Hort Innovation

Final Report

The IPM program for the Macadamia industry – IPM Technologies

Project leader:

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Delivery partner:

IPM Technologies Pty Ltd

Project code:

MC16006

Project:

The IPM program for the Macadamia industry – IPM Technologies MC16006

Disclaimer:

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Content

Summary

This project was part of a larger IPM program that aimed to strengthen the viability of the Macadamia industry by developing, demonstrating and facilitating the adoption of improved and truly integrated strategies to manage all arthropod pests. The larger IPM program aimed to bring together a team of experienced researchers with specific knowledge of the management of pests in Macadamias.

IPM Technologies role was to contribute to the broader IPM program by providing leadership and expert advice on the development and adoption of an IPM strategy. The initial aim was for IPM Technologies to train the program team in a research/extension model that has proven highly successful in many industries. The focus of this model was to work closely with local advisors, extension service providers and growers on real farms to help ensure that the Program has a lasting legacy.

The latter part of the project relied totally on a willingness to collaborate with on-farm demonstrations of practical IPM decision making. While some consultants and growers were keen to do this, there was not sufficient support from all major partners for these IPM extension activities to occur. IPM Technologies reached the limit of what it could contribute in the project earlier than expected and so requested to terminate their involvement at a project meeting in 2019.

Keywords

Integrated Pest Management; IPM; macadamias; workshops; advisory role.

Introduction

This project is part of a larger IPM program that aims to strengthen the viability of the Australian Macadamia Industry by developing, demonstrating and facilitating adoption of improved and truly integrated strategies to manage all arthropod pests. The larger IPM program brings together a team of highly experienced researchers with considerable experience, specifically in pest management in macadamias and in IPM strategy, extension and adoption. The collaborators in the program are as follows:

Partner	Key role
MC16003 Program Coordinator	Overall integration and delivery of the Program (resigned 2017)
MC16004 NSW-DPI	Biology and ecology of pests and beneficials, field validation of IPM tools, species diagnostics
University of Southern QLD (subcontract to DPI)	Entomopathogens in IPM of macadamias –PhD student
Southern Cross University (subcontract to DPI)	Insect pest Volatile analysis
Pest Consultants (subcontract to DPI)	Monitoring and data collection
MC16005 DAF	Pheromone, Entomopathogen development, Benchmarking
MC16006 IPM Technologies	Extension Strategy and Training
MC16007 University of Sunshine Coast	Insect Behaviour in response to insect pest volatiles
MC16008 BioResources	Inter-row management to encourage beneficials

The objective of IPM Technologies' contribution to the broader IPM program was to provide leadership and expert advice on the development and delivery of an IPM extension strategy to ensure optimal industry adoption of IPM.

Methodology

The aim for this project was that IPM Technologies would contribute to the overall outcomes of the broader IPM Program through providing leadership, with NSW DPI, for extension and optimal industry adoption of IPM. We did this through our involvement in five areas of the Program.

1). Paul Horne and subsequently Jessica Page, provided leadership and expert advice for the extension component of the IPM Program through participation in the Program Reference Group (PRG) and through input in team meetings and consultants meetings.

2). As independent experts in the field, IPM Technologies provided support for NSW DPI to develop a survey to gather baseline data on current pest management practice in the macadamia industry (Year 1).

3) IPM Technologies developed an IPM matrix and IPM extension strategy for arthropod pest management in macadamias. A region-specific IPM matrix and IPM extension strategy was developed for each of the four major growing regions (Bundaberg, Glasshouse/Gympie, Northern Rivers, and NSW Mid-North Coast (Valla - Yarrahappinni). These outputs were developed through a workshop process repeated in each region and facilitated by two IPM Technologies entomologists at each location. Invited to these workshops were NSW DPI and other researchers, growers, advisors and extension personnel.

The workshops incorporated knowledge and experience from all attendees and developed an agreed strategy that combines all currently available (and potential future) pest management options. It provides the framework for a participatory demonstration of current best-practice in each location, as well as highlighting the areas where further research is needed or is underway but not yet proven. These workshops were conducted in Year 1.

The aim of the workshops was to synthesise the existing knowledge provided by the participants into a one-page matrix. To achieve this IPM Technologies facilitated a discussion that first listed the pests of interest to each group, then the likely biological control agents that could be used. The next step was to identify cultural (management) options that would either make conditions better for beneficial species or worse for pest species. The final step was to look at what chemical or spray options could be used that would be compatible (or not) with the biological control agents. These were listed as either available now or potentially available in the future.

The results of these workshops are presented in Appendix 2 - Table 1 (from Macksville and Wollongbar) and Table 2 (from Nambour and Bundaberg). Pesticides listed in red in the tables should be avoided (or applied only in the form of spot sprays, baits or border sprays) in an IPM approach.

Feedback from the workshops was extremely positive (see Appendix 3) Some of the comments about the workshops included the small group size, clear, succinct, relaxed and interactive presentation, list of options for change, presenters listened to our concerns, discussing adoption process, having growers present, different perspective on IPM, informative presenters, lack of promotion, not imposing anything on us, balanced presentation, felt that the presenters were really willing to support us, challenging current practice, logical approach, Independent advice, good communicators, real examples of IPM, communicated on our level.

4). Following the workshop in each region, an IPM Technologies entomologist made visits to each of the four major growing regions to conduct intensive field training with local extension personnel. (One visit to each region per year in years 1 and 2.) Further workshops were requested and delivered in the Northern Rivers and Glasshouse Mountains regions.

5). In addition to on-the-ground training in extension methodology and delivery, IPM Technologies provided limited ongoing back-up support to extension personnel and other program team members to attempt to guide extension delivery throughout the life of the project. This included presentations at the Macadamia Society Conference and at Consultants Meetings.

6). IPM Technologies attempted to assist with trial design and extension activities being conducted by NSW DPI but there was little uptake of our suggestions.

A summary of these activities, as presented in Milestone Reports is as follows:

Milestone 102

Participated in first program team meeting (Paul Horne).

A two-day IPM Project meeting was held in NSW DPI offices, Wollongbar, 8 – 9 December 2016. Dr Paul Horne attended this meeting on behalf of IPM Technologies and presented the concept of implementing IPM progressively through the course of the project. Paul also was involved in the discussions throughout the two days which developed an M & E Plan and Programme Logic.

M&E Plan delivered

During the two-day meeting referred to above an M&E Plan was developed for this project as part of the overall planning for the entire project. The document produced is attached as **Appendix 1**.

Supported NSW DPI to develop IPM practice baseline survey

In conjunction with NSW DPI, IPM Technologies prepared draft surveys designed to provide baseline information on the current level of awareness and adoption of IPM in the macadamia industry in Australia. These were further developed by NSW DPI and will be distributed by them at appropriate industry meetings and conferences. The information collected from these surveys will be used to compare with data collected at the end of the project and so will allow a measure of change that may occur during the life of the project.

Milestone 103

The key achievement for this reporting period has been the involvement of IPM Technologies running a series of five workshops in 4 major growing regions. Each workshop ran for over 3 hours and in each instance an IPM strategy specific to the region was developed. These strategies now provide the basis for extension of IPM during the project, and are attached.

Paul Horne was involved in PRG meetings both by phone hook-up and in meetings in Bundaberg and Brisbane.

Milestone 104

Participated in Year 1 steering committee, team and consultants' meetings (Jessica Page).

Jessica Page participated in PRG meetings that were held as phone hook-ups (18th July, 3rd October and 4th October 2018) and at meetings in Caloundra (8th June 2018) and Ballina (7th and 8th February 2018). An additional brief meeting with Jolyon Burnett and Leonie Kojetin was held in Brisbane to discuss additional involvement from IPM Technologies (Paul Horne).

One field extension visit delivered in each of 4 major growing regions.

No extension activities have been proposed by NSW DPI during this reporting period which required our involvement, however Jeremy Bright participated in one of the additional workshops described below.

Back-up extension support and advice on IPM program provided.

Back-up support has been available to all involved in the project and specifically in workshops conducted in this project. Some advice has been given to consultants via phone and email for specific issues.

Additional Workshops and field visits

Following the original series of workshops there was interest from several key consultants in having IPM Technologies run a similar set of workshops involving consultants with some of the growers with whom they work. Four such workshops were conducted, as follows: One in the Glasshouse Mountains (Allan Coates and clients), Ballina (two with Jarrah Coates and clients; one with Bill Johnstone and clients). Each workshop ran for just over 3 hours and was capped at a maximum of 18 participants in any workshop. Numbers of people attending each were as follows: 14, 17, 16 and 15. Leonie Kojetin attended two of these workshops and Jeremy Bright attended one. Two entomologists from IPM Technologies (Paul Horne and Jessica Page) were present at each workshop to run these events.

As with the previous set of workshops, the aim was to synthesise the existing knowledge provided by the participants into a one-page matrix. However, a further goal was to identify growers who would work to then implement that strategy. To achieve this IPM Technologies facilitated a discussion that first listed the pests of interest to each group, then the likely biological control agents that could be used. The next step was to identify cultural (management) options that would either make conditions better for beneficial species or worse for pest species. The final step was to look at what chemical or spray options could be used that would be compatible (or not) with the biological control agents. These were listed as either available now or potentially available in the future.

Feedback from participants in the workshops was extremely positive. Feedback for each session is summarized in Appendix 3.

A summary of the workshops that was sent to all participants via the consultant. Appendix 2 contains the tables that summarize the IPM strategies that were developed in the 4 workshops.

Consultants Meeting – Caloundra

Paul Horne and Jessica Page presented a summary of the IPM approach, how it has worked in other crops and how it might look in macadamias. Following the presentation, we ran three short workshop – style sessions with assistance from Allan and Jarrah Coates.

Milestone 105

Participated in Program Reference Group, team and consultants' meetings (Jessica Page).

Jessica Page participated in the annual researcher meetings (12th Nov 2018 Gold Coast and 22nd October Brisbane) and PRG meeting (18th Feb Brisbane). An additional meeting was held at the Wollongbar research station (26/27 Nov. 2018) and was attended by Jessica Page, Ruth Huwer, Mark Hickey, Jeremy Bright and Craig Maddox. Jessica also attended a meeting on the 30th Sept 2019 in Brisbane to discuss the results of the mid-term review and provide recommendations on how to move forward.

Back-up extension support and advice on IPM program provided.

Back-up support has been available to all involved in the project. Some advice has been given to consultants via phone and email for specific issues.

Outputs

Two IPM strategies were developed as a result of the initial 5 workshops conducted in Year 1. These are attached in Appendix 2. Later workshops produced very similar strategies. These documents are the main Outputs of the IPM Technologies component of the program and provide a guideline to what is required for pest management in the Macadamia industry.

A summary of outputs, as presented in previous Milestone reports is as follows:

MS102

A thorough industry consultation conducted with the Macadamia industry to identify priority regions to target project delivery

MS103

Preparation of IPM strategies for the 4 major growing regions. (Appendix 2).

MS104

- IPM strategies for the range of pests to be dealt with in 4 different growing regions have been prepared.
- These draft strategies form the basis for any IPM extension in the future.
- The involvement of growers with advisors has resulted in greater levels of participation in implementing IPM.
- The draft strategies are now the basis for growers wanting to make change

MS105

Providing comment and backup on trial design and extension activities were important elements of the IPM Technologies component to the project. An example of the detailed comments on trial design was provided in MS105 and is shown below.

Proposed design for CTH trials 2019/2021
21/03/2019
Jessica Page, IPM Technologies

- The Alstonville trial farm provides an excellent opportunity to trial aspects of IPM that cannot be done on commercial farms where yield loss is unacceptable such as removal of some pesticides.

- Trials from the previous two years have successfully identified products that are not broad-spectrum that can be used for managing some of the key pests of macadamias. The issue with these products is that they are more expensive, target a narrow range of pests and may not be as efficacious. To get value out of using these products they need to be used strategically and supported by other management strategies.

- To add to the results from the previous trial work, I suggest using a simplified trial design with a more rigorous and complex assessment to answer; **"what happens to pest and beneficial populations over time when a habitat is changed by pruning trees, plant diversity is increased by interrow plantings and broad-spectrum insecticides are taken out of the spray program"**. The value in asking these questions is that the answer will help provide a better understanding of the limitations and benefits of using selective chemistry. This in turn will help growers and agronomists choose the right product for the right pest.

- The suggested design is for the Standard block (13-16) to remain the same. The remaining three blocks (1-12) are to be treated as one "Entomology" block. Decisions on pesticide use will be made based on monitoring and sampling for pests and beneficials and will be done before and after all pesticide applications. Sampling methods will be refined to allow for a timely assessment and are in-line with

consultants' methods. The pesticides used in the Entomology block will be selected from the list of IPM compatible products. The data collection will be based on a standardized grid pattern so that statistical analysis can be applied (check with biometrician).

- Assessment and reporting of the trial will be done collaboratively by NSW DPI and IPM Technologies.

Timing	Main target pest	Standard block (13-16)
August/ September	Macadamia lace bug and or felted coccid	Diazinon (i.e Diazinon)
October/ November	MSW	Acephate (i.e. Lancer) Hygiene
November/ December	FSB, MSW, MNB	Acephate (i.e. Lancer) Hygiene
December/ January	FSB, MSW, MNB	Beta-cyfluthrin (i.e. Bulldock)
January/ February	FSB, MSW, MNB	Beta-cyfluthrin (i.e. Bulldock)
February/ march	Mites, MNB*	Abamectin (i.e. Stealth)*
March	MSW	
	FSB = Fruitspotting bug **MSW** = macadamia seed weevil, **MNB** = macadamia nutborer	**ROW 1** Mown inter-row **ROW 2** Mown inter-row **ROW 3** Broadspectrum Chemical

BUFFER ROW

Products

Lace bugs - Transform

Seed weevil – Avatar

FSB – Transform, Sivanto, SYNFO121?

BayerDC163?

MNB – Prodigy? Venerate

Cultural

Hygiene

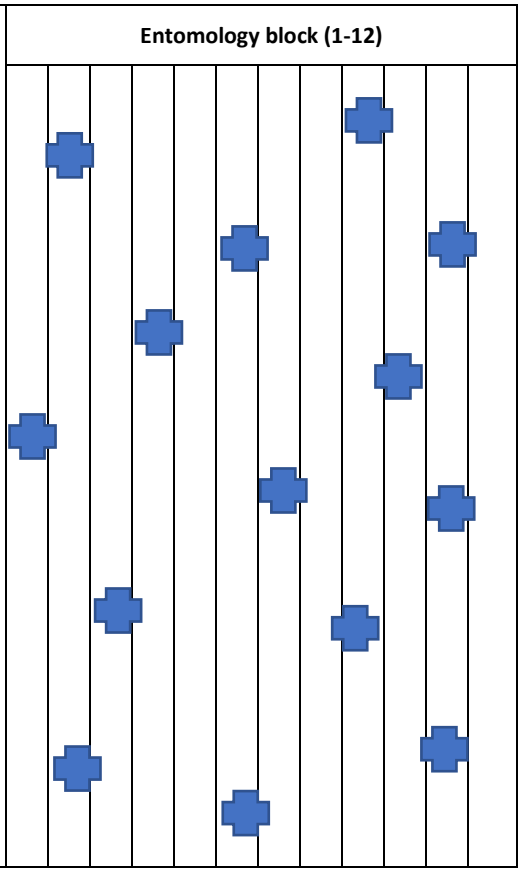
Inter-row plantings

Tree pruning

Beneficials

Naturally occurring

MacTrix



Sampling points (just as an example)

The above trial design was presented to NSW DPI after concerns about the validity of the results of the CTH trial site. Of particular concern was the complex trial design with limited replication. The proposed changes were intended to be the starting point for working collaboratively to improve the value for the industry of the CTH trials by reducing the number of variables and unnecessary data collection. This was discussed with NSW DPI but they were not supportive of this idea.

Outcomes

As a result of this project there is now a much greater awareness by the macadamia industry of what an IPM strategy involves and that the use of many of the current pesticides is unsustainable and is inducing secondary pests. The project has raised awareness that a more sustainable approach that relies more on biological and cultural controls is possible.

What was very clear from the workshops run by IPM Technologies was that the macadamia industry has a lot of knowledge about pests and beneficials and that there are a wide range of management options currently available that are known and, in many instances, being used in commercial operations. The workshops were able to synthesise these available options and show how integrating them in a compatible way would provide a much better and sustainable means of managing pests.

The main problem with implementing such an IPM strategy in the absence of a crisis is that some of the cultural control options are not easy and require a commitment to change. This includes factors such as tree height and spacing, canopy management and inter-row management.

Since the initial workshops control of Macadamia seed weevil (prev. called Sigastus weevil), indoxacarb has been registered and so during the life of this project it has changed from being "possible in the future" to being registered. This has been a great help in reducing the use of synthetic pyrethroid insecticides but should not be seen as a final answer.

Monitoring and evaluation

This project has contributed to the overarching goals of the program, specifically Objective 1: Sustainably increasing the productivity of Australian macadamia farms. This has been achieved through the immediate program outcome of Increasing awareness of IPM. The influencing activities that have achieved this are farm walks and workshops. Evaluation of the success of these activities is provided by the feedback from participants at these events. The feedback indicates that the participants gained increased knowledge and understanding that IPM is a viable alternative to a calendar-based spray program.

Recommendations

IPM Technologies has voluntarily terminated their contract for this project. The reason for doing so is due to fundamental differences between our approach to adoption of IPM, trial designs and extension activities to those of some other partners within the program. These differences cannot be resolved therefore IPM Technologies continued involvement with this project is of little value to the industry.

IPM Technologies has been highly successful in increasing the rate of adoption of IPM in a wide range of industries. The key to this success is understanding that there is a very big difference between what is typically regarded as extension and what is needed for IPM adoption. Extension primarily involves the collecting and sharing of information and adoption involves turning this information into usable advice. Information on life cycles, management practices, pesticides and monitoring tools are vital for the uptake of IPM and can be distributed to a wide audience through manuals, phone apps, webinars, id guides and fact sheets but this information alone rarely brings about wide scale adoption. Extension that relies heavily on presenting information and data can have the adverse effect of making IPM seem complicated and confusing and making a calendar spray program seem like a much easier and lower risk option. In the commercial world of farming the biggest barriers to adoption of IPM are cheap pesticides that work.

A very real driver for change in the Macadamia industry is the withdrawal of pesticides. While a range of insecticides are available at present, it is likely that some of the widely used broad-spectrum insecticides will be withdrawn in the near future. Another likely change is that countries to which Australia exports will require that certain products are not used, even though they may be registered and legal in Australia. These issues mean that the Macadamia industry in Australia needs to reduce reliance on broad-spectrum pesticides and this is widely accepted within the industry. This is the perfect opportunity for research and extension to bring about wide-scale adoption of IPM right now. There is enough information already known and there are growers and consultants wanting to make changes. Understanding that IPM is an integrated set of control options for all pests and not a spray program that includes IPM compatible products is a major challenge for this program as is the industries search for the silver bullet chemical control

of fruit spotting bug. Considering the impact of the control measures on the biological and cultural controls of other pests is integral for IPM as without it IPM will fail.

Working closely with consultants and growers to develop practical methods for monitoring and decision making on real farms is the key to successful IPM adoption. Our recommendation for the industry is to make this happen.

Refereed scientific publications

None to report.

Intellectual property, commercialisation and confidentiality

No IP

Acknowledgements

We wish to acknowledge Alan and Jarrah Coates, Abigail Makim, Richard Llewellyn and Leoni Kojetin for their commitment to IPM.

Appendices

Appendix 1: M & E Plan

Appendix 1: M&E Plan

IPM Extension and Adoption

IPM Technologies (MC16006)

- **Leadership for IPM extension and adoption**
- **Survey current practice**
- **Gain feedback on awareness, intentions, use and issues relevant to IPM program**

Program Name: IPM Program for the Macadamia Industry **Number:** MC16003-8

Date Started: 1/12/2016

Completion date: 28/02/2022

Evaluation Level	Program Details	Performance Measures	Evaluation Methods
Broader Goals Potential longer term impacts on industry productivity, profitability, environmental and/or social benefits **Contribution to industry Objectives** Macadamia Industry SIP Horticulture Innovation Australia	**Potential Long Term Impact** **Macadamia Industry – Strategic Investment Plan 2014-2019 (SIP)** Objective 1: Sustainably increasing the productivity of Australian macadamia farms Objective 3: Improving stakeholder confidence in the Australian macadamia industry Strategic investment areas ID opportunities to improve productivity in existing orchard base [or, in this case maintain productivity even though less use of broad spectrum pesticides] Promoting industry successes to increase the confidence and investment of the industry	**Extent to which IPM strategies and practices are used in the Macadamia industry** The extent of reduction of highly toxic or bioaccumulative pesticide use and of broad spectrum chemicals and their replacement with more targeted, sustainable chemicals The extent of reduction in nut loss and in rejections due to insect damage The extent of improvement in profitability and sustainability of the industry due to IPM strategies being used over time.	**[Not necessarily the direct responsibility of the funded Program]** Industry surveys/reports Surveys of stakeholders Collated data from the benchmarking component of the Program Industry benchmarking data Regional production data Consultants' meeting surveys
Immediate Program Outcomes [expected to be achieved in the life of the program] Extent of	***By February 2022:*** **Industry level** • Across-industry agreement of IPM definition and key components and	**Industry level** The extent of agreement with	*Collaboration with evaluation being used in Macadamia Innovation & Adoption Program – questions specific to IPM –*

Evaluation Level	Program Details	Performance Measures	Evaluation Methods
Awareness Gains in Knowledge and Skills Extent of practice change Indicative benefits Barriers and Enablers	widespread agreement that IPM is a valid, profitable and sustainable approach to Macadamia production **Capacity and Practice change** Increased understanding of biology and ecology of insects by consultants, researchers and growers – underpinning interest in IPM and willingness to progress and adopt • 80+% of scouts are using new/improved tools • 40+% of consultants/scouts and producers (by ha) have adopted or refined their use of two or more of the key IPM components (tools, chemicals, beneficials, lures, management approaches – e.g. monitoring thresholds)	the definition and the validity of IPM across the industry and the level of awareness of key components, improvement in understanding, skills and motivation to incorporate IPM into management and advice. **Capacity and practice change** The number of producers and the production base represented (and advisers) who have added one or more of the key IPM components to their enterprises (or advice) influenced by the program compared to target. Changes in broad spectrum chemical use compared to target – and sales of beneficials, tools and other recommended products Changes in the number of consultants using best management data to encourage IPM compared to target.	program specific methods where appropriate Feedback sheets from participants of extension activities/industry meetings - questions specific to impacts on understanding, skills and motivation re IPM. Follow-up adoption surveys of producers engaged in activities. Final adoption survey – across sample of producers and consultants.

Evaluation Level	Program Details	Performance Measures	Evaluation Methods
	• 50% of consultants are using best management (BM) reports as a tool for increasing the uptake of IPM • Reduction of use of broad spectrum insecticides by 20+% **Indicative Impact** • One-third reduction in insect damage • Increased productivity, profitability and sustainability at farm level	**Benefits** The calculated and measured impacts of the changes in terms of their indicative impact on productivity and/or reduction in costs and sustainability and farm gate value – farm level and collated industry level. Reductions in the extent of insect damage compared to target Barriers to change and benefits, learning and issues identified for future action.	
Influencing Activities Extension Activities – field days, farm walks	**Communication** **Extension activities** ***Overall – across program*** • On-going liaison and joint activities with Macadamia Innovation & Adoption program ○ Attend and engage with MacGroups	Extent of awareness of IPM program, outputs and messages and interest and confidence in the information and tools being produced. The extent to which consultants/scouts and producers (and the production base they represent) are engaged in program activities and their reaction (perceived value) to those activities – compared	*Collaboration with evaluation being used in Macadamia Innovation & Adoption Program and Communications project – questions specific to IPM* – program specific methods where appropriate Feedback on producer surveys about the different communication and extension activities in

Evaluation Level	Program Details	Performance Measures	Evaluation Methods
	Biology and Ecology • Engagement with other researchers • Grower and crop consultant training – improved understanding ***Extension development*** Field days on demonstration sites	to target. The number, type and quality of engagement activities undertaken compared to planned – support by stakeholders, reactions, and commitment shown.	terms of their value and use to them. Feedback sheets – questions on reactions, value, process. Observation/reflection sheets/team debriefs by team members.
Foundational Activities [planned to be used to undertake and advise the program] Program team – including producer members	**Governance** Steering Committee (Scouts, Growers, Adoption Specialist, IDO, Program Coordinator)	Make-up of Steering Committee, perceived value of meetings and their influence on the program.	Feedback sheets to Steering Committee at each meeting – satisfaction, issues, input and action.

Appendix 2: IPM Strategies developed in Year 1 workshops

IPM Technologies ran a series of five workshops in June and July 2017 to develop an agreed set of control options that would provide the framework for a participatory demonstration of IPM in each growing region. The workshops were held in Macksville, Wollongbar (two workshops), Nambour and Bundaberg.

The aim of the workshops was to synthesise the existing knowledge provided by the participants into a one-page matrix. To achieve this IPM Technologies facilitated a discussion that first listed the pests of interest to each group, then the likely biological control agents that could be used. The next step was to identify cultural (management) options that would either make conditions better for beneficial species or worse for pest species. The final step was to look at what chemical or spray options could be used that would be compatible (or not) with the biological control agents. These were listed as either available now or potentially available in the future.

The results of these workshops are presented in Table 1 (from Macksville and Wollongbar) and Table 2 (from Nambour and Bundaberg). Pesticides listed in red in the tables should be avoided (or applied only in the form of spot sprays, baits or border sprays) in an IPM approach.

What was very clear from these workshops is that the macadamia industry has a lot of knowledge about pests and beneficials and that there are a wide range of management options available that are known and in many instances, being used in commercial operations. What was also clear is that long term sustainable control of all pests relies on cultural or management practices. Reliance on broad-spectrum insecticides is not sustainable and is associated with an increase in pest problems and it is highly unlikely that a simple set of replacement insecticides will become available. In the IPM strategies that were developed the potentially available chemicals listed are very much the support tools and the basis for managing these pests lies with the combination of biological and cultural controls.The next step is for these strategies to be implemented (or as many of the options that can be used in practice) on farms where they can be both tested and demonstrated.

Table 1: IPM in Macadamias. Workshop 1, 2, 3 – Macksville and Wollongbar

Pesticides listed in red are incompatible with many beneficial species.

Pest	**Beneficial**	**Cultural**	**Chemical/ Spray CURRENT**	**Chemical/ Spray FUTURE?**
		General practices (apply to most pests) Manage tree height Open canopy Variety selection Soil and plant health Border and Inter-row management		
Sigastus weevil	Assassin bugs Predatory beetles Parasitic wasps and nematodes Birds Bats	Hygiene Location (Mulching?)	OP's; SP's	Beauveria Indoxacarb Lure and kill? Benevia?
Fruit Spotting Bug (FSB)	Spiders Assassin bugs	Variety (thick shell, time of flowering) Trap plants (macadamia variety or other species)	Border sprays Sero-X	Mainman Sero-X

Pest	Beneficial	Cultural	Chemical/ Spray CURRENT	Chemical/ Spray FUTURE?
Lace bug	Parasitic flies Green lacewings Parasitic wasps (e.g. Anastatus for FSB)	On-farm insectaries Border management Control out of season flowering	(Transform) Bulldock Acephate Methidathion Lepidex Pyrethrum Orthene (Oils)	Exirel/ Benevia Mating disruption Fungicides from viticulture
Green vegetable bug	Parasitic wasps (e.g. Trissolcus) Spiders Parasitic flies			
Nut borer	Trichogramma	Variety Avoid mangroves	Prodigy SP's and OP's	Prodigy
Pinhole borer	Lacewings?	Variety Health and nutrition Irrigation		
Flower caterpillars	Predatory bugs Parasitic wasps	Variety Grevilleas as trap crops	Dipel Prodigy	Dipel Prodigy

Pest	Beneficial	Cultural	Chemical/ Spray CURRENT	Chemical/ Spray FUTURE?
	Hoverflies Lacewings			
Thrips	Predatory thrips Predatory mites Predatory bugs	Control dust Irrigation	(Abamectin) Sero-X	Success Movento
Mites				Sero-X
Coccid	Lacewings Predatory caterpillars Parasitic wasps	Hygiene Biosecurity Nutrition	Oil Diazinon	Oil
Macadamia flower caterpillar	Predatory beetles Predatory bugs Birds	Either remove leaf litter or (preferably) increase habitat for beneficial species	Prodigy; Dipel Lannate Lorsban	Dipel Group 28 products
Fungal diseases			Cabrio Mancozeb	Fungicides from viticulture

Pest	Beneficial	Cultural	Chemical/ Spray CURRENT	Chemical/ Spray FUTURE?
			Carbendazim	

Table 2: IPM in Macadamias. Workshops 4 and 5. Nambour and Bundaberg.

Pest	Beneficial	Cultural	Chemical/ Spray CURRENT	Chemical/ Spray FUTURE?
		General practices (apply to most pests) Manage tree height Open canopy Variety selection Soil and plant health Border and Inter-row management		
Fruit Spotting Bug	Parasitic wasps (e.g. Anastatus) Spiders	Variety Border management	Border sprays Sero-X	Mainman Sero-X

Banana spotting bug	Assassin bugs Parasitic flies	Bamboo hedges Control out of season flowering	(Transform) Bulldock Acephate Methidathion Lepidex Pyrethrum Orthene (Oils)	Exirel/ Benevia Mating disruption
Green vegetable bug	Parasitic wasps (e.g. Trissolcus) Spiders Parasitic flies			
Nut borer	Trichogramma	"Sticktight" management, Variety	Prodigy	Prodigy
Flower caterpillars	Predatory bugs Parasitic wasps Hoverflies	Variety Grevilleas as trap crops	Dipel Prodigy	Dipel Prodigy
Thrips	Predatory thrips Predatory mites	Control dust Irrigation	(Abamectin) Sero-X	Success Movento
Mites	Predatory bugs			Sero-X
Banana fruit caterpillar	Predatory beetles Predatory bugs Birds	Remove leaf litter or (preferably) increase habitat for beneficial species	Prodigy Lannate Lorsban	Dipel Group 28 products

Leptocorus	Spiders Carabid beetles	Avoid foam-bark tree	Spot spray	Spot spray
Aphids	Hoverflies Ladybirds Lacewings Parasitic wasps	Plants to get aphids – in field insectary		Mainman Chess Pirimor
Fungal diseases			Mancozeb Cabrio EC Carbendazim	Fungicides from viticulture

Appendix 3: Feedback from workshops

Appendix 1: Feedback summaries from the 4 workshops

Event Feedback – Macadamia workshop Caloundra 24th July 2018

1. How would you rate the quality of the event?
   Excellent quality – 4/8
   Good quality – 4/8

Comments – presenters were open and happy to help with specific problems, good examples of IPM (x2,) good presenter knowledge (x 3), audience participation, highlighting the issues of spray based programs, learnt a lot about new methods.

2. How relevant was the event/training for you?
   Highly relevant 8/8

Comments – Industry is facing imminent problem with chemical use x 2, learnt how to reduce chemical use, new knowledge, focused on the integrated part of IPM, Grower x2, very interested in IPM.

3. What did you like best about the event/training?

Comments – open questions/feedback, farm walk, learning about biological control and how to improve our practices, pest knowledge, learning how important cultural practices are, practical and relevant x2, wide range of ideas x 2

4. What do you think could be improved?

Comments – greater industry specific knowledge, nothing, I couldn't see the screen.

Event Feedback – Macadamia workshop Ballina 1 25th July 2018

1. How would you rate the quality of the event?
   Excellent quality – 8/10
   Good quality – 2/10

Comments – Well presented x 2, quality of information x 5, addressed problems, interesting, relevant x2, excellent content, clear and concise, extremely professional presenters, the matrix.

2. How relevant was the event/training for you?
   Highly relevant 8/10
   Moderately relevant 2/10

Comments – new to industry so have a lot to learn, hate spraying, better use of alternative sources to solve problems, need to decrease spraying, desire to move to IPM, relevant content, going into spray season, already using IPM.

3. What did you like best about the event/training?

Comments – different perspective on IPM, informative presenters, lack of promotion, not imposing anything on us, balanced presentation, felt that the presenters were really willing to support us, challenging current practice, small group, soft chemical information, importance of beneficial insects, logical approach, interactive discussion, clearly presented

4. What do you think could be improved?

Comments – nothing, spread the word far and wide, all good, more handouts, more tests on chemicals, follow up sessions

5.

Event Feedback – Macadamia workshop Ballina 2 26th July 2018

1. How would you rate the quality of the event?
   Excellent quality – 11/16
   Good quality – 5/16

Comments – Independent advice, small group, good communicators x3, real examples of IPM x2, well organised, good strategies, communicated on our level x5, experts, new information x3

2. How relevant was the event/training for you?
   Highly relevant 12/16
   Moderately relevant 4/16

Comments – overuse of chemicals in macadamias, hands on approach to IPM x4, grower, pest scout opened my mind to new ideas x2, new information, pest problems, environmental concerns, new chemical options, already on this path x2

3. What did you like best about the event/training?

Comments – pesticide effects on beneficials, great communicators x5, the whole picture approach x2, informative, small group, examples from other industries, new control options, on farm setting, an approach that supports what I am trying (I don't get much industry support), videos of beneficials, interactive, new ideas, suggestions of other chemicals.

4. What do you think could be improved?

Comments – nothing (perfect workshop) x7, more time x3, more information on beneficials, excellent session, more time in field, fun facts

Event Feedback – Macadamia workshop Ballina 3 26th July 2018

1. How would you rate the quality of the event?
   Excellent quality – 10/14
   Good quality – 4/14

Comments -Well explained x 5, good presentation x3, succinct x 2, relevant x2 , credible, important topic, collaborative, knowledgeable and approachable presenters x2

2. How relevant was the event/training for you?
   Highly relevant 10/14
   Moderately relevant 4/14

Comments – want to move away from pesticides x 4, relevant to industry x 2, important and timely, already doing a lot, I am a farm worker and don't have a say in what happens.

3. What did you like best about the event/training?

Comments – presentation x3, relevance, clear, succinct and to the point, relaxed and interactive, list of options for change x2, presenters listened to our concerns, discussing adoption process x2, having growers present,

4. What do you think could be improved?

Comments – list of predators for each pest, transition plan process x2, more definitive outcomes, need to empower growers and consultants, input from industry reps, regarding research funding, keep going the way you are, it works well.