of parasitism. There was evidence of Aphytis and/or Comperiella parasitic wasps on each of the sampled fruit which included dead scales, exit holes and Aphytis faecal pellets.

Outputs and outcomes

Data and the learnings

Key learnings from growers:

- For best results, it is important to monitor to determine the correct timing of insecticide application.
- Exirel® is registered for LBAM and it appears Katydid control may be an additional bonus. Red scale is not controlled by Exirel® and an insecticide application was required later in the season.

Whole farm IPM

Region: Riverina

Collaborating grower:

Arcifa Bros orchard, 3977 Irrigation Way, Widgelli, NSW

Background

Mario Arcifa is an export focused grower who applies minimal insecticides and achieves comparable fruit quality to other growers whom have greater insecticide inputs. The IPDM extension program case studied Arcifa Bros orchard and assisted with California red scale management in Washington navel oranges and tried alternative management of long tailed mealybugs in a McMahon seedless Valencia block (Figure 19).

Aim

Test red scale male monitoring as a tool to assist pest monitoring. Manage seasonal citrus pests with minimal disruption to natural enemies of citrus pests. Use insecticide options that have the lowest impact to natural enemies of citrus pests. Assess augmentative beneficial insect release for some citrus pests.

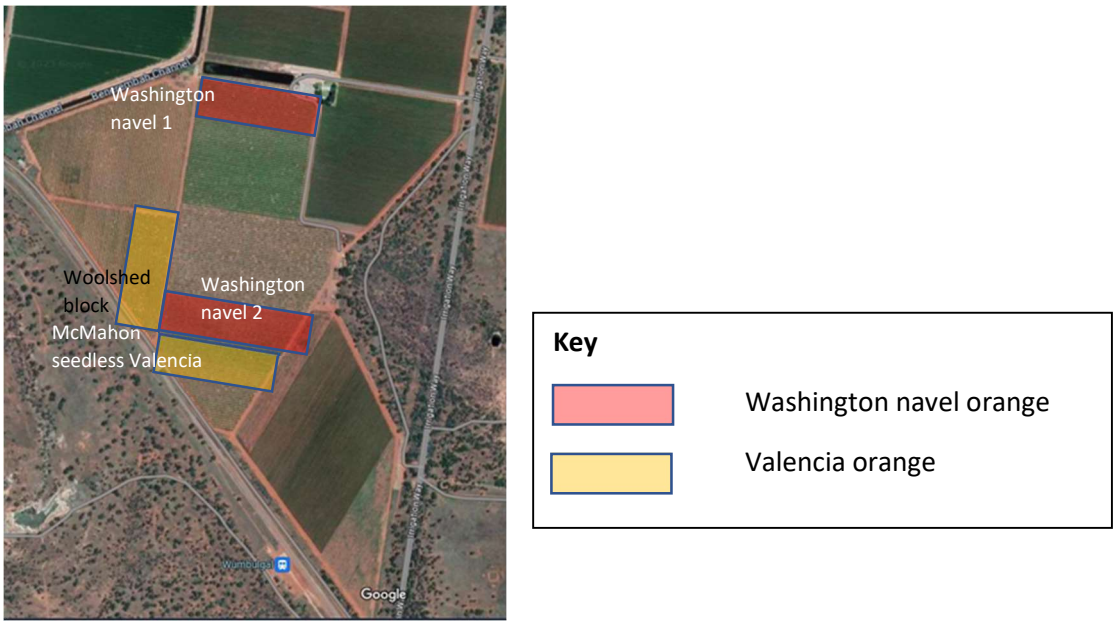


Figure 19. Map showing the location of the demonstration blocks on the Arcifa Bros orchard.

Method

Regular crop monitoring reports from the orchard were shared with NSW DPIRD to track progress of the demonstration blocks 'Washington navel 1' (WN1) (5 ha) and two McMahon seedless Valencia orange blocks. 'Washington navel 1' had a pheromone based Pherocon® male California red scale monitoring trap installed and regularly serviced. Contract release of *Aphytis melinus* (Aphytis) wasps was undertaken in WN1 for season 2023-24 and season 2024-25. 'Washington navel 2' had *Cryptolaemus montrouzieri* (Cryptolaemus) released to assist mealybug control during season 2023-24. Cryptolaemus release was undertaken earlier in the season and at higher rates to assist long tailed mealybug control in McMahon seedless Valencia.

Results

2023-24 season

18/12/2023 release Aphytis in block WN1 (15 cups)

Monitoring data 06/02/2024 indicated 12% California red scale (12% RS) in WN1. Even though Aphytis parasitism levels were considered moderate to high, an insecticide intervention was recommended. The reason being was, "That level of red scale in WN1 10 years ago we would have left it, but the tolerance is now very low for export destined fruit. We would also leave it if it was juice fruit, but risky for export". The seedless Valencia had three times more red scale and very high mealybug levels.

On 12/02/2024 the collaborating grower applied:

Seedless Valencia Movento® 30 mL/100 L, Hasten 50 ml/100 L at 5000L/ha
Washington WN1 – Movento® 30 mL/100 L, Hasten 50 ml/100L at 5000L/ha
Washington WN2, no Movento® spray further Aphytis were released.

20/12/2023 release Cryptolaemus in SW corner of block WN2, 4X 100 adults, 2x 200 larvae
16/02/2024 release Cryptolaemus release, block WN2, 8X 100 adults
08/04/2024 release Cryptolaemus release, block WN2 5X 100 adults, 1x 200 larvae 16/02/2024 release Cryptolaemus release, block WN2.

The Cryptolaemus releases in WN2 did not show a clear reduction to mealybug numbers in the regular crop monitoring data. The seedless Valencia block next door had a comparatively much higher mealybug population. The adult beetles most likely went to the seedless Valencia block for an easier feed. Plans were made for next season to commence Cryptolaemus releases early in the season in the seedless Valencia block, with a higher release density and compare results to the woolshed seedless Valencia block, that also had a comparative mealybug infestation.

Aphytis wasp releases were completed on 18/12/2023 and 12/03/2024 in the block WN1. Each release was 15 cups at $61.60 each, $34.00 freight.

The grower applied one insecticide for the season to WN1. This was 12/02/2024 Movento® 30 ml/100 L + Hasten 50 ml/100 L at 5000 L/ha. WN2 was sprayed with Trump summer oil 1.4 L/100 L on 10/01/2024. Further Aphytis wasps were released to WN2, rather than Movento® application. Grower observations were the Movento® application had a better result than the oil spray in January. The crop monitoring data from mid-May 2024 showed WN1 and WN2 had similarly, low 1% red scale and 2% mealybug fruit infestation levels. The seedless Valencia block had a moderate level of sooty mould due to the 18% mealybug level.

2024-25 season

The Pherocon® insect monitoring kit installed in WN1 attracted California red scale males. The data showed the first male peak to be mid-December and a second male peak at the end of January 2024 (Figure 20). The trap was useful to give an idea of seasonal timing early in the season, to predict crawler peak, particularly when trying to get season long control from an early insecticide application. Once California red scale generations overlap, they are not very useful. Most citrus crop consultants prefer to monitor fruit for red scale.

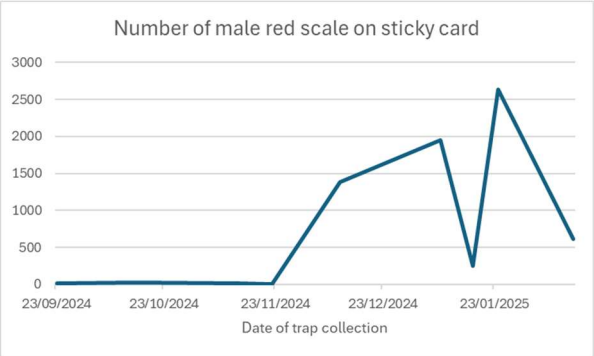


Figure 20. 2024-25 California red scale male monitoring data from block WN1.

Aphytis wasp releases were completed on 04/12/2024 and 16/01/2024 in the block WN1 at a rate of 15 cups per release.

Desire® Mealybug pheromone-based monitoring. UPL OpenAg® provided male longtailed mealybug trap that were set in the Seedless Valencia block (Figure 21).

01-09-2024 to 23-10-2024 = 0 males

23-10-2024 to 22-11-2024 = 11 males

22-11-2024 to 20-12-2024= 5 males

20-12-2024 to 14-02-2024= 20 males

Cryptolaemus were released in the McMahon seedless Valencia on 12/12/2024 and 17/01/2025. The release rate was 700 adult beetles at each release date. The Oct-25 harvest assessment will compare the impact of these releases.

Season 2024-25, Arcifa Bros was the lowest chemical user of Riverina IPM growers this year. Only one Movento® spray was applied to blocks that required chemical intervention. Arcifa Bros IPM strategies are cost effective, and they achieve similar fruit quality.

Outputs and outcomes

Seasonal field walk 20/04/2023 (Figure 21).

Figure 21. (Left and upper right) Seasonal field walk participants at the Arcifa Bros event released Cryptolaemus ladybird beetles and Aphytis parasitic wasps (bottom right).

Video - 'The citrus industry IPDM demonstration site at Arcifa Bros'. Part of the video content are instructions on how to release parasitic Aphytis wasps to assist California red scale management.

Key learnings from growers:

Establishing orchard and seasonal pests

Region: Riverina

Collaborating grower:

NSW DPIRD, Farm 217, Murray Rd, Hanwood, NSW

Background

A 5 ha, young orchard development planted in 2021 in collaboration with NSW Government and the Griffith and District Citrus Growers association (Figure 22). Also, a 1 ha mature common orange block which was contracted for juice.

Aim

Assess alternate row slashing to encourage natural enemies of citrus pests and reduce chemical use. Use lower impact insecticide chemistry to natural enemies on half of the orchard.

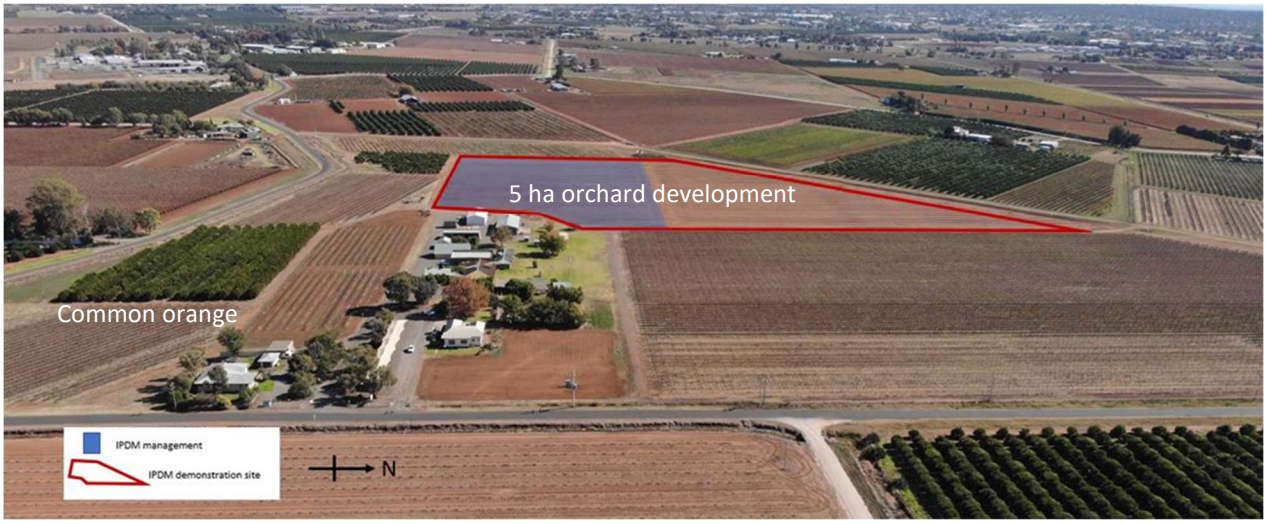


Figure 22. Location of the demonstration site on Farm 217, Murray Rd, Griffith NSW. The demonstration site area is bounded by the red bordered shape. The blue shaded area marks the trees managed with an integrated focus.

Method

The IPDM demonstration site will be monitored monthly by Riverina IPM and actively managed until 30 March 2025 (Figure 22). Insect pest management on the conventionally managed, northern side was sprayed based upon seasonal pest presence. Pest management on the southern, IPM side was based upon crop monitoring data.

Results

Conventional side chemistry applied over 3 seasons:

20/11/2021 Ambush® 10 mL/ 100 L water (Citrus leafminer and citrus gall wasp)
15/12/2022 Confidor guard® 350SC (Citrus gall wasp and soft scales)
10/02/2022 Ambush® 10 mL/ 100 L (Citrus leafminer)
18/11/2022 Ambush® 10 mL/ 100 L (Citrus gall wasp)
15/12/2023 6 mL /tree Nuprid® 350 (Citrus gall wasp and soft scales)
23/10/2023 Trivor® 40mL/100 L at 2000 L/ha (California red scale)
10/11/2024 Trivor® 40mL/100 L at 2000 L/ha (LBAM and Katydid)
10/12/2024 Nuprid® 350 (Citrus gall wasp and soft scales)
10/01/2025 Trivor® 40mL/100 L at 2000 L/ha (Citrus leafminer)

IPM side chemistry applied over 3 seasons:

15/12/2022 Confidor guard® 350SC (Citrus gall wasp and soft scales)
15/12/2023 6 mL /tree Nuprid® 350 (Citrus gall wasp and soft scales)
10/11/2024 Exirel® 50 mL per 100 L (LBAM and Katydid)
10/05/2025 Movento® 40 mL/100 L + Hasten® 50 mL/100 L (California red scale)

Applying Ambush to non-bearing trees with targeted nozzles did not create a secondary pest flare of two-spotted mites. The applications proved unnecessary, as the annual imidacloprid treatments, kept the citrus gall wasp under control in the young trees. The Hanwood, Yoogali local area has moderate to high citrus gall wasp pressure due to some abandoned orchards. Chemical use was minimal on the IPM managed southern side compared to the conventionally managed, northern side.

A **Common orange block** (Figure 22), on Farm 217 was seasonally treated in spring with Trivor® over two consecutive seasons to compare pest management. There was no crop monitoring protocol to decide when to apply the pesticide application. LBAM were present and Katydid was noticed in the orchard, chewing fruitlets. Trivor® 40 ml/100 L + Wetcit at 4000 L/ha was applied on 23/10/2023 and in the following season on

10/11/2024. Riverina IPM collected monthly crop monitoring data from both sides of the common orange block in season 2023-24. Trivor® gave adequate pest control both years for contracted juice oranges (Salustiana). Monitoring data showed high levels of infestation (80% red scale), to the unsprayed side (Figure 23). A recommendation to apply Movento® and Hasten® was given in January 2024, however, it was not applied. Natural Aphytis parasitism reduced the level of live scale to 9% at the harvest bin assessment of pests. The Trivor® application gave adequate control of red scale, LBAM and katydid as shown by assessment of the oranges in bins at harvest (Figure 23).

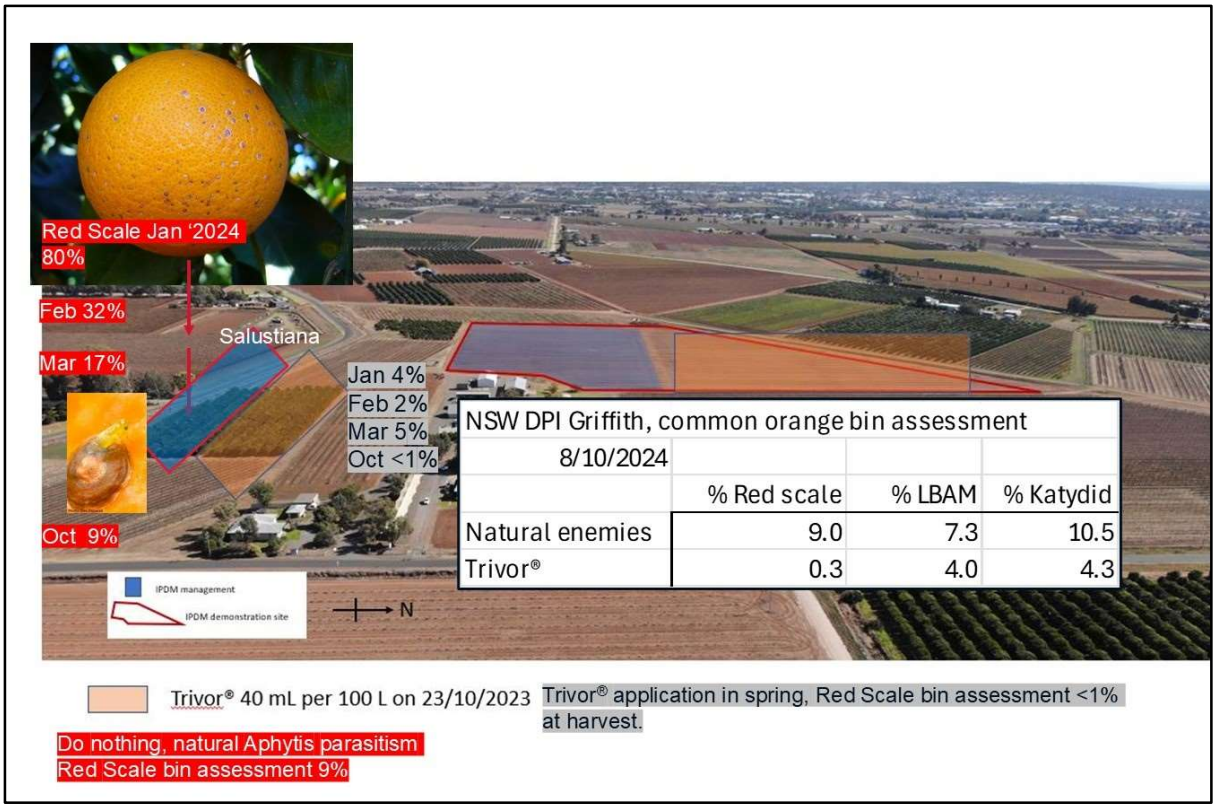


Figure 23. Percentage of California red scale infestation in the common orange demonstration 2023-24 season.

The second season of this demonstration (Trivor® application on 10/11/2024), was assessed on 30th April 2025 by a citrus crop scout. The Trivor® treated rows had 0% red scale and 8% katydid damage. The unsprayed rows had 9% red scale and 10% katydid damage.

April frame count data from the 5 Ha young orchard showed 0% LBAM and 8% katydid damage to fruit on the southern side (10/11/2024 applied Exirel® 50 mL / 100 L). The northern side with an application of Trivor® 40 ml/100 L, had 3.1% LBAM and 10.1% katydid damage. Harvest bin assessment data will give greater number of fruit assessed than 40 frame counts per treatment. Katydid control at Farm 217 Griffith NSW is relatively poor for 2024-25 season in comparison to the Marin and Red Belly demonstration sites. Discussion with Riverina IPM highlighted the importance to monitor fortnightly during the seasonal high-risk pest periods. NSW DPI was monitoring monthly, and the spray treatments were applied 14 days after the chemical recommendation, due to contractor delay.

At most monthly crop monitoring events, 25 sweep nets were taken in the inter-row (5 in each of 5 rows) and the diversity and number of natural enemies of citrus pests was recorded for both IPM and the conventional managed sides. Alternate row slashing was adopted in the IPM side (southern side) of the 5 ha planting. The combination of alternate row slashing and reduced chemical use contributed to both a greater diversity and number of natural enemies, with twice as many caught in the IPM side compared to the conventional side (Table 4). Spiders were the most common natural enemy of citrus pests caught in the sweep nets. The lowest number of natural enemies were caught in the sweeps during the summer period. Ladybird beetles and lacewings were most active over October and November each year (Table 4 and Table 5).

Table 4. Natural enemies of citrus pests caught in inter-row sweeps 2024-25 season – IPM block

Date	ladybird beetles	R&B beetles	predatory shield bugs	damsel bugs	assassin bugs	mantids	lacewings	mirrids	hover flies	wasps	spiders
26/01/2024	3	0	0	0	0	0	0	0	0	2	5
27/03/2024	0	2	0	0	0	0	0	4	0	1	14
30/04/2024	3	0	0	0	0	0	0	0	0	2	7
16/10/2024	27	0	0	0	0	0	4	0	7	7	12
30/10/2024	17	0	0	2	0	0	2	0	0	0	12
29/11/2024	13	0	0	1	0	0	0	0	0	0	30
11/12/2024	1	1	0	0	0	0	0	0	0	0	15
8/01/2025	1	0	0	0	2	0	0	0	0	2	11
5/02/2025	3	0	0	0	0	0	0	0	0	0	13
5/03/2025	0	0	0	0	0	0	0	0	0	0	7
2/04/2025	2	0	0	0	0	0	0	0	0	0	20
TOTAL	**70**	**3**					**6**			**14**	**146**

Table 5. Natural enemies of citrus pests caught in inter-row sweeps 2024-25 season – Conventional block

Date	ladybird beetles	R&B beetles	predatory shield bugs	damsel bugs	assassin bugs	mantids	lacewings	mirrids	hover flies	wasps	spiders
26/01/2024	1	1	0	0	0	0	0	0	0	0	0
27/03/2024	0	0	0	0	0	0	0	2	0	0	0
30/04/2024	3	0	0	0	0	0	0	0	0	1	4
16/10/2024	9	0	0	0	0	0	4	0	1	0	0
30/10/2024	2	0	0	0	0	0	0	0	0	0	7
29/11/2024	1	0	0	0	0	0	0	0	0	0	19
11/12/2024	6	1	0	0	0	0	0	0	0	0	19
8/01/2025	0	0	0	0	0	0	0	0	0	0	6
5/02/2025	0	0	0	0	0	0	0	0	0	0	7
5/03/2025	0	0	0	0	0	0	0	0	0	0	6
2/04/2025	4	2	0	0	0	0	0	0	0	0	4
TOTAL	**26**	**4**					**4**			**1**	**72**

Outputs and outcomes

Seasonal field walk 25/03/2024

IPDM poster 'Natural enemies of citrus pests'

Sunraysia regional on-farm demonstration site

California red scale and seasonal pests

Region: Sunraysia

Collaborating grower:

Grandview Orchards, Keenans Drive, Dareton, NSW

Background

The chosen block for the demonstration site is a triangular block (0.9 ha) of mature Chislett summer navels on Citrange rootstock planted at 5.0 m x 3.0 m (Figure 24). The trees had high red scale pressure during the 2021-22 season, to the point where some trees were defoliating in pest hot spots.

Aim

The 12 long rows of the block will be managed conventionally, treated with systemic soil applied insecticide annually to manage red scale and other seasonal pests. The planned insecticide choice for seasonal pest management, like LBAM is often broad-spectrum chemistry. The chemicals chosen to manage seasonal insect pests of the IPM side will be chemistry options that have least disruption to natural enemies of citrus pests.

Augmentative release of Aphytis wasps and some other natural enemies will be conducted on the IPM side. California red scale (CRS) mating disruption tabs will also be tested in the IPM side.

Pest control decisions will be made based upon monitoring data for both the conventional and IPM sides.

Figure 24. Location of the IPM demonstration site at Dareton, NSW. The orange trees in the blue shaded area were managed with an integrated pest management focus that is also testing California red scale mating disruption as an additional tool to assist seasonal pest management. Pest management in the longer rows is conventional grower practice.

Method

The red scale mating disruption tabs were hung in the tree annually (1 tab per tree) and cost $3.85 each. An Alpha Scents product registered with the USDA.

(https://www3.epa.gov/pesticides/chem_search/ppls/085354-00006-20221006.pdf) was the product tested in the demonstration (Figure 25).

Lower impact pesticides were used on the IPM managed, 15 shorter rows (0.3 ha). The short rows were excluded from systemic soil insecticide by means of individual taps on each dripper line. The IPDM demonstration site (both sides) will be monitored by Mannes Entomology as separate blocks and actively managed until 30 March 2025 by the Citrus industry IPDM extension program.

Figure 25. An Alpha Scents mating disruption tab was hung annually in each tree, with timing prior to the first male red scale flight.

Results

Conventional side chemistry applied over 3 seasons:

18/11/2022 Confidant® (350 g/L imidacloprid) 9 mL/tree (CRS)
23/11/2022 Lannomyl 225® (225 g/L Methomyl) 200 mL/100 L (LBAM)
2/2/2023 Movento® 40 mL/100 L + Hasten® 50 mL/100 L (CRS)

November 2023, Confidant® (350 g/L imidacloprid) 9 mL/tree (CRS)

3/11/2024 Surefire Spectrum 350SC (350 g/L imidacloprid) 9 mL/tree (CRS)
4/11/2024 Delegate® (250 g/kg Spinetoram) 10 g /100 L (LBAM)
30/01/2025 Abamectin & ParaMite (ETOXAZOLE) at label rates (Two-spotted mites)

IPM side chemistry applied over 3 seasons:

25/11/2022 – Prodigy® (240 g/L Methoxyfenozide) 25 mL/100 L (LBAM)
2/2/2023 Movento® 40 mL/100 L + Hasten® 50 mL/100 L (CRS)
2/3/2023 Movento® 40 mL/100 L + Hasten® 50 mL/100 L (CRS)

November 2023, Confidant® (350 g/L imidacloprid) - accidental application as the in-line taps were not closed.

03/11/2024 – Prodigy® (240 g/L Methoxyfenozide) 25 mL/100 L (LBAM) at 4000 L/ha

IPM side augmented beneficial insect release:

27/02/2023 release lacewing larvae (3x 2000 eggs) and Cryptolaemus (2x 200 larvae) for assistance with scale and mealybug control through IPM demo at Grandview. The weather this week is 27 to 30 degrees, so the hatched lacewing larvae should settle in well.

31/12/2024	*Neoseiulus californicus* (Californicus) (100 K/L) 1.5 L
	Aphytis melinus (Aphytis) (10 K/cup) 2 cups
05/02/2025	Californicus (100 K/L) 1.5 L
	Aphytis (10 K/cup) 4 cups
28/02/2025	Californicus (100 K/L) 1.5 L
	Aphytis (10 K/cup) 4 cups

2022-23 season: The tabs were placed in the orchard one month late. It took two consecutive Movento® sprays to clean up the heavy infestation of California red scale from the season prior.

2023-24 season: The mating disruption tabs were hung prior to red scale male flights. Both sides had Imidacloprid applied to the soil. Two-spotted mites became a pest issue by autumn on both sides. Miticides were applied.

2025-25 season: Only one 'soft' insecticide was applied to achieve export quality navel oranges on the IPM side. The conventional had four pesticides applied. The mating disruption tabs were hung prior to red scale male flights. The pre-emptive release of Californicus assisted two-spotted mite control in the IPM side as a miticide was not required in the 2024-25 season. The augmentative release of Aphytis works well with red scale mating disruption. Males are confused by the abundant pheromones allowing the female red scale to remain unmated for longer, making them susceptible to Aphytis parasitism.

Outputs and outcomes

Seasonal field walks were conducted on 18/04/2023 and 28/02/2025. The demonstration site findings contributed to Australian Citrus News, Issue 2, 2025, pp 22-23, 'Sustainable management of California red scale: A modern IPM approach'.

Commercial sized grower trials of CRS mating disruption are planned by Mannes Entomology for the 2025-26 season.

Key learnings from growers:

California red scale mating disruption with augmentative release of Aphytis wasps has managed red scale at the demonstration site, without the need for systemic soil applied insecticides. This has aided in reduced chemical use.

WA regional on-farm demonstration sites

Region: Harvey, Western Australia

Focus: Investigate the level of pests and beneficials in lemon orchards in the southwest of WA (Harvey).

Collaborating growers:

Richard Eckersley, Yambellup Estate, 399 River Rd, Harvey WA
Andrew Pergoliti, Harvey Citrus, Ninth Street, Harvey WA

Background

Site 1 is a two-hectare (ha) block of Eureka SL seedless lemon on Cox rootstock planted in 2019. The block is edged by windbreaks on east and west sides and surrounded by other citrus blocks with pasture on the north side.

Site 2 is a 3.7 ha block of 2PH Eureka seedless lemon on Trifoliata rootstock with Valencia interstock, planted in 2015. It is edged by windbreaks on east and west sides with other citrus blocks to the north and east sides, pasture on the south side and a minor road on the west side (Table 5).

Table 5. Demonstration site details

	SITE 1	SITE 2
Property name	Yambellup Estate	Harvey Citrus
Location	Harvey, WA	Harvey, WA
Block size (ha)	2 ha	3.7 ha
Year planted	2019	2015
Variety	Eureka SL seedless lemon	2PH Eureka seedless lemon
Rootstock	Cox	Trifoliata with Valencia inter-stock
Tree x Row spacing (m)	6 m x 3 m	6 m x 2.5 m
Pest history	Red scale, aphids, thrips, mealybug, citrus bud mite	Rust mite, thrips, mealybug, citrus bud mite

Aim

Demonstrate IPDM through regular monitoring to guide pest management decisions.

Method

Two commercial lemon orchard blocks of between 2-4 hectares in Harvey, WA were used for the demonstration sites. Weekly to fortnightly monitoring from September 2024 to May 2025 using recommended practices provided a record of the pests and their frequency. A record of damage on fruit was also kept and pesticide applications and other management practices that may affect pests.

Monitoring

At each monitoring event, 15 trees were randomly sampled at both sites. For each tree, samples were taken from four quadrants of the tree–north, south, east, and west and the fifth from the middle of the tree where pests often shelter. Presence or absence of pests were recorded to determine the percentage of samples infested.

At each site, four Light Brown Apple Moth (LBAM) pheromone traps were placed to determine timing of high LBAM activity. Traps were placed in each corner of the block (Figure 26).

Figure 26. Boundaries of demonstration sites with Light Brown Apple Moth locations.

Orchard management

Orchard management practices carried out at each demonstration site over the monitoring period are shown in table 6.

Table 6. Orchard management practices at each site during the monitoring period

MONTH	SITE 1	SITE 2
Aug-24	Movento® spray – early Aug + late Aug	Movento® spray – mid-Aug
Sep-24		Movento® spray – mid-Sep Snail bait, some rows pruned
Oct-24		Harvest (late-Oct)
Nov-24	Harvest (mid-Nov) Inter-row mowed (late-Nov)	Harvest (early-Nov) Hedged and skirted (mid-Nov)
Dec-24	Trivor® spray (late Dec)	
Jan-25	Harvest (late-Jan)	
Feb-25	Trees pruned	Snail bait

Results

The pests found at the demonstration sites over the monitoring period included thrips (Greenhouse and Kelly's Citrus Thrips), mealybugs, lemon bud moth, red scale, soft brown scale, citrus bud mite, cottony cushion scale, crusader bugs, light brown apple moth and snails. While most of the pests were found at both sites, soft brown scale and cottony cushion scale were only found at Site 1. Lemon bud moth was the most frequently found pest at both sites, followed by Kelly's Citrus Thrips (KCT) adults and mealybugs (Figure 27). The average number of infested samples was also highest for these three pests but varied between sites (Figure 28).

At Site 1, the pest with the highest average number of infested samples was KCT adults (21%), followed by lemon bud moth (18%) and mealybugs (14%). For Site 2, lemon bud moth was found on the highest average number of samples (12%), followed by KCT adults (10%). While mealybug was found at 67% of monitoring dates for both sites, the average number of samples infested was only 2% (Figure 28).

The pest levels and action thresholds for the main pests during monitoring from September 2024 to May 2025 are shown in Figures 29 to 32. Even though pests were found in the orchard, the percentage of samples infested rarely exceeded the action levels. At Site 1, KCT (larvae), mealybugs and lemon bud moth were the only pests to exceed the action levels (Figure 29 to 31).

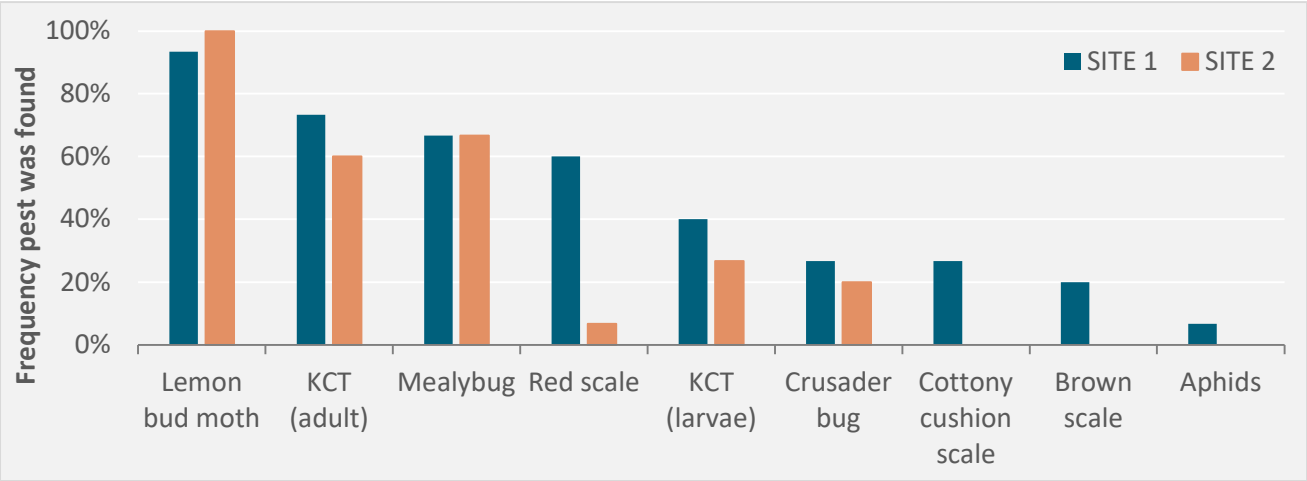


Figure 27. Frequency that each pest was found during monitoring.

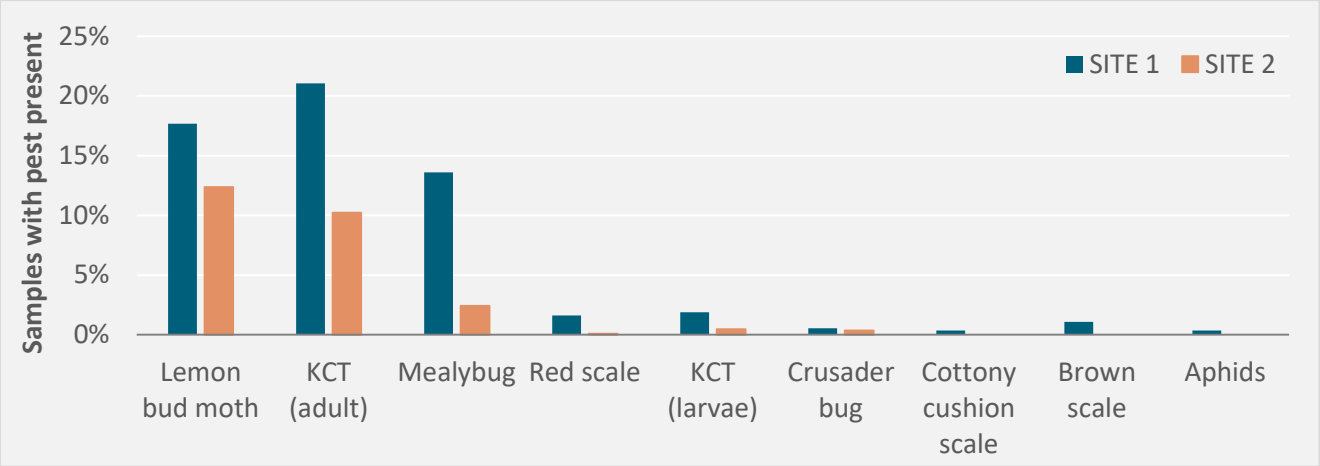


Figure 28. Average number of samples with pests present during monitoring at Site 1 and 2.

Thrips

Kelly's Citrus Thrips were found at both sites, mainly adults in flowers from September to early December (Figure 29). KCT damage is caused mostly by larvae during the first 4-5 weeks after petal fall (mid-October to mid–late November). At Site 2, KCT larvae was not seen frequently or in high enough numbers to cause damage, but Site 1 had levels over the threshold in November and thrips damage to fruit was observed during monitoring. During field monitoring, non-pest thrips were easily mistaken for KCT larvae, highlighting the need to inspect more closely with a hand lens or microscope to confirm identification and avoid unnecessary spraying.

Movento® was applied at both sites before monitoring began. This timing may have been too early for control of KCT. TRIVOR® was applied in mid-December at Site 1. The level of KCT adults and larvae reduced in December at both sites and remained low (Figure 29).

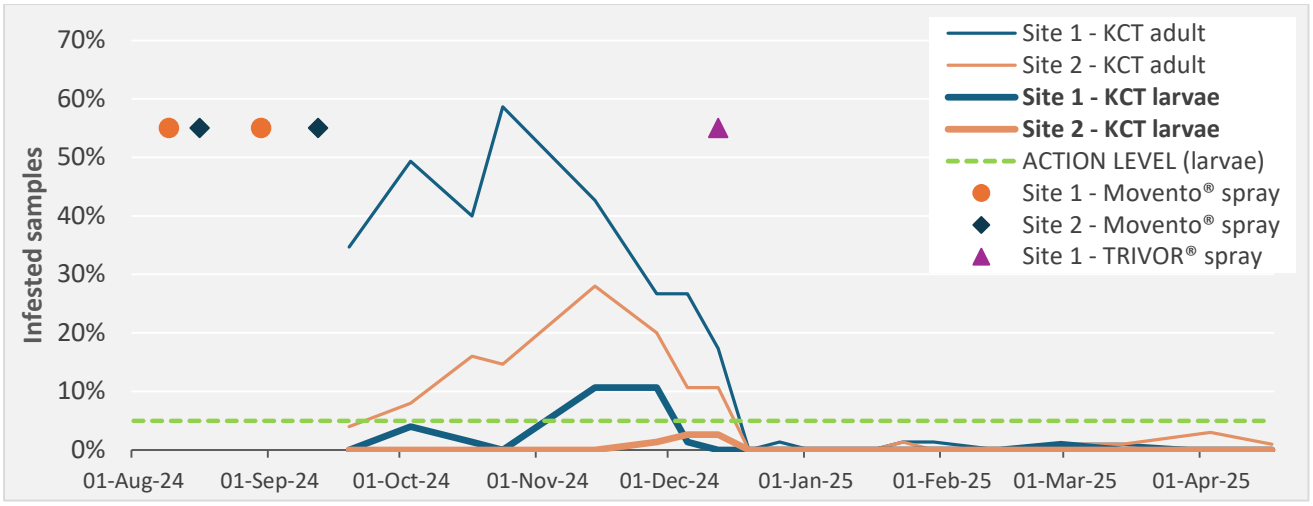


Figure 29. Proportion of fruit samples with Kelly's citrus thrips larvae and adults. Action level 5% or more fruit samples infested with larvae.

Mealybugs

High numbers of mealybugs were found at Site 1 from September to early December (Figure 30). At Site 2 low numbers of mealybug were found from September to 12 December, below the action threshold for lemons.

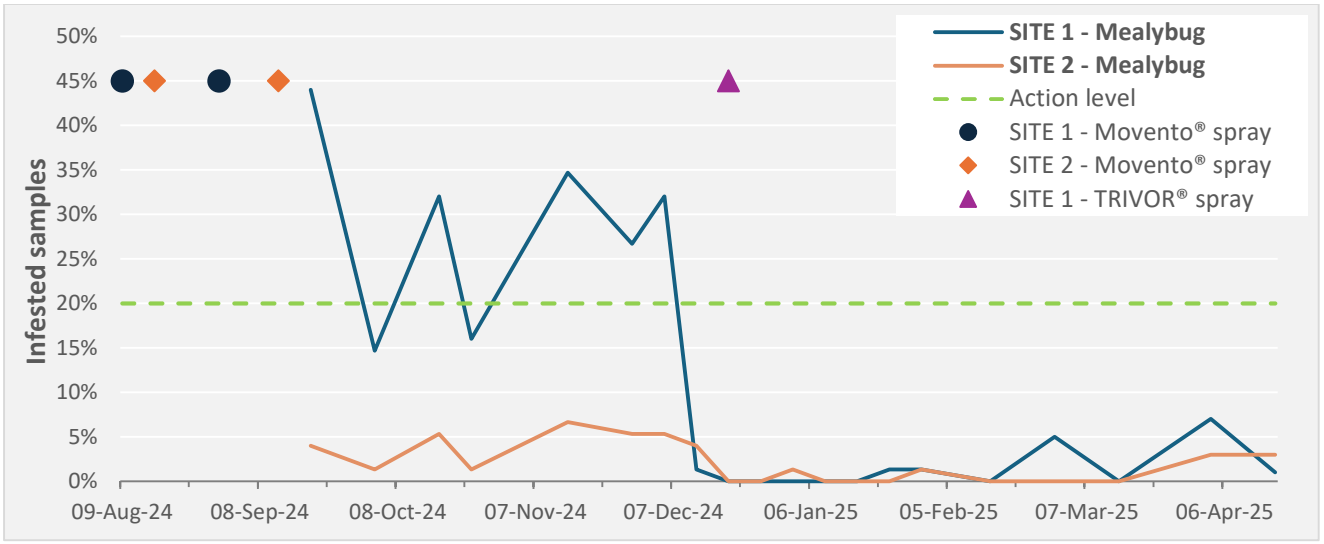


Figure 30. Proportion of fruit samples infested with mealybug. Action level is 20%.

Lemon Bud Moth

Lemon bud moth damage to flowers was frequently found at both sites, reaching the action level at Site 1 on 19 December (Figure 31). Larvae, pupae and adult moths were also observed.

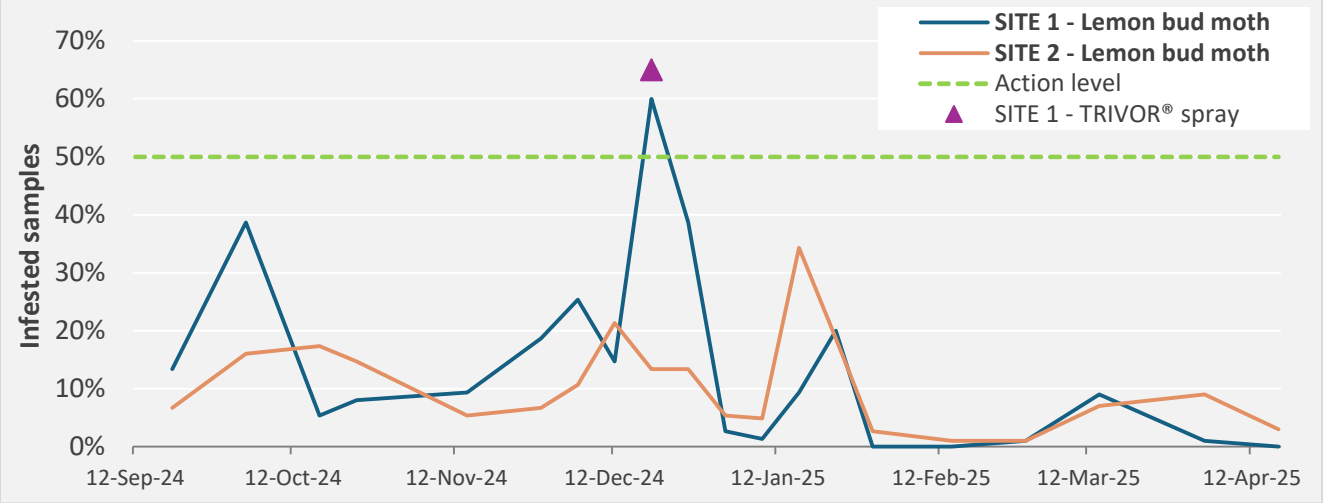


Figure 31. Proportion of flowers with lemon bud moth damage. Action level is 50% or more flowers infested.

Red scale

Red scale was found at Site 1 on most monitoring dates, but did not exceed the action level. Red scale was only found at Site 2 on one occasion in December (Figure 32).

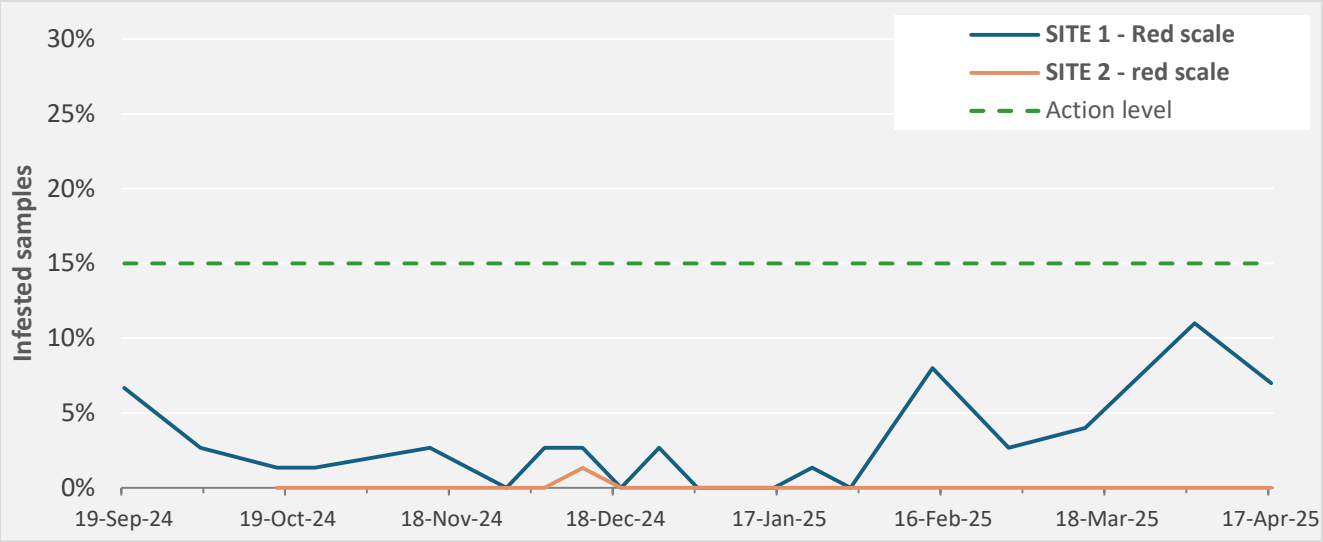


Figure 32. Proportion of fruit samples infested with red scale at Site 1 (did not exceed action level).

Light Brown Apple Moth

The average number of Light Brown Apple Moth (LBAM) caught in four traps in the block are shown in Figure 33. While moths were caught in traps, no eggs or larvae were found in the orchard during monitoring. Numbers were highest in December at both sites but dropped off and remained low for the rest of the monitoring period.

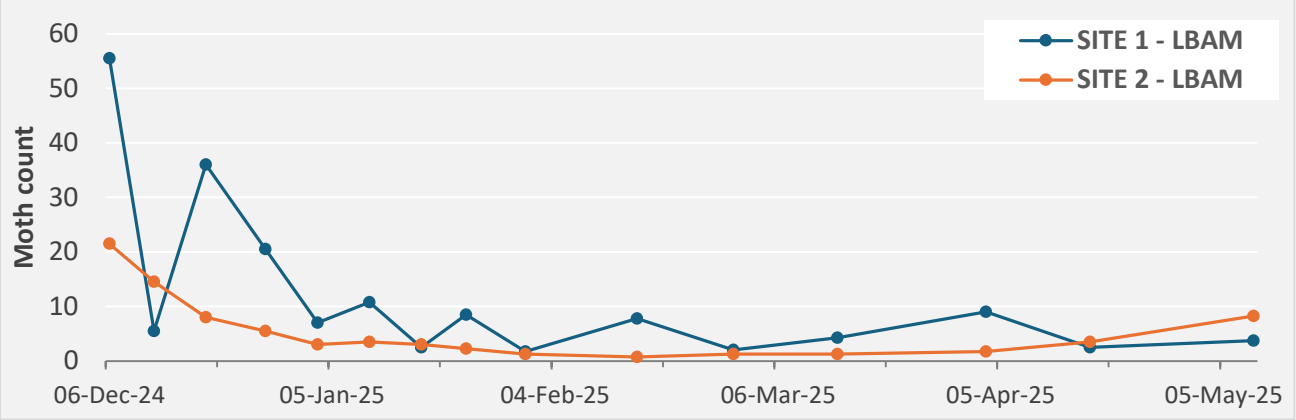


Figure 33. Average Light brown apple moth trap counts from December 2024 to May 2025. Monitoring was conducted weekly until mid-February and then fortnightly.

Beneficials

Beneficials were observed at all monitoring dates at both sites (Figure 34). Green lacewings, *Cryptolaemus montrouzieri* lady beetles and jumping spiders were found. Green lacewings were most commonly observed, mainly eggs. Larvae were less commonly seen and adults rarely seen.

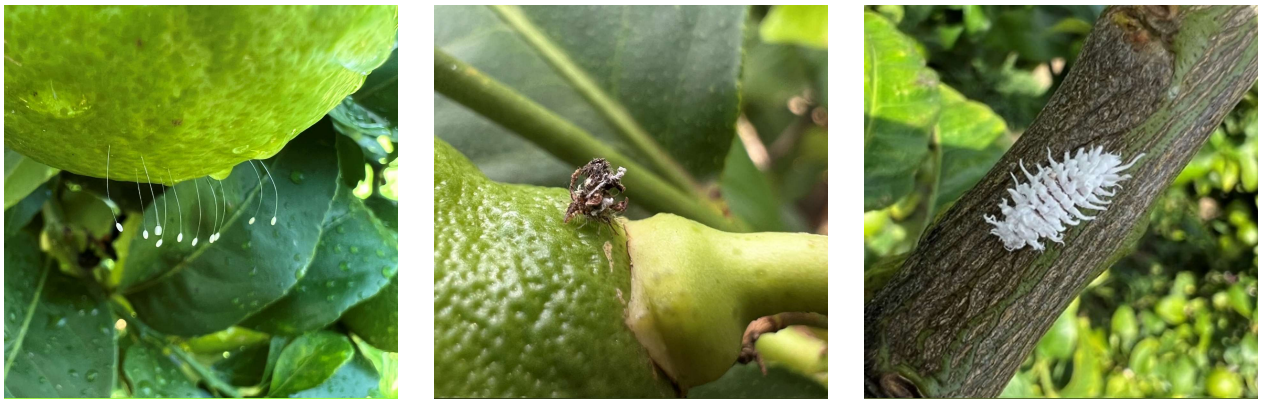


Figure 34. The most common beneficials found at both sites were green lacewing eggs (left), larvae (middle) and Cryptolaemus montrouzieri larvae (right).

At Site 1, beneficial numbers increased from late October, peaking in late November to early December on 33% of samples (Figure 35). At Site 2 numbers increased in late October, peaking on 6 December at 32% of samples. The number of beneficials dropped substantially in mid-December at both sites.

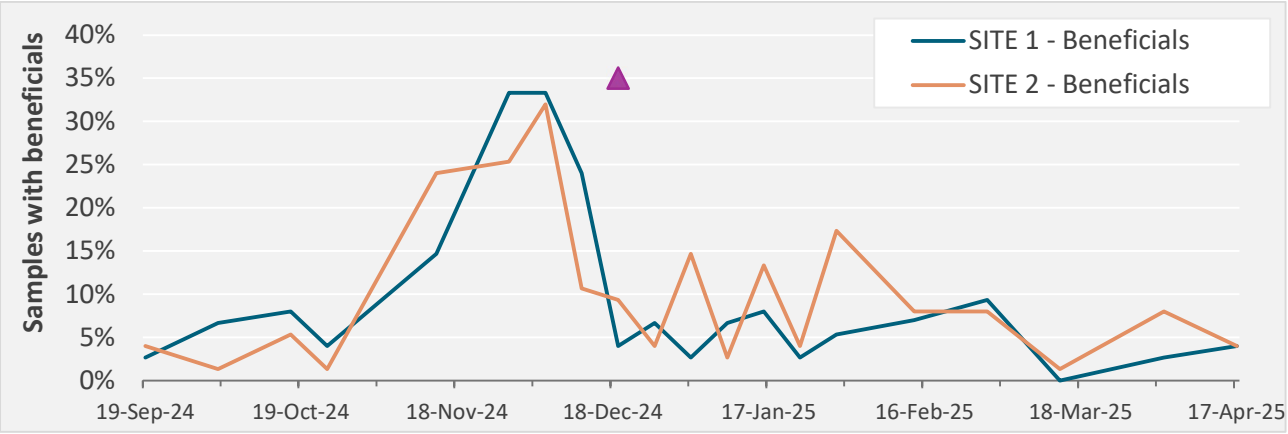


Figure 35. Proportion of samples with beneficial insects present at each site.

Fruit Damage

Damage to fruit observed during monitoring included chewing, thrips damage ('halo' around the calyx), and citrus bud mite damage (distorted buds, leaves and fruit) (Figure 36).

Figure 36. Thrips damage (left) and citrus bud mite damage (right) at demonstration sites.

Outputs and outcomes

The growers who hosted a demonstration site on their property indicated this activity was very beneficial to them to understand what pests were in their orchard. Both growers have adopted IPDM practices including an increase in pest monitoring practices. This has helped guide their pest management decisions including the timing of management options and a reduction in sprays used.

Key learnings from growers:

If a pest is present, this doesn't mean there are enough to cause economic damage.
Every season and orchard are different – regular monitoring provides the confidence to make the decision to act or wait.
Understanding tree phenology and pest lifecycle is important for timing sprays.
Monitor pests after spray applications to check efficiency.
Not everything that moves is a pest – natural enemies can be part of managing pests.
Results and key learnings from the demonstration sites were shared at a farm walk in February 2025 (Figure 37). An article was also published in the WA Grower.

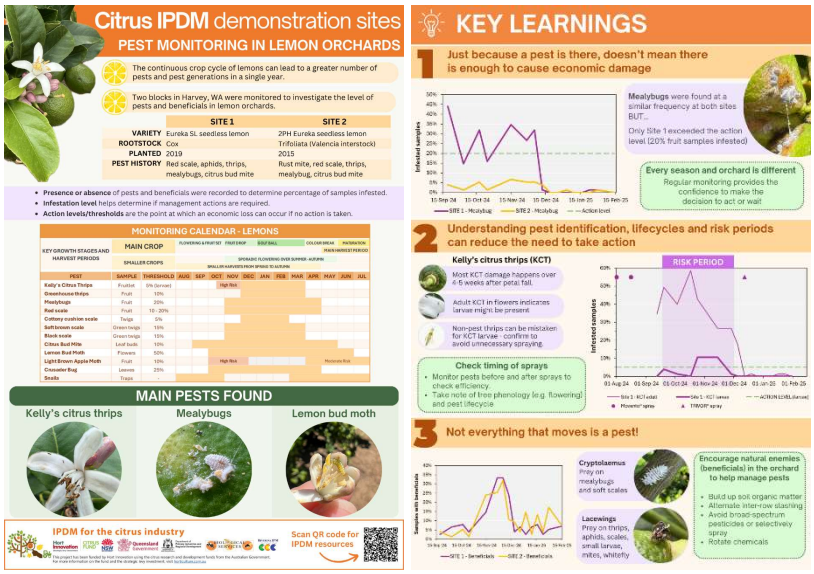


Figure 37. Handout with key results from the demonstration sites

Central Burnette regional on-farm demonstration site

See QDPI website for Citrus black spot and Emperor brown spot videos

FNQ regional on-farm demonstration sites

See appendix 7 Poster QDPI Australian Citrus Congress

An IPM Approach to Controlling Oriental Spider Mite (*Eutetranychus orientalis)* in North Queensland Citrus

Emily Pattison[1]*, Rebecca Dumbrell[2], Charlee Macdonald[1] and Stef De Faveri[1]

[1]Queensland Department of Agriculture and Fisheries, [2]EE Muir & Sons, Mareeba

* Corresponding author emily.pattison@daf.qld.gov.au

North Queensland citrus growers ranked Oriental spider mite the no. 1 pest issue. Growers rely solely on chemical control for the pest.

Left to right: 1. Oriental spider mite adults. Females larger with long legs held in a cross, males smaller with legs held along the side; 2. Spider mite colony on leaf, white casts can be seen, indicating long presence; 3. Oriental spider mite damage on fruit, giving washed out look caused by grey stippling; 4. Comparison between healthy leaf (left) and leaf affected by Oriental spider mite (right)

Demonstration 1 – Cultural and Biological Control Focus

Introduction

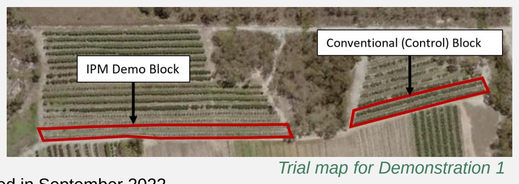
- An integrated pest management (IPM) demonstration was conducted to determine potential for conservation biological control (CBC) of Oriental spider mite in citrus orchards in North Queensland.
- Demonstration focussed on releasing beneficial mites and manipulating the environment to favour predators of the pest.

Methods

- Two lemon blocks consisting of two rows side-by-side was selected in Mareeba, Queensland. One block was managed using the grower's conventional practices for Oriental spider mite; the second block managed was using IPM principles.

IPM block treatments:

- Release of 10,000 adult predatory mites (*Neoseilius californicus*) fortnightly
- Interrow grasses allowed to flower and provide protein source for predatory mites
- Spraying 'softer' chemistry



Trial map for Demonstration 1

The different mite management systems and weekly monitoring was initiated in September 2022.

Interrow grass cover of the IPM block and conventionally managed block.

IPM block

Neoseilius californicus adult. Source: Natural Solutions

- Oriental spider mite populations monitored and recorded weekly at six sites within each block using 0-5 rating scale.
- Results expressed as the sum of the ratings, giving a score out of 30 for each block

0 No mites

1 1 mite/leaf

2 <5 mites/leaf

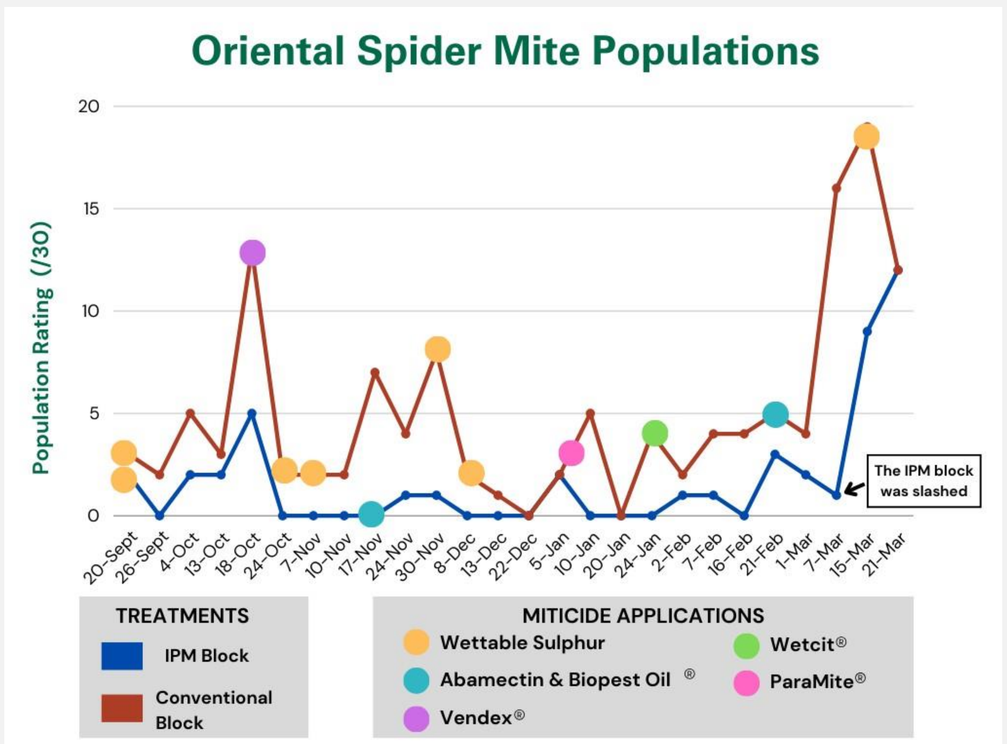
3 <10 mites/leaf

4 >10 mites/leaf, confined to midrib, moderate damage

5 >10 mites/leaf, covering whole leaf, high damage

Results

- 75% reduction of Oriental spider mite population in IPM block
- Only one miticide applied in IPM block vs. 10 in Conventional block
- Oriental Spider populations increased when interrow grass was slashed



Changes in the populations of Oriental spider mites with corresponding miticide applications in blocks under different management systems

Conclusion

1. Predatory mite releases and CBC (allowing interrow grass to flower) can provide effective mite control.
2. Further research is required to validate the results and evaluate predatory mite and CBC combination models:
   i. How often and at what rate do predatory mites need to be released?
   ii. Are there improved strategies for interrow slashing?

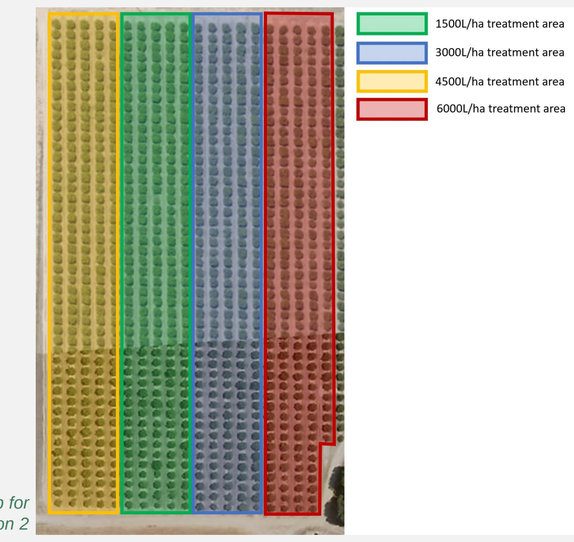
Demonstration 2 – Improving Chemical Control

Introduction

- Heavy reliance on wettable sulphur for Oriental spider mite control in North Queensland.
- Poor efficacy of wettable sulphur for control of Oriental spider mite.
- Site established to demonstrate spray volume requirements of wettable sulphur against Oriental spider mite.

Method

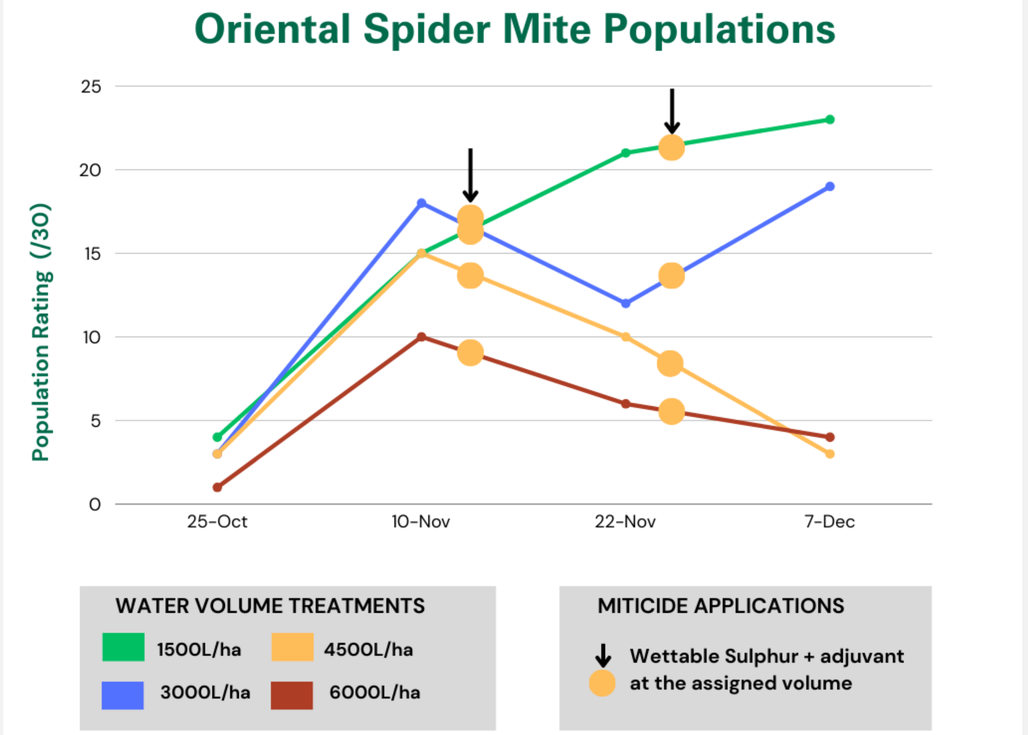
- 20 row lime block in Dimbulah, Queensland
- 4 sections of 5 rows
- Grower applied wettable sulphur (400g/100L) with surfactant. Volumes listed in figure to the right.
- Middle row of each treatment monitored at 6 locations for Oriental spider mite populations and damage.
- Oriental spider mite populations recorded using same rating scale outlined in demonstration 1.



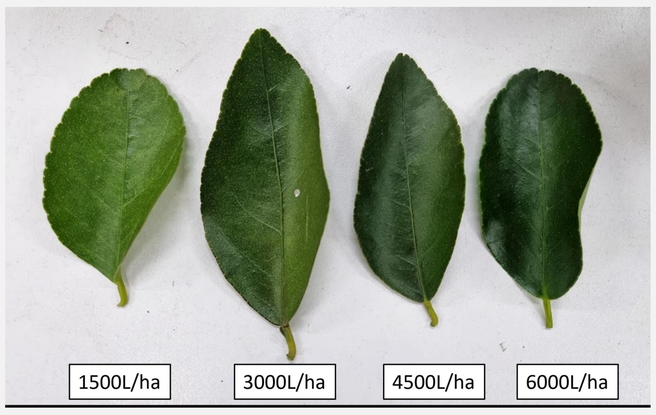
Trial map for Demonstration 2

Results

- The population monitoring results show two applications at 1500L/ha and 3000L/ha had poor mite control compared to 4500L/ha and 6000L/ha.
- More Oriental spider mite damage to leaves and fruit of blocks treated with 1500L/ha and 3000L/ha compared to 4500L/ha and 6000L/ha.



Populations of Oriental spider mites in blocks treated with wettable sulphur + adjuvant at different water volumes



Left: Representative leaves taken from each of the treatments demonstrating typical Oriental spider mite damage; Above: Representative fruit taken from the lowest and highest treatments demonstrating the difference in Oriental spider mite damage.

Conclusion

1. Wettable sulphur used at volumes above 4500L/ha and 600l/ha showed reduced Oriental spider mite populations and decreased damage on leaves and fruit.
2. Repetition of demonstration on more properties with a range of spray equipment required to validate results

Acknowledgements

Thank you to Hilltop Farming, Mareeba and Rocky Tops Farms, Dimbulah for hosting and assisting with the trial. Thank you to Darcy Filmer from Natural Solutions Australia for his assistance with technical knowledge.

Poster presented at the Australian Citrus Congress, 5-7th March 2024, Sunshine Coast, Australia.

daf.qld.gov.au

IPDM for the citrus industry

This project has been funded by Hort Innovation using the citrus research and development funds from the Australian Government. For more information on the fund and the strategic levy investment, visit horticulture.com.au

Queensland Government

Citrus gall wasp demonstration site

Citrus integrated pest and disease management extension program (CT19011)

Andrew Creek[1], Steven Falivene[1], Amanda Warren-Smith[1] and Rob Weppler[2]
[1]New South Wales Department Primary Industries, [2]Riverina IPM Pty Ltd

Introduction

This pest management demonstration was established on heavily-galled, unproductive Valencia orange trees (Figure 1). Differing management tools for citrus gall wasp (Figure 2) are being tested:

- systemic insecticide chemistry
- heavy hedge and calcined kaolin (Surround®) application (Figure 3)
- parasitic wasps.

Results

- Systemic insecticides had the trees productive in a year.
- Heavy hedging and good spray coverage of calcined kaolin was effective over 2 years.
- A repository of *Megastigmus brevivalvus* was successfully established (Figure 4). Many years are required for gall wasp control with parasitoids.

Program outputs

Seasonal farm walks (n=30) encouraged participants to observe trials and discuss seasonal pest management (Figure 5).

Fact sheets and videos from the extension program are published on the IPDM extension accordion of the NSW DPI horticulture website.

Figure 1. Heavily galled Valencia tree.

Figure 2. Female citrus gall wasp oviposits eggs into spring flush shoots.

Figure 3. Good spray coverage of kaolin.

Figure 4. Parasitic wasp *Megastigmus brevivalvus*.

Figure 5. Farm walk participants discuss seasonal pests and beneficials at the citrus gall wasp demonstration site.

Acknowledgement

We thankfully acknowledge collaboration with Ray Durkin from Corbie Hill, NSW for hosting this demonstration site.

Further information

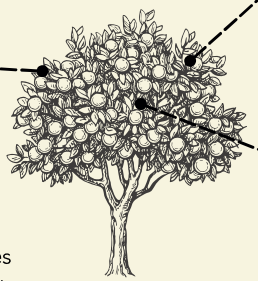
andrew.creek@dpi.nsw.gov.au

IPDM for the citrus industry

This project has been funded by Hort Innovation, using the citrus research and development levy, contributions from the Australian Government and co-investment from New South Wales Department of Primary Industries, Queensland Department of Agriculture and Fisheries and the Agricultural Produce Commission. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

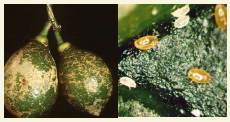
Major pests of North Queensland citrus

Mite pests

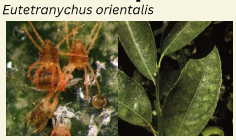


Broad mite
Polyphagotarsonemus latus

Attacks fruit from fingernail to golf ball sizes. It leaves a 'shark-skin' effect on fruit and can cause large amounts of damage. They are present all year, but not visible to the naked eye. Prefers shady areas.



Oriental spider mite
Eutetranychus orientalis



Found on fruit and leaves in full sun. Damaged fruit and leaves have a grey stippling that creates a 'washed out' appearance. Numbers peak in dry, hot conditions from October to March. Adults are visible to the naked eye.

Citrus rust mite
Phyllocoptruta oleivora

Found inside the canopy, generally on older fruit. Causes grey-brown scarring. Can downgrade large volumes of fruit. Numbers peak in humid conditions. Not visible to the naked eye.

Pests of leaves and shoots

Citrus leafminer
Phyllocnistis citrella

A small caterpillar that feeds beneath the leaf cuticle, causing silver mining trails and distorted foliage. It can be a major pest in young trees. Present all year.

Spherical mealybug
Nipaecoccus viridis

A spherical-shaped mealybug found inside the canopy and can move to fruit. Distorted flush is an early sign of infestation. It can cause copious amounts of sooty mould and deformed fruit. Numbers peak from September to January.

Ectropis looper
Ectropis sinistraria

The looper resembles a twig. They target fresh to recently hardened flush. Numbers peak after the wet season and breed very quickly. If not controlled, they can cause substantial defoliation.

Citrus aphid
Toxoptera citricida

Affects new shoots and flowers during winter and early spring when they feed as a colony. They can cause black sooty mould and stunted shoot growth.

Planthoppers
Colgar peracutum; Colgaroides acuminata; Siphanta acuta; Siphanta hebes

Juveniles are flat with angular heads. Adults are slim triangles, resembling sails. They are associated with white, waxy residue from tail filaments. They feed on fresh flush, primarily inside the tree and on fruit stems. They can cause copious amounts of sooty mould. Present all year.

Pests of flowers and small fruit

Citrus blossom midge
Cecidomya sp.

Eggs are laid into the ends of unopened flower buds. These buds enlarge, become pyramid-shaped and have a slightly green tinge. The larvae are present inside the bud if opened. Causes deformation of fruit and flowers to abort. Coincides with flowering.

Caterpillars produce silk to spin cocoon-like structures in flush or flowers and young fruit. They feed within this and can cause substantial damage to young fruit. Numbers peak from January to March.

Citrus leafroller
Psorosticha zizyphi

Lemon bud moth
Prays parilis

Similar to the leafroller. The caterpillar burrows into flower buds and eats the developing flower and fruitlets. It is not distinguishable by colour as it ranges from light green to dark brown. Coincides with flowering.

Banana spotting bug
Amblypelta lutescens lutescens

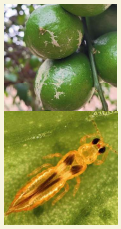
A sucking insect that attacks young fruit, causing a corky callus, which extends into the flesh and will be present until fruit maturity. It can also cause large volumes of young fruit to abort. Present all year.

Pests of fruit

Queensland fruit fly
Bactrocera tryoni

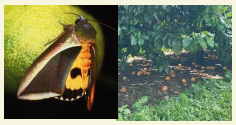
QFF is a major pest of green mature citrus. The adult is about 7 mm long, often mistaken for a wasp. It has implications for interstate and international trade. Numbers peak during summer.

Citrus rust thrips
Chaetanaphothrips orchidii



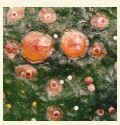
Small yellow thrips that cause grey-brown scarring on fruit. They can reproduce in large numbers particularly in the wet season. They prefer sites where fruit touch or under the calyx.

Fruit piercing moth
Eudocima phalonia



A seasonal moth that attacks ripening fruit, especially those that develop high brix. They live in scrub, and fly into the orchard at night. Attacks will cause fruit to decay and can cause widespread fruit drop close to harvest. Numbers peak in the wet season.

Red scale
Aonidiella aurantii



A reddish-brown scale that will cover fruit, twigs and leaves. They can breed very quickly, downgrading fruit and reducing tree vigour.

Pests of trunks

Citrus snow scale
Unaspis citri

Common on citrus trunks where airflow is low. Causes trunk splitting and reduces tree vigour.

IPDM for the citrus industry

CT19011 (Citrus industry IPDM project) has been funded by Hort Innovation using the citrus research and development funds from the Australian Government. For more information about strategic investment visit www.horticulture.com.au Produced in 2024.

Author:
Emily Pattison (QDAF)
Acknowledgements:
Jeff Watson
Ebony Faichney (Farmour)
Luke Trabucco (TGT)

CITRUS SOIL-BORNE DISEASE WEBINAR

Citrus Industry IPDM extension program presents an interactive session for growers with experts.

RSVP with your name by sms
to mobile: 0428 934 952
or email
andrew.creek@dpi.nsw.gov.au

4-5 PM AEST
3.30-4.30 PM ACST
2-3 PM AWST

Thursday 17 July

PRESENTATION 1:

Dr Tony Pattison, QLD DPI

Basic soil health, managing soil constraints and the benefit of biologically healthy soil

PRESENTATION 2:

Dr Nerida Donovan, NSW DPIRD

Phytophthora spp., symptoms, cause and management

IPDM for the citrus industry

This project has been funded by Hort Innovation, using the citrus research and development levy, contributions from the Australian Government and co-investment from New South Wales Department of Primary Industries, Queensland Department of Agriculture and Fisheries and the Agricultural Produce Commission. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

National integrated pest and disease management extension program (CT19011)

Andrew Creek[1], Ebony Faichney[2], Stefano De Faveri[2], Steven Falivene[1], Amanda Warren-Smith[1], Rachelle Johnstone[3], Bronwyn Walsh[4], Rob Weppler[5] and James Altman[6]
[1] New South Wales Department Primary Industries, [2] Queensland Department Agriculture & Fisheries, [3] Western Australia Department Primary Industries & Regional Development, [4] Agricultural Produce Commission, [5] Riverina IPM Pty Ltd, [6] Biological Services

Managing pests and diseases is one of the most critical practices for citrus growers to achieve short- and long-term goals for their business.

Protecting the crop each year is made more difficult by the ever increasing demands by consumers and communities for high quality citrus that is produced with reduced impact on the environment, as well as a greater emphasis on food safety.

This 4-year Hort Innovation project (CT19011) is designed to:

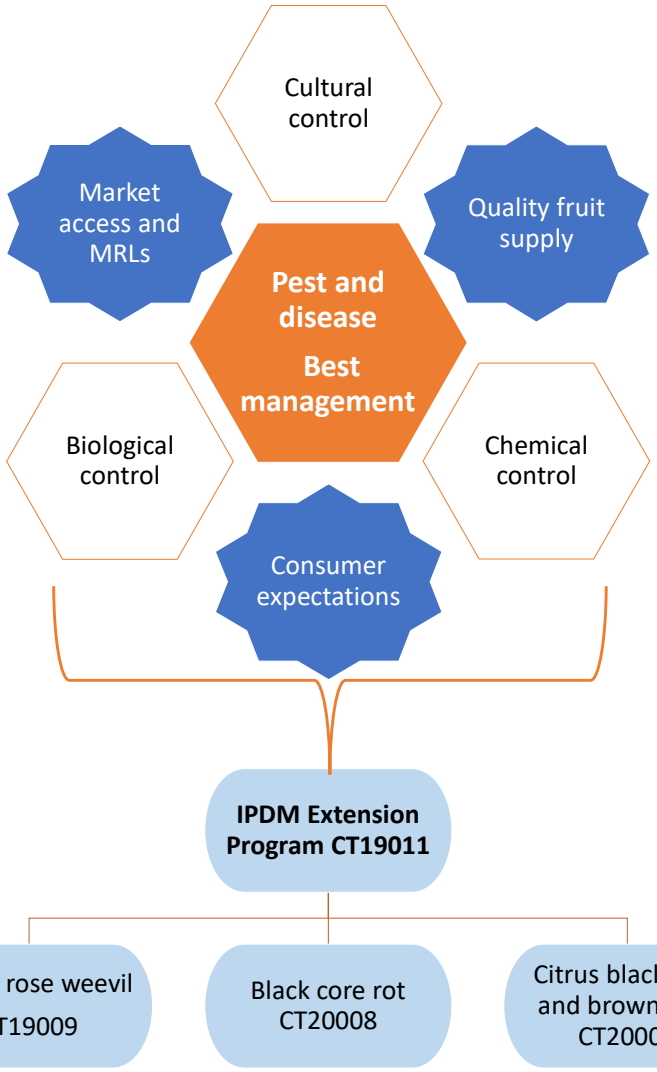
1. improve our understanding of how the citrus industry is currently managing pests and diseases
2. provide a roadmap for practice change to best meet business needs while meeting the broader requirements of domestic and global supply chains and societies' expectations of modern agriculture.

Aphytis spp. wasps in cups ready for release as part of an IPM program to manage red scale.

IPDM best practice

IPDM challenges

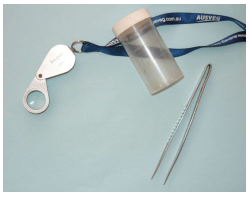
Current projects



CT19011 will bring together outcomes from previous and current citrus IPDM research projects to implement best practice crop protection strategies.

Septoria spot: applying fungicide before autumn rain will reduce disease incidence. Pruning trees annually after harvest will improve air circulation in the canopy and spray penetration.

Integrated pest and disease management requires multiple methods.



Monitoring tools are cheap and effective.

Grassed inter-rows provide shelter and food for beneficials.

Good spray coverage is critical for any chemical controls.

Farm walks and IPDM workshops will be held in all major growing areas. Growers and researchers will collaboratively design and manage regional on-farm IPDM demonstration sites to try practical and sustainable pest and disease management alternatives.

IPDM for the citrus industry

This project has been funded by Hort Innovation using the citrus research and development funds from the Australian Government. For more information on the fund and the strategic levy investment, visit horticulture.com.au

M&E reporting – NQ and SQ

End of Project Outcomes

1. How did you/this project increase growers' and crop advisors' knowledge of citrus pests and diseases?

North Queensland
This project significantly increased awareness and knowledge through targeted extension materials and events. The *Major Pests of North Queensland* poster received an overwhelmingly positive response and was distributed widely, including at the Oriental Spider Mite Field Walk (15 March 2025), via agronomy branches, and will be featured at the upcoming NQ Rotary Field Days, which draws approximately 8,000 attendees.

In addition, factsheets were developed on key regional pests such as mite pests, Spherical Mealybug, Flatids, and Fruit Spotting Bug. These resources have provided accessible, practical information to support pest identification and management decisions across the region.

Southern Queensland
In response to diseases (Citrus black spot and Emperor brown spot) being identified as the region's key concern (based on initial survey results), the project developed factsheets on these two diseases. These resources have helped improve understanding of disease epidemiology and support more informed management decisions.

A webinar is also being produced to address soil-borne diseases such as Phytophthora, another priority identified during the project, with a focus on improving soil health and disease suppression.

2. How did you increase growers' and crop advisors' knowledge of IPDM?

North Queensland
Knowledge of IPDM principles was strengthened through multiple activities. The *Mite-y Mites of North Queensland* resource, developed with Citrus Australia, highlighted biological control options and increased understanding of non-chemical approaches.

On-ground demonstration trials, such as those focused on Oriental Spider Mite, provided first-hand learning opportunities. Post-event evaluations showed that 55% of participants gained new IPDM knowledge, and 66% reported increased confidence in applying IPDM strategies.

Additionally, extensive but informal support was provided to agronomist to administer the use of Cryptolaemus (*Cryptolaemus montrouzieri*) a ladybug predator of mealybugs as an alternative to spraying. This was a highly successful programme and increased advisor confidence in IPDM strategies.

Southern Queensland
Grower and advisor engagement was enhanced through the *Mandarin Canopy Management and Pests and Disease Workshop* in Mundubbera, which featured expert insights on cultural control methods and improving spray coverage.

A study tour to the Riverina enabled cross-regional learning on Gall Wasp management—an emerging issue for Southern Queensland as well as Red Scale and canopy management. Additionally, two targeted videos showcased cultural practices aligned with project CT20009 (Integrated disease management of citrus black spot and 'Emperor' brown spot), further supporting practical IPDM uptake in the region.

3. How did you increase adoption of IPDM strategies to manage pests and diseases in citrus?

North Queensland
This project led to tangible changes in pest management practices. Most notably, the adoption of Cryptolaemus as a biological control for Spherical mealybug increased. With support from CT19011 staff, four growers adopted the practice—three for the first time—and all reported successful outcomes and intent to continue.

The project team provided technical support on optimal release timing, compatible chemicals, and application techniques, helping overcome past barriers. Initial baseline surveys showed 44% of growers were already using beneficials, mostly early adopters. Project efforts helped shift adoption toward the "early majority" phase, indicating growing momentum.

Southern Queensland
Although IPDM adoption was already high, the project fostered further improvements—especially in cultural disease control. Case studies highlighted enhanced orchard hygiene practices, such as the removal of deadwood to lower Citrus black spot inoculum. This message was reinforced at the 2023 Citrus Regional Forum, where growers reported increased prioritisation of this practice.

4. Was there a reduction of chemical residues in Australian citrus as a result of this project?

North Queensland
The project addressed high chemical use (averaging 38 pesticide applications/year) by promoting efficiency and alternatives. Spray calibration workshops and volume demonstrations targeted to agronomists and growers to improve application accuracy and reduce the need for follow-up sprays. IPM demonstration trials—such as "An IPM approach to Oriental spider mite control"—reinforced these principles, although this practice has not moved into an adoption phase but is still considered progress in that direction. Oriental spider mite is responsible for most of the pesticide applications in the region, therefore addressing this pest was a priority. These efforts contribute to reducing both overall chemical use and residue levels in the long term.

Southern Queensland
Residue management is a critical issue for export markets. The project built on CT20009 by exploring and promoting low-residue and organic product alternatives for late-season disease control. While registrations are still pending, this work provides growers with a framework for safer chemical use aligned with market requirements and progresses industry knowledge as preparedness for when these chemistries become available.

5. Is the Australian citrus industry better equipped to continue production with the future loss of some chemical options?

North Queensland
The project directly addressed the loss of critical chemistries—such as chlorothalonil—and the risk of resistance to others like abamectin. By supporting beneficial insect releases and offering alternatives through IPDM strategies, the project has helped the industry prepare for reduced chemical availability. The success of Cryptolaemus releases for Spherical mealybug shows the industry's growing capacity to manage key pests without sole reliance on chemicals.

Southern Queensland
In anticipation of the potential loss of mancozeb—a critical fungicide for this region—the project promoted cultural controls and the use of lower residue risk chemical alternatives, such as copper fungicides. These strategies, combined with outputs from CT20009, are already being adopted by some growers. This work positions the region to adapt more readily to regulatory changes, safeguarding long-term production capacity and access to export markets.

Intermediate outcomes

6. Did the project engage with growers and advisers at a farm level through workshops, farm walks, and IPDM grower group meetings?

This project prioritised farm-level engagement with growers and advisors in both North and Southern Queensland, using hands-on learning formats such as field walks, workshops, and on-farm demonstration trials to showcase practical IPDM strategies.

North Queensland
The field walk model proved effective, with strong grower attendance and engagement. The on-farm demonstration sites helped growers relate directly to the management strategies presented, increasing the relevance and adoption of IPDM practices.

Southern Queensland

Engagement was more challenging due to time constraints among growers, many of whom delegated pest and disease responsibilities to crop advisors. In response, the project strategically adapted its delivery approach. Instead of traditional workshops, key outcomes and trial results were communicated via short, accessible videos featuring real growers and on-farm case studies. This maintained a strong connection to the farm context while accommodating the region’s preference for flexible, time-efficient formats.

This dual approach ensured the project remained responsive to regional needs and maximised the reach and impact of IPDM messaging.

7. Was on-farm engagement supported by additional resources such as guides, factsheets, industry articles, and videos?

On-farm engagement was reinforced through a comprehensive suite of extension resources, including a field guide, region-specific factsheets, published industry articles (Citrus Australia News), and a series of targeted video resources designed to support knowledge transfer.

North Queensland

Key pests and diseases in each region were addressed using a multi-faceted approach that combined practical on-farm demonstrations with follow-up learning opportunities. In North Queensland, the focus was on mites—particularly Oriental spider mite. Two on-farm demonstration trials, two field walks, a factsheet, and a supporting video were developed around this pest. Additionally, technical support was provided to agronomists managing Spherical mealybug, complemented by a dedicated factsheet to guide decision-making.

Southern Queensland
In Southern Queensland, the emphasis was on disease management, particularly Citrus black spot and Emperor brown spot. Information from field trials was extended through field walks, videos, and factsheets that highlighted cultural and chemical control options.

This layered approach ensured that growers had access to consistent, regionally relevant information across multiple platforms—empowering them to make informed decisions and supporting the broader adoption of IPDM strategies.

8. Extend current knowledge, skills, and tools on IPDM of pests and diseases in citrus orchards in collaboration with current citrus pest and disease management projects

North Queensland
While opportunities for collaboration with levy-funded projects in North Queensland were limited due to the lack of relevant activity in the region, partnerships with private industry—including EE Muir and Sons and Nutrien—were effectively leveraged to strengthen IPDM extension. Additionally, the demonstration trial *"An IPM Approach to Oriental Spider Mite Control"* led to the commissioning of a similar project supported Queensland Government Reef water quality funding. Learnings from the original CT19011 demo were carried forward and supported by project staff, ensuring continuity and impact beyond the life of the project.

Southern Queensland
In Southern Queensland, collaboration with CT20009 was central to project delivery. Although CT20009 had strong field trials and valuable technical outcomes, it lacked extension capacity. CT19011 addressed this gap by working closely with CT20009 staff to co-deliver workshops, produce videos, and develop factsheets, ensuring that knowledge and tools reached growers and advisors effectively. Nearly all activities in Southern Queensland were delivered in alignment with CT20009, providing a consistent and coordinated extension effort.

9. Undertake regional participatory on-farm demonstration sites to support the further development of IPDM for the citrus industry. At each demonstration site, growers and horticultural agronomists participate in both the collection of monitoring data and the management decisions of the site.

All demonstration trials were conducted on commercial citrus farms, enabling strong grower engagement through direct involvement in the trial setup, management decisions, and data collection. This participatory approach fostered a sense of ownership and ensured the relevance of results to real-world production systems.

North Queensland
Two on-farm demonstration trials were undertaken in this region. Both were hosted and actively managed by commercial growers, with support from the project team.

- *An IPM approach to Oriental spider mite control*
  In this trial, the grower agreed not to apply miticides, allowing beneficial populations to establish. Pest scouting was conducted in collaboration with the grower's own crop scout, facilitating shared learning across the industry. At the conclusion of the trial, the grower expressed surprise and satisfaction with the fruit quality, commenting on how clean the fruit was despite no miticide sprays being applied.
- *Optimising spray volumes for wettable sulphur for Oriental spider mite control*
  The grower was actively involved in planning and implementing the trial, including the application of treatments based on a spray map provided by the project team. The grower followed the protocol to compare spray volumes and expressed strong interest in the outcomes, reinforcing the value of hands-on, collaborative demonstration work.

Southern Queensland

A demonstration trial was conducted in collaboration with a grower to assess the impact of infected dead wood on Citrus Black Spot inoculum levels. The grower maintained regular block management but agreed not to harvest the fruit so that it could be assessed for trial purposes. He later participated in a project video, where he described his surprise at the results and confirmed he had adopted improved tree hygiene practices as a result of the findings.