Project Code MC16008

Project Title The IPM Program for the Macadamia Industry – BioResources Conserving and encouraging beneficial insects in macadamias

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Project Summary

- This project is part of a larger IPM program with different components. The larger IPM program brings together a team of highly experienced researchers with considerable experience, specifically in pest management in macadamias and in IPM extension and adoption.
- A major opportunity is now emerging in the macadamia industry for re-positioning growers and consultants to better apply inter-row management practices to benefit beneficial insects.
- In recent years arthropod pests including lace bug, sigastus weevil, banana fruit caterpillar, fruitspotting bugs and green vegetable bug have caused significant yield and/or quality loss. Increased use of insecticides has provided a short term remedy, but is likely also exacerbating the problem by creating selection pressures for resistant pests as well as disrupting local beneficials. Further, some insecticides currently used may be withdrawn from use in the near future while newer, more selective insecticides are expensive.
- A growing body of knowledge in macadamia management practice, theory, field observation, and data indicates that there are more beneficials where there is diverse inter-row growth. Furthermore, it is proposed that environments favourable to beneficial insects can enable the suppression of pests and make farms more resistant to their incursions.
- These issues have been considered internationally and in Australia in a number of crops, with promising results.
- Beneficial populations can also provide a buffer in the system and give more time to make spray decisions, while refuges for non-pest insects will enable quicker recovery after spraying. If demonstrated as effective, as recent observations suggest, such practices can become an integral IPM component in macadamias.
- The project will conduct a desk-top study, field surveys and comparative field-trials.
- The study hypothesis is that changes to inter-row management practices can increase the presence of desirable beneficials. A number of changes in inter-row cultivation practices will be compared with the convention of regular, close mowing. Changes in inter-row practice to be considered include:
  - reduce mowing
  - alternate row mowing
  - half-row or partial mowing
  - disturb the soil to break up grass dominance and allow germination of seed bank, including naturalized “weeds”
  - seeding with specific insect-friendly species

This study considers what growers and consultants can do now to preserve and enhance beneficial activity in macadamia orchards to help make their farms more resistant to pest incursions.

The study will provide recommendations on inter-row management practices, supporting resources for insect identification and plant selection, and extension as participatory action research for growers and consultants.

The project team is experienced in the field and project delivery for Horticulture Innovation. It is led by Richard Llewellyn of BioResources and includes: consulting expertise from Coates Horticulture; a dedicated researcher, and experienced entomologically trained field surveyors.

Conserving and encouraging beneficial insects in macadamias

Background

In recent years arthropod pests including lace bug, sigastus weevil, banana fruit caterpillar, fruitspotting bugs and green vegetable bug have caused significant yield and/or quality loss in the macadamia industry (Carr, 2016; Govender, 2015). With few demonstrated options for management, the increased reliance on insecticides has resulted. This approach has provided a measure of short-term resolution but brings with it a number of limitations including pest resistance and other unintended consequences (Llewellyn 2016a). Further, some insecticides currently used may be withdrawn from use in the near future while newer, more selective insecticides are expensive.

Macadamia crop consultants and other specialist advisors working in the Australian industry, including Alan Coates, Jarrah Coates, Dave Forrest, Bob Maier and Richard Llewellyn, are currently working with farmers in applying innovations in managing pest problems. Via personal communication (15-17 September 2016), they have confirmed that they see an especially promising direction associated with ensuring robust activity from beneficial insects. Especially salient is that all confirm that they have observed more beneficial insects where there is good inter-row growth. These advisors propose that environments favourable to beneficial insects can contribute to the suppression of pests and make farms more resistant to their incursions.

A growing body of literature proposes that agricultural and horticultural landscapes with low vegetation diversity and complexity will be prone to significant problems with arthropod pests (Bianchi et al., 2006; Diekötter & Crist, 2013; Kadoya & Washitani, 2011; Tscharntke et al., 2007). This is because the removal of non-crop vegetation also results in the removal of the beneficial insects that feed, breed and live there. As predators and parasitoids of other insects, the removal of beneficials leaves an ideal set of stress-free conditions for the remaining specialised crop pests (Rusch et al., 2012; Rusch et al., 2013; Rusch et al., 2016). By contrast, the maintenance and restoration of diverse and complex plant communities in inter-rows and field margins will support beneficial populations (Zandstra & Motooka, 1978). This is likely to suppress pests. This has been extensively observed empirically and is now widely promoted as an important strategy for pest management (Bertrand et al., 2016; Gurr et al., 2003; Landis et al., 2000; Sarthou et al., 2014). Pest suppression by beneficials, where complexity and diversity of field margin or inter-row vegetation is cultivated, has recently been tested internationally in: tomatoes (Balzan et al., 2016), soybean (Woltz et al., 2012); blueberries (Blaauw & Isaacs, 2015), orchard systems (Simon et al., 2010), and in citrus in China where it is now common practice to sow weed seeds to provide breeding grounds for predatory mites (pers comm., Song, 2016) amongst others.

In Australia, a number of industries have begun investigating and applying the proposed benefits of field margin and inter- row vegetation, including: cropping and grazing systems (Smith et al., 2013; Schellhorn 2014), vineyards (Danne et al., 2010; Retallack, 2011) and apples and pears (Ridland, 2006). The approach has been effectively utilised in citrus since the 1990s (Smith et al., 1997); while potato growers in South Australia are now planting barley alongside the crop to provide a refuge for non-pest aphids, specifically to allow aphid parasitoids a guaranteed host across the season and to keep them in the field after spraying for controlling potato aphids (per comm., James Altmann 2016). To date, the general principals of utilizing interactions amongst vegetation, pests and beneficials in macadamia orchard management have received very limited attention (Govender, 2015), while the specific potential for pest suppression via inter-row cultivation and/or seeding is yet to be investigated. Seen in this light, inter-row vegetation is thus a highly significant and currently under-utilised resource in macadamia orchards. For macadamias in particular, this is especially important because pests do not usually breed in the inter-row, with the possible exception of green vegetable bug and banana fruit caterpillar, which can sometimes be found on silverleaf nightshade, amaranthus, and ink weed (Llewellyn, 2016b). Where appropriately cultivated, inter-row vegetation serves as an insectary, with diverse and complex vegetation providing a year-round variety of pollens and nectars. This increases the longevity and fecundity of general populations of non-pests, including so-called “non-economic” insects and beneficials. It is a complex and self-sustaining, resilient ecology. And because it is largely outside the scope of spraying, it recovers ahead of pest populations after spraying. In this way, it is speculated that the inter-row and preserved and active beneficial populations are an important first line of defence and can also provide a buffer in the system and give more time to make spray decisions (Llewellyn, 2016b; 2016c).

If demonstrated as effective, as recent observations and the literature suggest, such practices can be a major component of integrated pest management (IPM) in macadamias. These propositions have not as yet been rigorously tested or formalised. There is now an opportunity to study these interactions more closely to provide evidence-based recommendations as well as engage in participatory action research (PAR) with industry partners to further develop these practices.

This study should be considered a preliminary one. It is an area that is likely to continue to develop in the years ahead as it becomes increasingly necessary to adopt more sustainable practices and as more is learnt about the most suitable plant species for inter-row insectaries and the technologies for establishing them.

Team - personnel and background

- Richard Llewellyn. Owner and manager of BioResources Pty Ltd. BioResources and Richard have a long track record in the development of biocontrol agents and IPM programs in a range of horticultural crops including "MacTrix " and Anastatus for macadamias.
- Jarrah Coates. Experienced crop consultant in the macadamia industry.
- Alan Coates. Experienced crop consultants in the macadamia industry. Alan has been running TAFE courses on
- IPM in macs for many years and now in conjunction with processors.
- Abigail Makim, PhD, BSc (Hons), Grad Cert Applied Agricultural Science. Researcher. Abigail is experienced in the delivery of complex multi-disciplinary research projects.
- Christopher Carr, B.Sc (Hons) PhD near completion. He is well experienced in this type of field work.
- Peter Osborne, B.Sc (Hons), an employee of BioResources with a good background in entomology.

This project is part of a larger IPM program with different components. The larger IPM program brings together a team of highly experienced researchers, specifically in pest management in macadamias and in IPM extension and adoption.

Methodology

Hypothesis - This study takes as its starting point the proposition that all insect pests of macadamias have natural enemies. The study hypothesis is that changes to inter-row management practices which increase vegetation complexity and diversity can increase the presence of desirable beneficials.

Desktop study – as discussed above, the benefits of pest suppressive landscapes have received considerable attention internationally. Within Australia, cultivation of the inter-row as an insectary has been explored in a number of different industries, including citrus, potato, vineyards, apple and pear orchards, and broad-acre cropping. This work has not been done for macadamias. A desktop study will review the literature and consider it within the context of the specific concerns of the Australian macadamia industry. The desktop study will consider the findings of current research into pest suppressive landscapes. It will review findings from a number of horticultural industries, which have investigated interactions between diverse and complex vegetation and beneficials; and interactions between beneficials and pest insects. It will do so within the context of the specific concerns of the macadamia industry. For example, managing the inter-row for harvesting, for rats, soil compaction and so on. The desktop study will also consider plant species most suited to the requirements of an insectary and those of the macadamia orchard.

Field trials - The study considers what growers and consultants can do now to preserve beneficials. It also considers what can be done now to enhance the activity of beneficials. A number of changed inter-row management practices will be reviewed against the standard practice of close mowing:

- reduce mowing
- alternate row mowing
- half-row or partial mowing
- disturb the soil to break up and allow germination of seed bank, including naturalised "weeds"
- seeding with specific insect-friendly species

The mix of sites will be distributed across northern New South Wales, the Sunshine Coast (Queensland) and the Bundaberg area (Queensland). The sites will be monitored 4 times per year approximately at:

1. pre harvest clean up
2. mid harvest
3. flowering
4. mid nut development

Focused Survey – a detailed survey at 3 sites for treatments of changed inter-row management will be made to produce time series data to consider changes in vegetation complexity and diversity and total insect numbers and insect diversity. In the first few months of the project we will review the literature on sampling methods for this type of work and test in the field and select those appropriate for focused and grower sites.

Farm surveys - participatory action research (PAR) with growers and consultants at 6 sites, where changed inter-row practice is trialed alongside the standard practice at the same site.
The farm trials will be used to observe changes in orchard management practice in the inter row.
against the standard practice of regular, close mowing:
Total insects (including "non-economic insects", beneficial and pest insects) will be monitored via selected methods as mentioned above as will inter-row plant species. Assessment of the benefits or otherwise of the program will be assessed using data collected and in conjunction with the grower and consultant. Growers will provide in-kind contributions for their time surveying and record keeping. And this may include, cultivating and/or spreading seeds.

Data collection methods may include:
Plant surveys

- plant height and width of inter-row growth (focused and grower sites)
- dry matter per square meter (focused)
- number of plant species found per square meter (focused, grower)
- plant species name per square meter (focused)
- presence/abscence of nectar and pollen producing plants (focused, grower)
- details of pollen and nectar producers (focused)
- time of mowing and height of inter-row when mowed (focused, grower)

Insect surveys

- Insect density on sticky traps (focused and grower returns for assessment)
- Insect Family and/or species breakdown on sticky traps and in other traps (focused)
- Species found in light traps (focused)
- grams of insects found in suction samples, water traps, pitfall traps, light traps. (focused)
- standard crop monitoring for pests in the trees, e.g. Lacebug, FSB, GVB, Sigastus, nutborer. (focused and grower)
- incidence of known pollinators in the inter-row (focused and grower)

The study will investigate various means for preparing and seeding the inter row in practical ways. We will endeavor to test some of these methods. For larger inter-row seeding exercises we envisage the use of, for instance, seeding equipment used in pasture management.

Issues of implementation will be documented. For example: was specialized machinery required; were there issues in establishing inter-row vegetation; did the new practice influence rat numbers or rat damage?

The project will provide training of participants in sampling methods, site treatment set up, resources for insect and plant identification, telephone and field support, web resources and grower/consultant manuals will be developed. This project will be part of the larger Program team and will be collaborating where it is efficient and effective to do so. A representative of the project will also be participating in all Program Team meetings.

Team - personnel and roles

- Richard Llewellyn. Team leader. Assistant project management, project review, presentations, report writing. In- kind.
- Jarrah Coates. In-kind. Information source, assist with site selection and set up, grower liaison, crop monitoring.
- Alan Coates. In-kind. Information source, assist with site selection and set up, grower liaison, crop monitoring.
- The study will investigate various means for preparing and seeding the inter row in practical ways. We will endeavor to test some of these methods. For larger inter-row seeding exercises we envisage the use of, for instance, seeding equipment used in pasture management.
- Abigail Makim. Abigail will bring together the current thinking and research on inter-row management by reviewing theory, literature and developments in other crops and via interviews with leading proponents of these practices. She will be responsible for managing stakeholder relationships, data base development and management and statistical analysis. She will also assist with field surveys, collation, report writing, articles for publication (30% FTE).
- Christopher Carr. Chris will conduct field sampling, insect identification, compilation and collection of data (11% FTE).
- Peter Osborne. Will assist Chris Carr with field surveys (4% FTE).

Outputs

- Guidelines on suitable and unsuitable plant species and communities and their management for the inter-row and design considerations for new plantings
- Knowledge transfer via participatory action research for consultants and farmers, adopting, trialing and developing inter-row approaches suited to specific sites
- Presentations at Consultant and Grower meetings. Articles for Industry publications

Outcomes

- Adaptive, effective and participatory research collaborations for IPM of macadamias
- Better knowledge about arthropod pests and beneficials in macadamias
- Wider adoption of IPM by macadamia growers
- Improved skill of scouts and consultants providing advice to macadamia growers
- Cost-effective, sustainable and integrated management of arthropod pests

Adoption

- Target audience for adoption of project deliverables – consultants, farm managers and owners
- The strategies for adoption - on farm trials involving consultant and grower participation, publications, presentations at workshops etc.
- Timeframe - 3 full seasons of trials
- Detail the specific adoption targets – all growing regions, relevant to young and/or open orchards with inter-row vegetation and close planted mature planted orchards where row removal has or will take place.
- Consider the critical success factors – Good indications from anecdotal observations in macadamias that these practices are of benefit. The attraction of minimising chemical use. Many growers are concerned about their dependence on chemicals and are keen to make their farms more resistant to pest incursions. These practices may reduce chemical use, save time and labour and reduce damage from pests.
- Impediments to adoption – the standard practice is keeping orchards looking like a park. Owners may pressure their managers and workers to keep the farm unnecessarily "clean" which may be counterproductive in relation to pest management; the need to keep orchard floor clean during harvest; rats are considered a problem by many that they believe requires close mowing in rows and on headlands.
- Indicate the time to impact of the project - Within 5 years
- Time-lag between completion of the project to initial adoption - some growers are already adopting similar practices and we expect these numbers to increase rapidly as more information comes available.
- Expected level of maximum adoption - 50% of existing orchards. Many mature close-planted orchards are too dark to have any inter-row vegetation. If these orchards have alternate rows removed they are prime candidates for these practices.
- Expected time to maximum adoption – 10+ years. Refinement of these practices will be ongoing. Newly planted orchards may consider modifying their design to enable flower strips through harvest and/or the occasional wider row for flower strips or shrubs to encourage beneficial insects, birds and pollinators.
- Expected time to abandonment of the R&D - It's a 3 season project, so do not envisage that any issues would require abandonment of this research. process
- Linking in with existing industry adoption programs such as development and publication of the macadamia industry "Integrated Orchard Management" booklet
- Publications for industry publications such as AMS bulletin, e-newsletter etc. throughout the project.
- Link in with existing industry extension such as MacGroups.
- Presentations at industry meetings such as the Annual Consultant Meeting.
- Direct involvement with pest consultants and growers in the project throughout the project.
- Use of BioResources and Coates Horticulture customer bases to disseminate information.

Monitoring and Evaluation (M&E)

The Program-wide M&E will be done at the Program team meeting on Dec 8 and this will inform the plan for this component of the Program. A M&E plan, including program logic will be delivered as part of MS102.

IP Considerations

Nil. These practices are in the public domain.

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