NSW GOVERNMENT | Department of Primary Industries

Macadamia plant protection guide 2018–19

NSW DPI MANAGEMENT GUIDE

Jeremy Bright

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Jeremy Bright
Development Officer – Macadamia
NSW Department of Primary Industries

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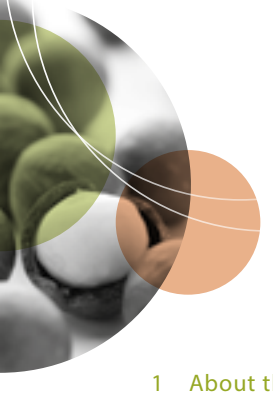
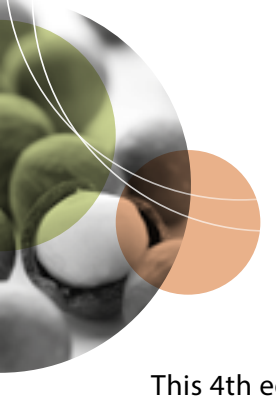
The Author

Jeremy Bright, Development Officer – Macadamia
NSW Department of Primary Industries
Wollongbar Primary Industries Institute
1243 Bruxner Highway, Wollongbar NSW 2477
Email: Jeremy.bright@dpi.nsw.gov.au
Phone (02) 6626 1346
Fax (02) 6628 1744
Mobile 0427213059

Cover photos: (Large photo), Peak flowering macadamia, Rous, NSW, Jeremy Bright, NSW DPI Wollongbar. (Smaller photos left to right) macadamia nuts, NSW DPI; *Pseudocercospora macadamiae*, NSW DPI. *Amblypelta nitida* nymph, Craig Maddox NSW DPI, Wollongbar.



Contents



About this guide

This 4th edition of the *NSW Macadamia plant protection guide* will follow closely to the original format as seen in previous years. It provides up-to-date information on all aspects of protecting your orchard from pests and diseases.

Feature article

Dr Femi Akinsanmi is an applied plant pathologist at The University of Queensland, working with the Queensland Alliance for Agriculture and Food Innovation (QAAFI). Femi's research approach incorporates modern tools relating to plant disease epidemiology, host genetics and pathogen taxonomy; all of which help with planning disease management systems in agricultural ecosystems. Femi has been influential within the Australian macadamia industry and has strived to develop systems for control of diseases that are inherent with this crop. In this year's feature article, Femi discusses the requirement for this industry to develop a more sustainable system involving cultural, chemical and biological considerations. He describes the challenges of an integrated pest and disease management (IPDM) system and issues that the industry needs to consider when implementing IPDM.

Spraying pesticides in the orchard

There is a need within the macadamia industry to develop sound information relating to spray coverage and avoiding drift. In searching for an independent spokesperson, I came across a government extension worker located in Ontario Canada, Jason Deveau. Jason has kindly accepted my invitation to discuss the three key elements of spraying which apply to all spraying jobs regardless of tree size. They are spray setting, geometry of the target and environmental conditions. It is a "*well informed outsider looking in*" article that I think most growers will appreciate.

Jason holds a BSc (Hons) in Biology and Psychology from Mount Allison University, a MSc in Plant Cell Physiology and Metabolism from York University and a PhD in Plant Cell Electrophysiology from the University of Guelph. Based in Ontario's Simcoe Resource Centre since 2008, his current focus is on developing educational materials for sprayer operators and researching practical methods to optimise spray effectiveness and reduce waste. Jason is the author of *Airblast101 – A Handbook of Best Practices in Airblast Spraying*, and he co-administers www.sprayers101.com.

Pesticides

We do not list every pesticide that is registered for a specific use but rather guide growers in their choice of chemicals. It is our policy to use common chemical names or active ingredients, not trade names, when referring to pesticides, crop regulation compounds and nutrient sprays in the body of the guide. Some users find this inconvenient because the chemical name is often in small print on product labels compared with the prominence given to the trade name. Unfortunately this practice is necessary because there can be many product names for the same active ingredient and it would be impossible to list them all at each mention in the guide.

Under the pesticides registration system administered by the Australian Pesticides and Veterinary Medicines Authority (APVMA), individual products are registered for use in or on specific crops for specific weeds, pests or diseases. Also, there can be variations in use recommendations between states for the same crop, even differences in times of application or treatment intervals.

Our use of common chemical names in recommendations in the guide is intended to simplify the advice. It means that at least one product containing that active ingredient is registered for the purpose given. The onus is on the pesticide product user to ensure that the use of that product is consistent with the label or a permit issued by the APVMA.

Use of pesticides is under constant scrutiny through residue surveys. It is imperative that these valuable tools for nut production are not misused.

Development stages for macadamia

This section of the guide contains images that will help growers identify growth stages of macadamias that are mentioned in the pest and disease calendar. The growth stage of a plant is determined when the majority of the plant is in a specific stage of development. The stages are:

- **pre flowering**, including bud development through to fully extended, green raceme (Figure 1 and Figure 2)
- **early flowering**, a mix of pre-flower and some open florets (Figure 3 and Figure 4)
- **peak flowering**, majority of the tree has fully opened flowers (Figure 5 and Figure 6)
- **nut set**, pollinated nut is up to and including match head size (Figure 7 and Figure 8)
- **pea size nut and spring flush** (Figure 9)
- **shell hardening and oil accumulation**, nut size increases to harvest (Figure 10).

Distribution

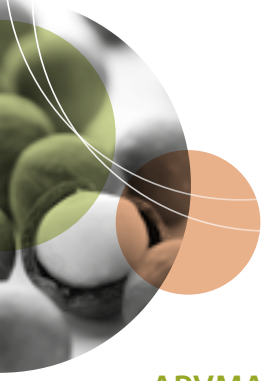
This guide is available free of charge to macadamia growers in Australia. It has been distributed to all macadamia processors within Australia. Copies are also available free of charge from NSW DPI offices in Wollongbar and Coffs Harbour, the Australian Macadamia Society office, Local Land Services offices and selected rural retail stores across NSW. The guide is also published on the NSW DPI website (http://www.dpi.nsw.gov.au/content/agriculture/horticulture/nuts/growing-guides/macadamia-protection-guide).

Acknowledgments

We thank the officers of NSW DPI and other organisations who have helped to revise this issue of the guide. We welcome suggestions, comments and ideas from growers and technical people alike that can improve the usefulness and relevance of the guide.

Photo credits

DPI staff and archives.
Olufemi Akinsanmi, University of Queensland.
Stage 4 nymph photos courtesy of A Dane, University of Queensland.



What's new?

APVMA review continues

During 2015, the APVMA consulted with the public, industry and government agencies to seek input on prioritising a list of 19 chemicals, or types of chemicals, that the APVMA had identified for review.

From this, five chemicals have been prioritised for detailed scoping, none of which are used by the macadamia industry. The remainder are prioritised for reconsideration after the first five have been commenced. Further information regarding the process and the list of chemicals to be reviewed is on the APVMA website (http://apvma.gov.au/node/10876).

Before the formal review starts, the APVMA will undertake a range of preparatory work, including:

- determining the detailed scope of each review
- developing a work plan setting out expected milestone completion dates
- holding discussions with industry and user groups to ensure that all relevant information is received by the APVMA.

Chemicals relevant to the macadamia industry include:

- methomyl
- carbamate
- triazole
- acephate
- trichlorfon.

It is imperative for this industry to continually search for different management options to be able to stay viable. With our most effective chemistry continually under review, we must look for other options such as introducing new predatory pests, identifying chemistry that is as effective as the old chemistry (and not under review), adopting better systems for monitoring and managing trees to be less desirable to pests. Essentially, we need to be developing a sustainable integrated pest and disease management (IPDM) system for the industry.

New permit for control of Pytophthora trunk canker in macadamia trees

A permit (PER84766) was issued by the APVMA for using the active constituent phosphorous acid to be used as either a trunk application (curative) or foliar (preventative) for phytophthora root rot and trunk stem canker. This permit is effective until 30 November 2022.

New Sulfoxaflor registration

Sulfoxaflor registration was approved for the control of both fruit and banana spotting bugs. Sulfoxaflor is a group 4C chemical which will assist in enhancing a resistance management strategy on farm.

Controlling pests and diseases

The aim is to grow this section of the guide. It is hoped that a quick reference section of common pests and diseases for our industry will make it convenient for growers and workers in orchards to identify issues of concern.

Native bee update

Chris Fuller of Kin Kin Native Bees has updated the native bee article for this year's guide. He describes some of the recent work being performed to optimise pollination for macadamia and also looks at cross-pollination versus self-pollination. He also mentions the need for providing out of season forage points throughout the orchard to sustain the bee population all year round.

IPM project updates

The macadamia IPM project is now 1 year old. Some of the partners within this project have provided updates for the Plant Protection Guide showing how their section of the project is progressing.

IPM is not an outcome; IPM is a journey.

Many growers are already well into that journey through the:

- release of wasps for control of nut borer
- the reduction of massive tree heights to promote ground cover and an easier target for pest control
- better understanding of pest life cycles which results in more effective sprays at the right time.

IPM will not have a final destination along this journey. Industry will continue along the path as we understand further the significance of cultural, biological and chemical practices.

Macadamia development stages

Pre-flowering

Figure 1. Pre-flowering.

Figure 2. Pre-flowering.

Early flowering

Figure 3. Early flowering.

Figure 4. Early flowering.

Peak flowering

Figure 5. Peak flowering.

Figure 6. Peak flowering.

Nut set

Figure 7. Nut set.

Figure 8. Nut set.

Pea size nut and spring flush

Figure 9. Pea size nut and spring flush.

Shell hardening

Figure 10. Shell hardening.

IPM project begins

The Macadamia Integrated Pest Management (IPM) Program, using Hort Innovation funds from the Macadamia Levy, was launched in January 2017. The program involves a team of researchers and crop consultants with a diverse range of skills, focussing their efforts on the development of sustainable pest management practices for the macadamia industry (Figure 11). Combinations of biological, cultural and chemical controls are being tested on commercial farms and research stations as part of the program. This section of the 2018/19 Macadamia Plant Protection Guide features reports from each of the program components.

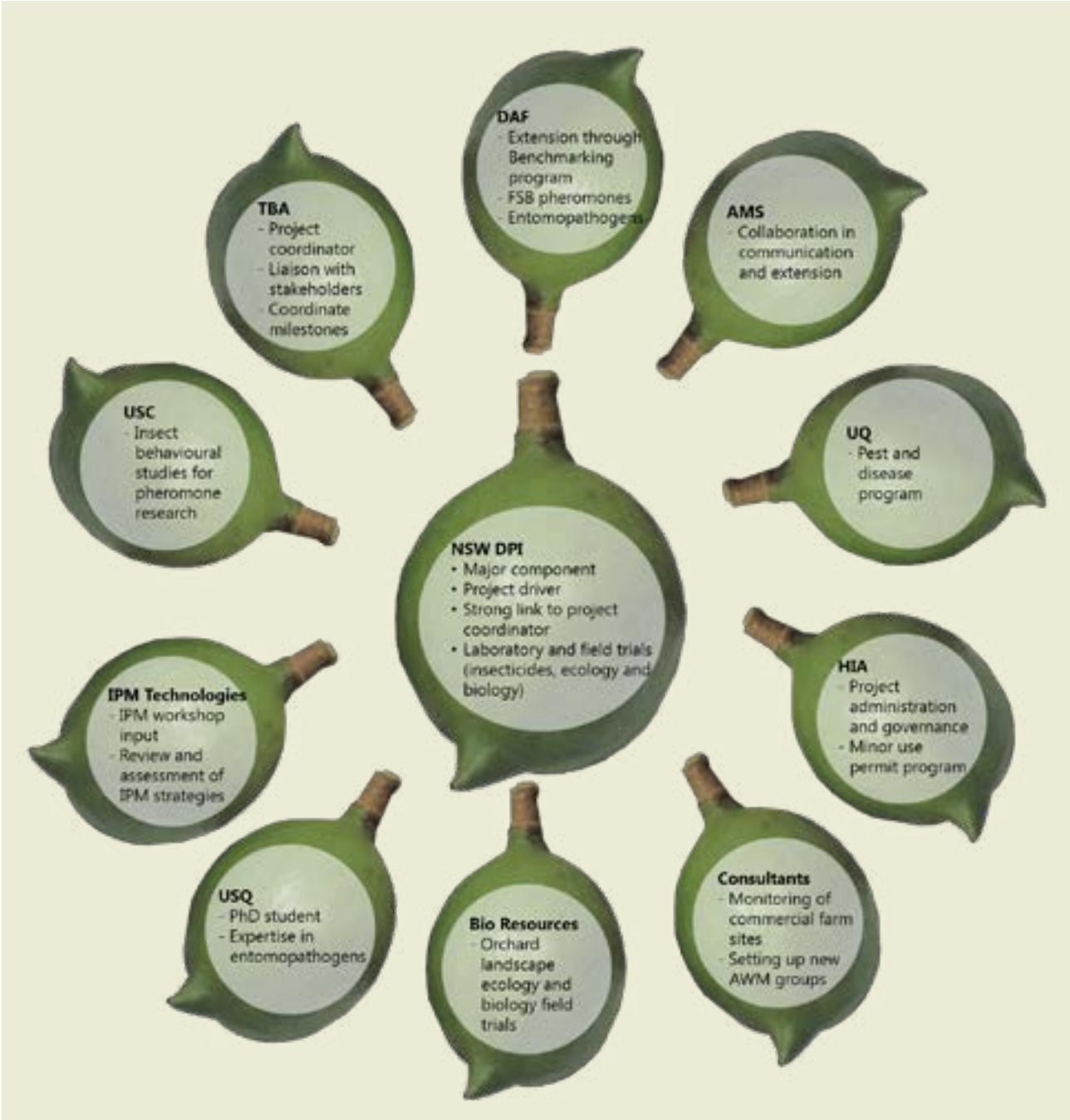


Figure 11. The IPM project team.

IPM project updates

IPM Technologies Pty Ltd

Jessica Page

The role of IPM Technologies in this project is to provide input into the development, extension and adoption of IPDM for the macadamia industry. So far, we have run a series of workshops (Figure 12) where IPM strategies based on existing knowledge and available tools were developed. Some of these strategies will be demonstrated on farms with the collaboration of interested farmers, consultants and researchers later this year.

Having worked in many different industries that all face their own unique challenges (including insecticide resistant pests and withdrawal of insecticides), we have been able to see the common issues that cross all industries when it comes to IPM adoption. Based on this experience, we have identified three main points that are relevant to the macadamia industry:

1. The first is a warning about the use of broad-spectrum insecticides and the associated pest problems that this may create. We believe that pesticides have contributed to the pest issues that the macadamia industry is currently facing. This project aims to develop sustainable pest management strategies, not to just identify alternative insecticide products for today. Selective chemistry will help to achieve sustainability but will need to be incorporated into an IPM strategy.
2. The second point is that IPDM means integration of a range of management options that will provide sustainable long-term control of all pests; unfortunately this part is often forgotten (or ignored). Integration is important because it makes sure that the control of one pest is not causing problems with another pest, as in point one. In the search for the next new chemical, other options (particularly cultural methods) are often disregarded. It is these other options that make up an IPDM strategy.
3. The third point is that there is enough information currently known for growers to begin making changes right now. The macadamia industry has a lot of knowledge, but the challenge is how to integrate and use it. We are strong advocates for a collaborative approach for the adoption of any practice change. This means that researchers, advisors and farmers need to work together to find answers on real farms under real conditions. This way pest management can be tailored to suit the needs of the individual and to the site-specific issues on each farm. IPM Technologies plans to be involved in on-farm collaborative trials this year.

Figure 12. IPM Techonologies intial workshop for the IPM project.

Hort Innovation Strategic levy investment | MACADAMIA FUND

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

IPM project updates continued

QDAF

Grant Bignell

There are three components to the DAF section of the IPM program. These include:

1. Investigating the effectiveness of entomopathogenic fungi as an insect control agent
2. Assessing the performance of pheromone traps on banana spotting bug and developing guidelines for their use
3. Evaluating the economics of emerging IPM management strategies.

Entomopathogenic fungi have evolved to infect and kill insects and therefore offer potential as non-chemical control agents for insect pests in agriculture. Fungal bio-control agents for pest control in agriculture are already registered for use both overseas and in Australia, but they are mostly based on Metarhzium and Beauveria fungi. Sigastus weevils infected with Beauveria have been observed on a number of occasions in macadamia orchards in Northern New South Wales (Figure 14). The entomopathogen development component of this project aims to isolate and culture entomopathogenic fungi from both Sigastus weevils and soil in macadamia orchards. The selected isolates can then be formulated for field testing in macadamia orchards against insect pests.

A pheromone trap has been developed and commercialised for banana spotting bug, Amblypelta lutescens (Figure 13). This trap was developed as a monitoring tool with damage thresholds that allowed growers to make accurate insecticide spray decisions. It also has some promise as a lure and kill approach. In this project, DAF Entomologists will advise on optimising pheromone traps when used with trap crops for monitoring and controlling fruit spotting bugs. This will culminate in the generation of data sets used to make informed recommendations on the use of existing pheromone traps as part of an orchard-wide IPM strategy.

The team from the Benchmarking the Macadamia Industry 2015-2018 project (MC15005) collaborated with members of the previous IPM project (MT10049) to evaluate the economic viability of specific IPM strategies. They also provided links to growers and consultants via its network of Benchmark Groups. Continuation of this collaboration and linkage with industry is important for uptake, feedback and ultimately industry adoption of emerging IPM strategies.

The benchmarking group will contribute to the IPM program through periodic provision of insect damage data from the factory. NSW DPI Entomologists will also be involved to ensure the relevant information is passed on to the appropriate parts of industry. Financial analysis of specific pest management scenarios will assist growers with decision making for their own businesses.

Figure 13. Banana spotting bug trap.

Figure 14. Beauvaria on sigastus. Source: Craig Maddox.

NSW DPI

Development of an IPM Program for the Australian Macadamia Industry commenced in January 2017. Since the start of the project we have collected baseline data, particularly at the Centre for Tropical Horticulture (CTH) at Alstonville. In discussions with IPM Technologies, a trial at CTH was set up investigating two IPM strategies with different IPM compatible pesticides, releases of biological control agents and cultural controls. The trial treatments include different broad spectrum insecticides and cultural control and a treatment including broad spectrum insecticides, cultural control and releases of biological control. Trap hedges were established (Figure 15). The block was monitored fortnightly for pests and beneficials.
Additionally, in each of the four major macadamia growing areas (Mid North Coast, Northern Rivers, Gympie/Glasshouse Mountains and Bundaberg), case study sites with two trial blocks were set up. One of these is using the grower's standard treatment with broad-spectrum insecticides and the other is using IPM treatments using IPM compatible chemicals, biological control and cultural control. One of the professional pest consultants in each of the regions is monitoring the trial sites fortnightly (Figure 16).
Monitoring at CTH and case study sites was conducted between July and March. The monitoring included the following components:

- visual observations of pests and beneficials
- deployment of pheromone traps for macadamia nutborer, Amblypelta lutescens, scolytids (bark beetle, pinhole borer and trunk borer)
- use of monitoring hedges for both Amblypelta spp. using yellow sticky traps and intercepting randomly different species of pests and beneficials
- checking of fallen nuts for pest damage, including:
  - fruitspotting bug
  - Sigastus weevil (feeding, oviposition, larvae and pupae)
  - macadamia nutborer.

It is important to gain a better understanding of the ecology and the relationship between pests and beneficials. At the end of the season nut samples are assessed for evidence of pest and disease/damage on husks, and kernels are assessed for insect damage. First trends are showing that standard treatment blocks appeared to have a higher occurrence of thrips and in the IPM blocks, there is a higher diversity of beneficials.

Figure 15. Trap hedges were established.

Figure 16. Monitoring a macadamia trial site in the IPM project.

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Managing Sigastus sp. with entomopathogens: green zombie weevils

Kim Khuy Khun and Dr Bree Wilson
University of Southern Queensland, Centre for Crop Health

Kim Khuy Khun, a PhD candidate at the University of Southern Queensland's Centre for Crop Health, is examining the use of entomopathogenic fungi to manage Sigastus weevil.

Targeted spraying with acephate coupled with good orchard hygiene is crucial to reduce numbers of Sigastus weevil. Combining existing control measures with biological control can offer growers alternative forms of management, while at the same time limiting the build-up of insecticide resistance. Entomopathogenic fungi (for example *Metarhizium anisopliae* and *Beauveria bassiana*) are able to kill insects during inactive (eggs and pupae) and active stages (larvae or adults) of their life cycle.

Currently, about 10 isolates of Australian entomopathogenic fungi are being bio-assayed in the laboratory (Figure 17) against different life stages of the Sigastus weevil.

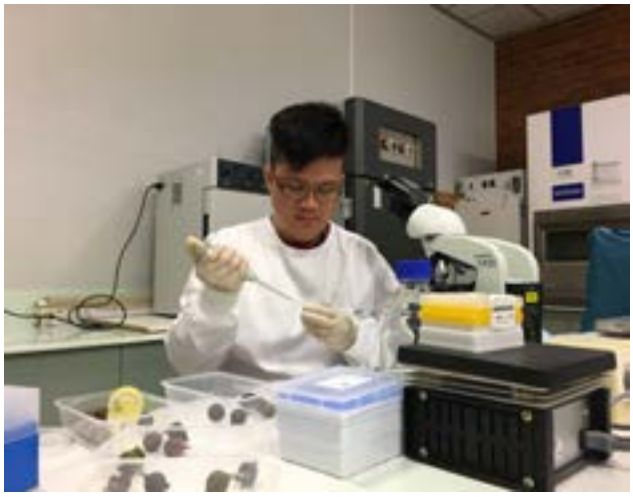

Figure 17. Kim Khuy Khun innoculating nuts in the laboratory.

The main objectives of this study are to examine:

- fungal virulence
- dose response
- duration of effectiveness
- impact of pesticides on fungal efficacy
- timing of application in order to avoid the unintentional impact of current recommended pesticides on non-target organisms and the environment.

The outcomes of this study will improve our understanding of the interactions between pesticides and biocontrol agents, allowing the development of integrated management plans for both Sigastus weevil and other significant insect pests.

So far, Kim Khuy has:

1. Challenged Sigastus weevil with two virulent entomopathogens; *M. ansiopliae* QS155 and *B. bassiana* B48 (Figure 18), with successful results in both laboratory (Figure 19) and glasshouse studies (Figure 20).

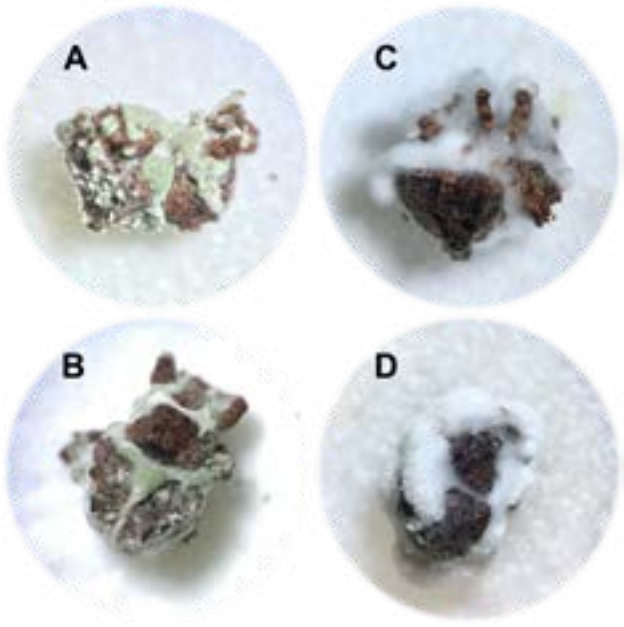

Figure 18. (A) and (B) Sigastus weevils infected with *Metarhizium anisopliae* QS155; (C) and (D) Sigastus weevil infected with *Beauveria bassiana* B48.

Figure 19. Larva infected with *Metarhizium anisopliae* QS155.

Figure 20. Bioassays with *Metarhizium anisopliae* QS155 in the glasshouse.

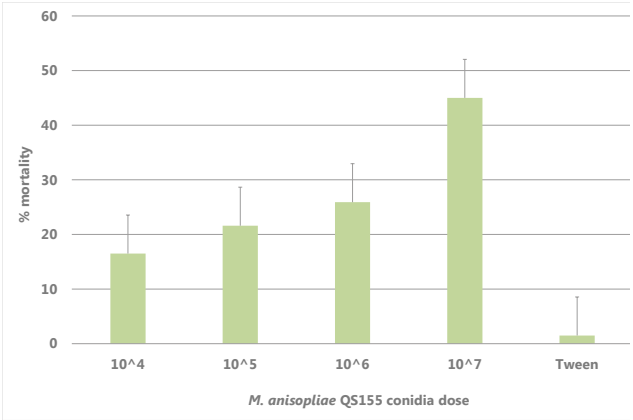

Figure 21. Percentage adult weevil mortality after the application of different concentrations of *M. anisopliae* QS155 to macadamia leaves.

2. Performed bioassays to assess the efficacy of different concentrations of the non-formulated fungus, *Metarhizium anisopliae* QS155 on adult Sigastus mortality. All concentrations of *M. anisopliae* caused significantly greater mortality than the control (Tween) and unsurprisingly, the highest concentration of *M. anisopliae* caused the greatest mortality at 45% (Figure 21).
3. Filmed and documented the life cycle of Sigastus weevil (available at https://www.facebook.com/CCHUSQ/videos/134028747281317/).
4. Examined the emergence of adults from thousands of infested nuts and found:
   - 51% successful weevil emergence
   - 16% were not able to chew through the husk and died inside the nut
   - 8% were in diapause in the larval stage
   - 25% of the nuts were empty.

Contact details: Bree Wilson bree.wilson@usq.edu.au or Kim Khuy Khun kimkhuy.khun@usq.edu.au.

Kim Khuy Khun and Dr Bree Wilson in the orchard.

Hort Innovation Strategic levy investment | MACADAMIA FUND

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Insectaries in the macadamia inter-row

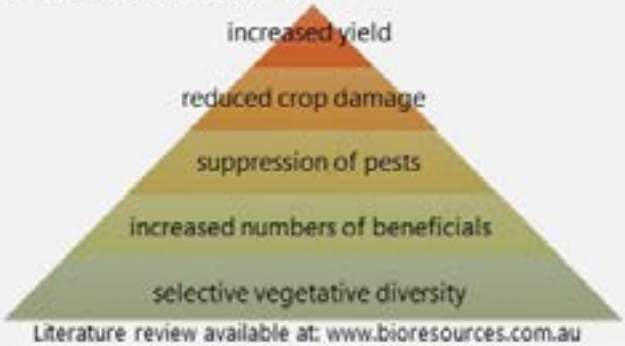
Abigail Makim and Richard Llewellyn

PROJECT AIMS

This project reviews and trials insectaries established in the macadamia orchard inter-row, which are designed to encourage beneficial arthropods.

- The inter-row is currently an under-utilised resource in macadamia orchards.
- It can make a valuable contribution as an insectary where selective vegetative diversity is cultivated.
- The macadamia industry is looking for new pest control options as a result of new pests, emerging arthropod resistance, withdrawals, and community concern with chemistry.
- Pests of macadamias are unlikely to live or thrive in inter-row vegetation.

PROPOSED BENEFITS



Literature review available at: www.bioresources.com.au

Above, reduced mowing practices such as this mohawk provide an insectary, with habitat and food resources for beneficials throughout harvest. This means beneficials are established in the crop before flowering and ahead of pests.

Insectaries provide generalist predators such as ladybugs with additional food resources so that they can complete their life-cycle and remain active in the orchard all year round.

It is often the larvae of familiar beneficials such as the hoverfly or ladybug that are most active as predators.

Spiders will thrive and be most effective in undisturbed habitat. Image (left) shows a fruit spotting bug (FSB) caught in a spider web.

Spiders are important generalist predators of many macadamia pests. Image (left) shows a spider dispatching a banana spotting bug nymph.

Biocontrol adult parasitoids including MacTrix (parasitoid of nut borer) and Anastatus (parasitoid of FSB) will be more fecund and long-lived if they have access to food sources such as flower nectar.

Insectaries in the orchard will also attract and shelter pollinators.

REDUCED MOWING FIELD TRIALS

- 10 farms over 2 years: Bundaberg region, south east Queensland, NSW northern rivers and Nambucca Heads region.
- Trialling reduced mowing practices that allow greater vegetative diversity and bulk.
- Assessing changes in vegetation and arthropod populations in relation to changes in mowing.
- Recommendations on row width, tree spacing, mowing programs, machinery set up, cover-crops.

INDUSTRY APPLICATION

- Insectaries can conserve beneficials in macadamia orchards, which can in turn contribute to the suppression of a range of pests.
- Insectaries can be designed into many different kinds of farms, providing consultants and growers with options for the suppression of pests.
- Insectaries work in conjunction with biocontrol and insecticides.

This project is funded by Horticulture Innovation Australia (HIA) with in-kind contributions from BioResources Pty Ltd and Coates Horticulture.

Integrated crop protection in macadamia – a perspective

Dr Femi Akinsanmi

The University of Queensland, Centre for Horticultural Science, Queensland Alliance for Agriculture and Food Innovation.

Crops compete with thousands of species of weeds, insects, mites, fungi, bacteria, viruses and rodents. The interaction of a plethora of pathogens and pests in tree crops is a very complex system. Plant pathogens and pests are among the most important limiting factors affecting crop productivity. Their impact depends largely on climatic and environmental conditions. The interactions of these organisms with two or more environmental variables determine the extent of a disease or pest epidemic and often have significant detrimental effects on tree health, farm productivity and the quality of produce. Therefore, a good understanding of these interactions is required to deploy preventative and/or suppressive crop protection or management strategies.

The wide range of pests and pathogens, their preferred niche, ecology and part of the plant they affect, all pose great challenges to their management. A holistic management strategy is required to control pests and pathogens in orchards. Strategies including biological, physical and chemical activities are more effective when coupled with improved agronomic practices, monitoring and warning systems, and the use of tolerant or resistant varieties. Developing and implementing alternative control measures that conserve natural enemies of pests, or biological control agents of pathogens in the orchard, is an essential component of integrated pest and disease management (IPDM).

Principles of **IPDM** have moved beyond a one-plant-one-pathogen or one-pest control approach, towards a more holistic approach as **integrated orchard management**. A primary objective in IPDM is to maintain pest and disease intensities below the economic injury threshold, thereby preventing reductions in yield and quality. A holistic IPDM should involve strategies to control multiple pests and pathogens. These measures should reduce the initial levels of pathogen inoculum or pest populations. They should also involve tactics to reduce the rate of spread and the time that the pathogen or pest interact with the crop.

Metrics of IPDM

Measuring the level of IPDM implementation is not a simple matter; it involves complex metrics. A common metric is reduction in pesticide use. The problem with this metric as a measure of effective IPDM is that too often it becomes an end in itself. This perpetuates a quick fix mentality that targets symptoms rather than addressing the root causes of the problems. Good agricultural practices in plant protection incorporate a holistic approach to dealing with pests, diseases and weeds. This approach would ultimately reduce the type, frequency and number of pesticides used. A good IPDM plan should provide economic benefits and protect both the environment and human health.

Efforts toward IPDM

Efforts to reduce or streamline the type and use of pesticides are currently occuring worldwide. Plant industries are keen to adopt low-input farming practices and to produce food that is free of pesticide residue. These expectations are often countered by the lack of alternative control options to manage pests and pathogens effectively. In order to alleviate environmental, health and social concerns, the challenges associated with pesticide toxicity, residues, resistance and withdrawal of products, are important to all industry stakeholders. Therefore, management strategies for plant pathogens and insect pests have undergone significant changes including the use of new and more targeted pesticide products, development of strategic cultural controls and the integration of biological control agents.

IPDM under threat

Many plant pests and diseases that affect other crops are potential threats to macadamia production. The economic and environmental consequences of introducing new pests and pathogens into the Australian macadamia production system could be devastating. Incursion and spread of new pests and pathogens into macadamia orchards could lead to changes that disrupt current control measures and reduce the effectiveness of the established IPDM systems. For instance, lace

bug (Figure 22) and sigastus weevil (Figure 23) are recent endemic pests and the emergence of these has caused significant losses in production for several years. It has also disrupted biological controls and led to an increase in pesticide use. The emergence of husk spot (Figure 24) and dry flower disease (Figure 25) in macadamia has caused excessive yield and financial losses to macadamia growers. Dry flower disease is a new disease of significant economic importance in macadamia.

Case study of integrated disease management (IDM) in macadamia

Research and development (R&D) activities continue to demonstrate ways to integrate various control methods for pests and pathogens. In macadamia, the management system for husk spot is within the IDM framework. IDM is applied for husk spot in response to environmental conditions, crop growth stage, the degree of presence of the pathogen, crop monitoring and cultural practices, in a manner that is as compatible as possible to each production system.

Adoption of an IDM system for husk spot has significantly increased productivity for the macadamia industry. Every macadamia grower now commonly integrates the new tools developed for husk spot control into their crop protection operations. The use of simple on farm monitoring and self-assessment tools, combined with knowledge of the principal source of inoculum, helps application of targeted fungicide sprays at specific crop growth stages based on the prevailing weather conditions.

Integrated control of husk spot

The husk spot control strategy is a well-demonstrated example of a good IDM practice in macadamia, in a manner that is compatible with reducing and preventing economic losses.

IPDM and farm biosecurity

Good on-farm biosecurity awareness is critical to maintain IPDM.

Figure 22. Adult lace bug.

Figure 23. Adult sigastus weevil.

Figure 24. Husk spot on macadamia.

Figure 25. Dry flower disease.

Assess the risk of husk spot in your orchard using the guide set out in Table 1. Then complete the scoring system in Table 2 to obtain your score. Relate this to the score card (Table 3) and then proceed with control measures as recommended.

Table 1. Risk assessment guide for husk spot in macadamia.

Likelihood of infection (Based on presence of infected sticktights and history of husk spot in the orchard)		Consequences (Yield loss due to premature nut drop)		Control measures
Unlikely	• Young trees (less than 10 years old). • No history of husk spot in the mature trees from 10 years old in the orchard. • Relatively open canopy.	Low	• Usually no or insignificant yield loss. • In disease conducive seasons, less than 5% of crop load may drop earlier than expected, e.g. cultivar 333.	• None to minimal treatment is required. • May apply cultural control measures such as removal of sticktights and monitor kernel maturity for start of harvest.
Likely	• Infected sticktights with husk spot lesions in few trees. • Historically very low level of husk spot occurrence. • Husk spot susceptible varieties in the orchard.	Moderate	• Extensive early nut drop of 20-30% of the crop load may occur in a season with husk spot favourable conditions. • Significant yield loss and poor kernel quality may occur if the start of harvest is delayed, e.g. A4, 816, 246, Daddow, 344, 660, 741, 842, 849, Own venture.	• Apply standard control measures and monitor kernel maturity for start of harvest.
Almost certain	• Annual history of husk spot. • Husk spot susceptible varieties in most parts of the orchard. • Disease conducive conditions.	Severe	• Severe (over 30%) premature nut drop if disease control measure is not effective, e.g. A16, A38, H2.	• Apply multiple routine control measures annually as a priority. • Requires application of preventative and curative control measures.

Table 2. Risk assessment table for husk spot in macadamia.

Risk	Risk description	Score (0 or 1)*
1	Does your orchard have a history of husk spot?	
2	In the last season, was the premature nut drop due to husk spot before harvest (January or February) greater than 10%? (e.g. 2 in 10 nuts under the tree with husk spot lesions).	
3	Do you have blocks or rows with susceptible varieties such as A38, A16, H2, 816, 508 or Own Choice?	
4	Do you have sticktights infected with husk spot in your trees?	
5	Do you have out of season flowering and nut set?	
6	Are favourable weather conditions expected for husk spot development during nut development stage (e.g. temperatures between 20-30 °C with frequent showery or prolonged wet conditions during September–December)?	

*Assess your risk (1-6) before flowering. Score each risk either 0 = No or 1 = Yes, then add your scores from the end column to get a value for your risk level.

Table 3. Score card for husk spot in macadamia.

Total score	Risk level	Actions	Control measures
0–1	Low	Minimal control	• Monitor kernel maturity
2–3	Moderate	Apply standard treatment	• Protective spray applications at match-head size nut stage and ensure good spray coverage • Monitor kernel maturity
4–6	High	Apply a series of control measures	• Sticktight removal • Multiple protective and curative spray applications (from match-head size nut stage and ensure good spray coverage) • Monitor kernel maturity

Challenges of IPDM systems

1. Emergence of new or resurgence of major pests and pathogens.
2. Withdrawal and regulation of crop protection products.
3. Knowledge of pest ecology and disease epidemiology.
4. Acceptable economic thresholds.
5. Diverse environments.
6. Dynamic pest and disease complex.
7. Host resistance.

Emergence of new or resurgence of major pests and pathogens

New pathogen and pest encounters occur either through expansion of production into new geographic areas, or through long distance incursion of exotic organisms. The resurgence of major plant pests and the incidences of potentially damaging new pests are increasing worldwide. This is due in part to increasing globalisation and ease of travel that invariably causes an easy exchange of pests, pathogens and weeds. Short term solutions often include application of pesticides at different times, changes to application rates or switching to a pesticide with a different mode of action. It is important to know that if a holistic management approach is not adopted, the successful control of one primary pest can lead to an outbreak of a secondary pest. Likewise, growers need to avoid the factors that can exacerbate the resurgence of pest or disease epidemics. Such practices may include indiscriminate use of a particular pesticide, indiscriminate use of pesticides that can impact on populations of beneficial mites, insects and microbes, as well as reduction in crop protection practices that keep pest and pathogen populations below harmful levels. For growers that encounter these problems, it is essential to adopt a long-term view for an integrated management strategy and adhere to the use patterns of crop protection products.

Withdrawal and regulation of crop protection products

Crop protection products help plant industries increase yield and produce high quality food and fibre that is competitive in world markets. In Australia, the production and use of crop protection products is highly regulated by the Australian Pesticides and Veterinary Medicines Authority (APVMA). It is likely that the withdrawal of certain pesticides may cause the resurgence of new major pests. For instance, it is unclear if the withdrawal of endosulfan resulted in the emergence of new pests including lace bug, sigastus weevil, bark beetle and banana caterpillar in macadamia. Nonetheless, the management of these pests might require the use of multiple and more specific products over an extended period of time per season, compared with a single application of a broad-spectrum pesticide. How changes in pesticide management programs influence the application and timing of release of beneficial insects as a biological control option for other pests is unknown. Hence, re-developing and evaluating the use patterns and integrated strategies needs to be investigated. Therefore, plasticity of IPDM strategies is important to deal with differences in farm structures and inevitable changes in regulatory, social, market and environmental conditions.

Pesticide resistance usually evolves following the intensive or inappropriate use of the same mode of action pesticide products to control pests or pathogens. The risk of pesticide resistance developing varies between different chemical groups and organisms. Some pathogens, such as *Botrytis,* are considered to have a very high risk of pesticide resistance. In Australia, all products are classified according to the chemical activity group of their active constituent. This classification helps to safeguard against development of resistance or cross-resistance to multiple chemical groups, and to prevent or manage pesticide resistance. It is critical that growers in the macadamia industry follow the established pesticide resistance management strategies. The use of consecutive applications of the same active ingredient, or products from the same activity group, should also be limited by alternating between products from different activity groups. See section *Avoiding resistance to pesticides on page 71*. In environments susceptible to continuous infection and consistently high disease pressure, always follow the recommendations and apply the most stringent strategy within the IPDM program. Some tolerant or resistant varieties require fewer or less frequent pesticide applications. When products are used in a tank mixture, growers must give attention to the label recommendations, rates and coverage.

Knowledge of pest ecology and disease epidemiology

The potential losses of crop yield and quality caused by each pest will only be realised when growers and crop consultants have a thorough understanding of the pest ecology including fecundity, feeding behaviour and ecological environments. This is a major challenge when growers deal with multiple pests, and more challenging when new or uncommon pests emerge. The ecological context of IPDM must be considered with the phenology and growth stages of the tree.

Acceptable economic thresholds

As much as judicious use of pesticides should be encouraged, other factors also come into consideration. Tactical use of agrochemicals and appropriate application practices, including plans for long-term strategies to minimise pest and disease epidemics, must also be implemented. Monitoring pests and diseases serves as a tool

that growers and consultants can use to obtain information that underpins decisions for control measures. Economic and treatment thresholds for chemical applications have been developed over the past few years to give growers confidence that they will not suffer yield and quality losses. The use of natural enemies or antagonists still requires further development in order for the industry to gain confidence.

Diverse environment

Biodiversity plays an important role in safeguarding crop protection. However, persistence of functional diversity depends on the ability to maintain integrity and diversity in the ecosystem. The complexity and uncertainty that can influence pest and pathogen dynamics are sometimes very difficult to predict. Therefore, R&D will give the industry a better understanding of the ability of biological control measures to adapt to different pests at different stages of growth and in different seasons.

Just as the above-ground biodiversity is essential for aerial insect pests and pathogens, a diverse soil environment is an important part of **soil resilience**. Soil resilience is the ability of the soil to maintain its health, integrity and to recover from adverse conditions. Creating a diverse soil microbial environment could help against certain plant pathogens such as *Phytophthora cinnamomi*. In the soil near healthy trees, the occurrence of pathogenic organisms is low. This is due to the presence of microbes that interfere with pathogen growth, survival and infection. ***A healthy soil is an integral part of IPDM.***

Dynamic pest and disease complex

The interactions of pests and plants are dynamic because what happens in one season may not occur in another. For example, loss of biodiversity, extreme weather, climate change, protection practices and human activities such as traffic and transmission of pest and pathogen from affected areas to new locations, can all influence pest and disease emergence and severity. Changes in the surrounding landscapes can also provoke changes in the dynamic pest systems in the orchard. For instance, clearing of vegetation or planting of certain host species around neighbouring properties may put selection pressure on phytophagous insects to find alternative or more quality hosts like macadamia. Practical application of certain control measures in a suburban environment is a challenge. Thus, the ability to use varied tools for managing pests and diseases is essential.

Host resistance

Varietal resistance is an effective method of pest and disease control. Choice of variety is an essential decision for growing a healthy crop. Benefits of using resistant varieties include reduction in the rate of development of pesticide resistance, increased activity of beneficial organisms due to reduction in pesticide use, and reduced sprays required (economical and environmentally friendly). Development of varieties that are resistant to insects and diseases should be a major criterion in IPDM R&D and breeding programs.

IPDM myths and dogmas: confirmed or busted?

Applying a quick fix might seem simple and represent the path of least resistance for the farmer or crop consultant. Often the application of pesticides is viewed as a cheap insurance policy when there is a risk of crop loss. In spite of all efforts, overcoming the apparent failures or challenges to implement IPDM to any significant extent would require a change in attitude and perception (Table 4).

Table 4. Common myths and myth busters of IPDM.

Common myths	Myth buster
IPDM is time consuming and complicated	IPDM requires dedication and attention to detail
Application of pesticides is a cheap insurance policy when there is a slight possibility of crop loss	Applying a quick fix solution that represents the path of least resistance may not be a sustainable option
The same IPDM strategies work in all environments	IPDM must be developed for each farming system; there is no one size fits all approach. The tendency to generalise and make recommendations for farms across highly diverse areas should be discouraged
There is a single ingredient for crop protection	Good crop protection programs are an integration of many elements

Concluding remarks

Growers and crop consultants need to work around the constraints of implementing an IPDM strategy. Given the pressures already on farm production practices, growers will require assistance to fully integrate multiple, often time consuming and complicated systems, to suppress all classes of pests and diseases. Good agricultural practices are underpinned by evidence-based research and development programs.

In the macadamia industry, the focus of IPDM is not just a reduction in the number of pesticides used, but also an integrated use of three or more control options. The use of resistant cultivars and cultural practices will minimise pest and pathogen inoculum pressure. It will also help to maximise the use of natural beneficial organisms and the application of biological control measures. Investment in R&D programs for IPDM should continue to be a priority for the industry. Evidence-based IPDM strategies will increase confidence in management decisions. These strategies should feature a degree of plasticity to manage any changes in the balance between pest and disease and beneficial organisms.

Spraying 101

Dr Jason Deveau (@spray_guy)
Application Technology Specialist

Introduction

Full disclosure: I have never sprayed a macadamia tree.

However, I have studied spray applications in a diversity of crops, both broad acre and speciality, but nothing as challenging as a >10 metre high, >4 metre deep canopy wall. So in writing this article I face the opposite situation I normally encounter when advising on airblast sprayer settings.

In my region, fruit orchard, cane, bush and vine crops are typically sprayed with airblast sprayers. Over the years, through breeding and crop management, these operations have densified. The idea is that smaller, uniform crops can be managed, protected and harvested more efficiently. The ratio of quality fruit to planted area goes up, and input costs go down.

However, our aging fleet of sprayers are overpowered relative to the target. This means much of what I do involves demonstrating to sprayer operators what sufficient coverage looks like, and then teaching how to restrain sprayer parameters to achieve this ideal coverage as efficiently as possible.

So, should I keep reading?

Yes! The need to understand what 'good coverage' looks like, and the parameters that affect it, are universal to any airblast operation. Assuming the operator already has product choice and pest staging well in hand, there are three major factors that influence the quality of the spray application:

1. sprayer settings
2. geometry of the target
3. environmental conditions.

In theory we can discuss each of these factors individually, but in practice they interact with one another. It is wrong to adjust one factor without considering the other two. This is also why you should be wary of anyone that tries to sell you a sprayer by demonstrating it in an empty lot on a calm day! Always calibrate a sprayer in the planting, in the weather conditions you would normally spray in.

Air volume and direction

Air adjustments are perhaps the most impactful changes you can make to your operation. The air stream created by the sprayer not only conveys the spray solution to the target, but opens the canopy and exposes leaf surfaces to the spray. In order to achieve adequate coverage, the volume (and speed) of sprayer-generated air must be sufficient to span the distance from sprayer to target, and then displace the volume of air in the canopy while depositing the spray.

I admit to a bias when it comes to air shear systems. These sprayers utilise sprayer-generated air to atomise the spray liquid as well as convey it. As such, you cannot easily adjust the air without affecting spray quality (aka average droplet size or visual molecular dynamics (VMD)). My preference is an arrangement where nozzle selection allows you to control spray quality independent of air settings. In any case, adjusting air settings requires the operator to 'see' air.

In my region, I advise tying 25 cm lengths of flagging tape at the top, middle and bottom of the far side of the upwind tree. Then, drive past with the air on and the nozzles shut off. If the ribbons stand straight out, the sprayer is over-blowing and the operator can drop to a lower fan gear, reduce the tractor RPMs (if using a positive displacement-style pump), or drive faster. If the ribbons do not move, the opposite steps can be taken. If the ribbons still will not move, the sprayer is under-powered, it is too windy to spray, or the canopy is too large.

Learn more here:

http://sprayers101.com/adjusting-airblast-sprayer-settings-part-2/

http://sprayers101.com/adjust-the-direction-of-the-air-stream/

Let's explore that last point. In the case of a canopy as large as macadamia, it is unlikely a low-profile axial sprayer can produce sufficient air volume to displace all the air in the canopy – particularly at the top of the tree. In this case a more humble goal would be to move the leaves at the trunk, indicating that the sprayer is managing to drive the air to the centre. In order to monitor this, an observer wearing safety goggles would have to stand at the far side of

the upwind trunk and (while being very careful of flying debris), watch for leaf movement.

This becomes increasingly difficult to monitor as the target gets fuller, higher, and farther away from the sprayer. Consider the following figure (Figure 26):

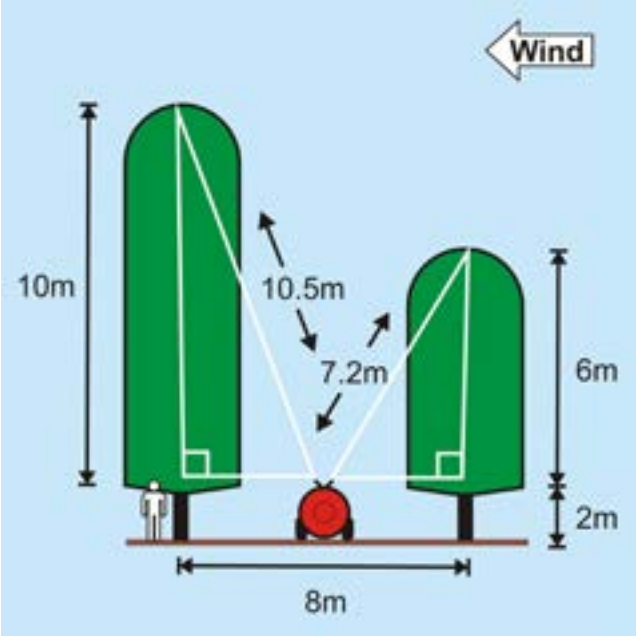


Figure 26. An observer should monitor leaf movement to ensure sprayer-generated air is displacing the air within the canopy. This becomes more difficult to accomplish, and to observe, as a function of canopy height.

Our observer will have difficulty seeing leaf movement at the top of either the taller or shorter tree, but we can safely assume there will be less movement as a function of height. Since our goal is uniform penetration throughout the canopy, we must somehow compensate for this differential.

Consider the following figure (Figure 27) which extrapolates the path between the sprayer air outlet and the tree. In this figure we have divided each side of a low-profile axial sprayer into halves. The bottom half of the air outlet must produce enough air volume to displace area X. I realise I am mixing area and volume, but bear with me. For the taller tree, the upper half of the outlet must produce enough air to displace 2.5 times the area versus the bottom half. Given that it is a single air outlet, this means inconsistent coverage.

Comparatively, the shorter tree requires a more uniform air distribution. While this improves matters, there are further challenges. Sprayer-generated air slows and disperses proportional to distance, requiring more air to compensate. Also, orchard wind speed increases with elevation, increasing the potential for interference and dispersion. So, the taller the tree, the harder it is to achieve uniform canopy penetration.

Spraying shorter macadamia trees with a low-profile axial sprayer might be possible. The sprayer would require a large fan (≥1 m diameter), an aggressive fan blade pitch and a high fan speed. Air deflectors and air separation vanes would also be needed to segregate and focus the air. Also, travel speed would play a significant role.

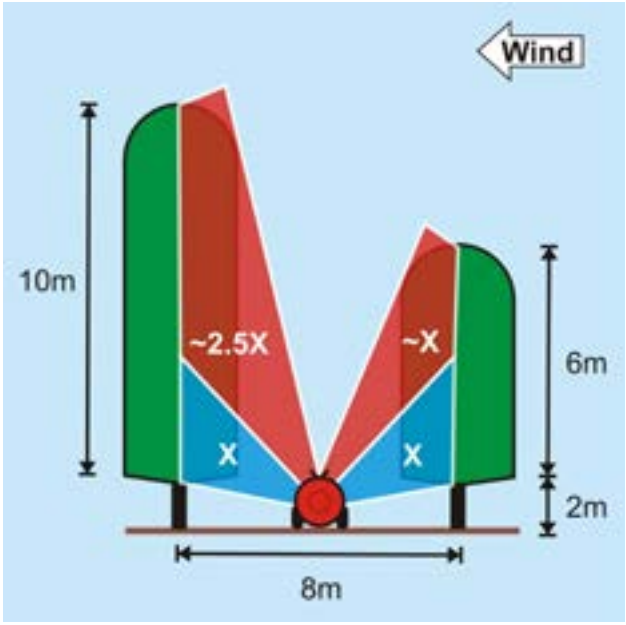


Figure 27. The effectiveness and consistency of canopy displacement by sprayer-generated air has an inverse relationship with distance. For tall trees and low-profile axial sprayers, one can expect over-blowing in the lower canopy and insufficient air delivery to the upper canopy.

Travel speed

Travel speed should be considered as function of air penetration. Speed is critical and is the easiest method to improve coverage. A slower travel speed (~2 km/h) facilitates the displacement of stagnant canopy air with sprayer-generated air. Further, a slower travel speed reduces the wake effect that can suck finer droplets from the swath.

It may seem counter-intuitive, but slower speeds may result in greater spray efficiency. There is no need to increase the volume sprayed per hectare, so additional refills are not an issue. Further, improving spray coverage at slower speeds may prevent the need for an additional clean-up application later on, saving time and reducing environmental impact. Time lost to slower travel speed can be reclaimed with more efficient loading practices.

Learn more here:

http://sprayers101.com/how-fast-should-I-drive-my-sprayer/

http://sprayers101.com/increase-sprayer-productivity-without-driving-faster/

Directed sprays and off-target deposition

When the height of the target tree exceeds alley width, or when branches overgrow alleys, many low-profile axial sprayers suffer from line-of-sight issues. Lower branches and leaves block the upper canopy and too many nozzles target the lower canopy (Figure 28).

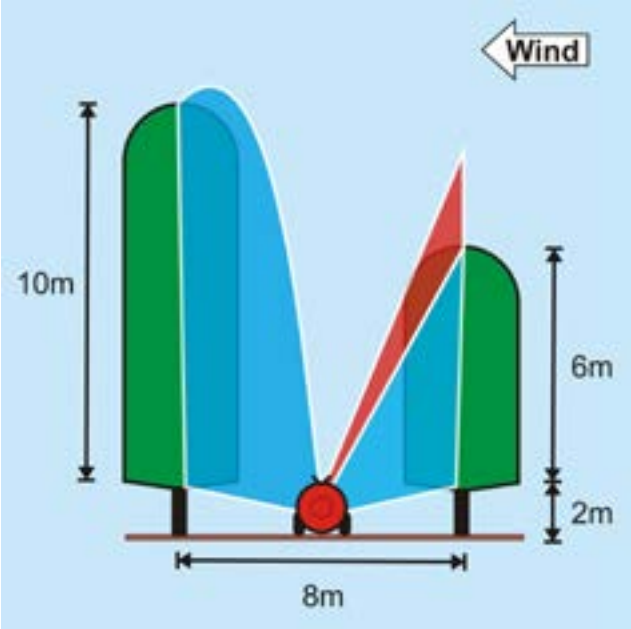


Figure 28. Line-of-sight issues are challenging when spraying tall trees. Spray must either move through the canopy to reach the top, or must be directed vertically. In either case, the potential for inconsistent coverage and for off-target drift is high.

One option is to direct spray vertically to ensure the swath reaches the top of the canopy. In this case it is hoped that droplets remain coarse enough to fall from the swath and penetrate the canopy, or blow laterally with prevailing wind (left side of Figure 28). This unadvisable strategy is unlikely to achieve consistent results and greatly increases the potential for drift.

Alternately, the top of the swath can be vectored directly at the top of the tree, but must pass through the canopy to reach it (right side of Figure 28). This strategy also increases the potential for drift, risks missing a portion of the upper canopy and is also unlikely to yield consistent results.

Ideally, we would use a sprayer design that brings the air (and nozzles) closer to the target. Hypothetically, there are several possible configurations, but in practice their success will be hampered by boom sway (from sloped plantings or uneven alleys) and pressure drop restrictions (from boom height). Here are a few possibilities (Figure 29):

A. A vertical boom with a tapered inflatable bag to convey and redirect the air laterally (typically one-sided).
B. An axial sprayer topped with a ducted tower with vertical booms, terminating in either a second axial fan or one-sided cannon.
C. An axial sprayer with a vertical mast with a series of Sardi-style nozzle/fan assemblies distributed along the height.

Learn more here: http://sprayers101.com/tower-power/

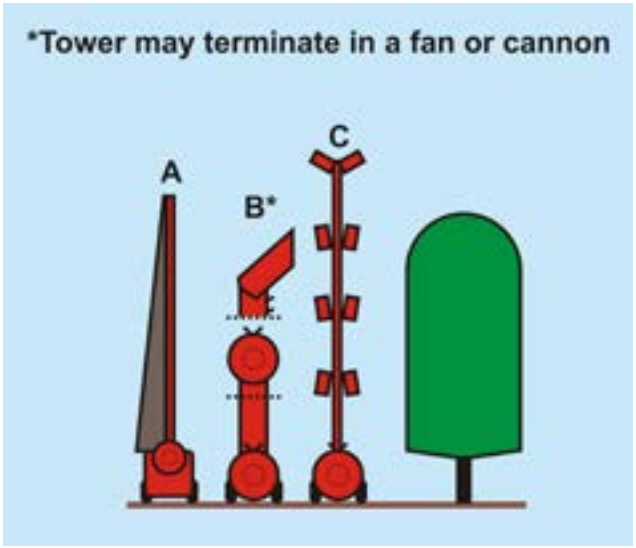


Figure 29. Low-profile axial sprayers are highly unlikely to provide effective and efficient coverage in tall trees. Directed applications by means of vertical booms with air-assist bags, ducted towers or a series of fan/nozzle assemblies on a mast would be preferred. Practical limitations to these approaches include the slope of the planting, alley evenness, and pressure drop.

Two possible arrangements might work (Figure 30). On the left is a vertical boom with a tapered air assist system. This provides the shortest distance-to-target for each nozzle and in moving laterally, the air will more easily penetrate horizontal limbs. It also reduces the potential for drift.

On the right is a novel arrangement proposed by Dr Ken Giles (UC Davis, California). A Sardi-style fan and nozzle assembly is elevated above the canopy from an axial sprayer. His intention was to create air and fluid interaction to generate turbulence that could improve uniformity and decrease drift. He proportioned 70% of the overall spray to the top fan, and the remaining 30% from the ground. Working in almond, he saw more even coverage distribution compared to a low-profile axial sprayer and noted it reduced off target drift. For a target as tall as macadamia, additional fans would likely be required.

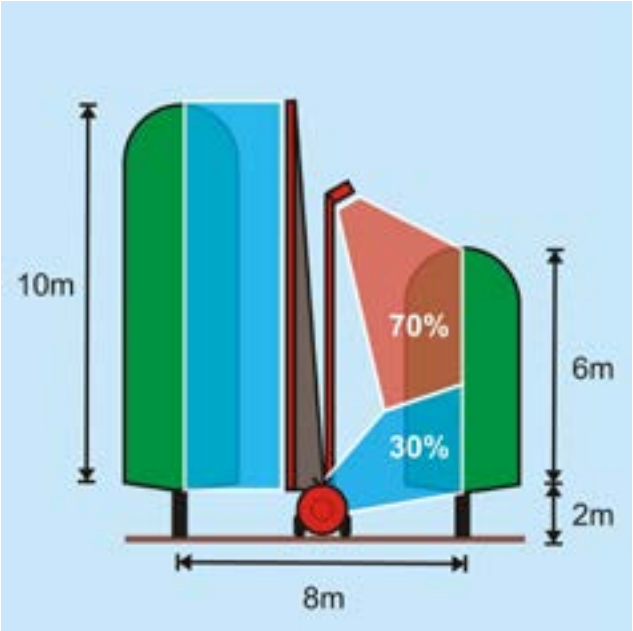


Figure 30. Directed applications bring nozzles and air closer to the canopy. Spraying laterally (on left) improves canopy penetration by reducing line-of-sight issues. Spraying down into a rising swath (on right) creates turbulence that can improve coverage uniformity and reduce the potential for off-target drift.

Droplet size

Droplet size influences droplet behaviour. There are pros and cons to changing droplet size when overall spray volume (e.g. L/ha) remains constant (Table 5).

It is preferred to use nozzles that create coarser droplets at higher rates (to compensate for fewer droplets) in the higher boom positions. They are more likely to stay on course to the tops of the trees, and when they miss, many fall out of the air rather than contribute to drift.

Learn more here: http://sprayers101.com/how-do-airblast-spray-droplets-behave-or-misbehave/

Learn more here: http://sprayers101.com/strategies-to-spray-the-top-of-a-canopy/

Finer spray has very little mass and therefore very little kinetic energy. This means it slows quickly (imagine throwing a feather) and requires the entraining air to carry it to the target. Finer droplets also evaporate quickly, particularly on hot and dry days (unsuitable Delta T conditions). If employed, they should be distributed in the lower-middle portion of the boom where they have the least distance to travel and are most likely to be intercepted by canopy.

Table 5. The pros and cons of coarse and fine droplet sizes when overall spray volume (e.g L/ha) remains constant.

Relative spray quality	Pros	Cons
Coarser droplets	• Lower drift potential because they resist deflection by wind and evaporation from hot temperatures and low humidity. • Greater mass means they move ballistically, propelled by pressure, for greater distance.	• Lower droplet count may reduce coverage. • May fall out of spray swath before reaching the centre of the canopy • Coarser droplets do not penetrate dense canopies as well as finer droplets.
	Redistribution due to bounce, shatter or run-off may either improve or compromise coverage.	
Finer droplets	• Higher drift potential from wind, and evaporation from hot temperatures and low humidity. • Finer droplets penetrate dense canopies better than coarser.	• Higher droplet count may improve coverage (if they arrive at target).
	Finer droplets move unpredictably and require air entrainment to direct them to target. Good for nearby targets and bad for distant targets.	

Boom distribution

Unlike a broad acre boom sprayer, where each nozzle emits the same rate, an airblast boom can distribute spray unevenly. For a curved (axial) boom, the rule of thumb is to produce 2/3 of the overall volume from the top 1/3 of the boom. This compensates for the distance and greater proportion of canopy it is intended to cover.

A vertical (tower) boom positions each nozzle roughly the same distance from the target, and if that target is a hedged canopy, the spray can be distributed equally over the boom. There is no appreciable advantage to one spray shape over another (e.g. flat fan, hollow cone or full cone) other than the spray quality they produce.

In extreme cases, operators might elect to 'fire hose' spray to the tops of canopies using high pressures. This is achieved by using streaming nozzles or removing the swirl/whirl/disc plate in a disc-core combination nozzle in the top few nozzle positions. Given the heavy demand on the pump and the inaccuracy of the method, this should only be considered when air fails to reach the tops of trees.

Learn more here: http://sprayers101.com/airblast-nozzle/

Spray coverage and diagnostics

It is well understood that spray coverage has a negative correlation with tree height. The irony is that the upper portion of the macadamia canopy produces much of the harvest. Taken collectively, this may explain why pest activity is also highest in the upper canopy. When choosing a spray volume and boom distribution, the metric is threshold coverage in the top 1/3 of the canopy. This requires us to define threshold coverage.

If ribbons and leaf movement represent the feedback mechanism for air settings, then water sensitive paper (WSP) is the choice for spray coverage. Placement is tricky, given that we are most concerned with coverage at the top of the tree, but this can be overcome by mounting the WSP on telescoping poles. Papers can be oriented horizontally to represent a leaf, or curled around the pole to give panoramic coverage and emulate a nut. However, beware of overblowing in the lower canopy, which creates a shingling effect where leaves cover one another (or the WSP) and block coverage.

Fluorescent dyes and kaolin clay show spray coverage *in situ*, but there are drawbacks. Few growers will spray dye and come back at night with a black light to examine targets. Further, a target sprayed with dye or clay cannot be sprayed a second time, which means the grower cannot adjust the sprayer and try again in the same canopy. Finally, it is very difficult to determine if there is more or less coverage with clay or fluorescent dye.

Learn more here: http://sprayers101.com/confirm-coverage-with-water-sensitive-paper/

WSP is fast, cheap and effective. With the exception of drench applications, the most demanding spray application (e.g. contact fungicide) should produce a spray coverage pattern of 85 drops per cm^2 and 10-15% total coverage (Figure 31). This threshold comes from collective research and experience in horticultural crops, and should hold true for macadamia.

Be prepared to make changes to your sprayer calibration to compensate for tree height, canopy density and weather conditions throughout the season. The feedback from water sensitive paper is far more accurate than shoulder-checks and leaf residue. It takes some time and effort, but it is well worth it. *Coverage is King*.

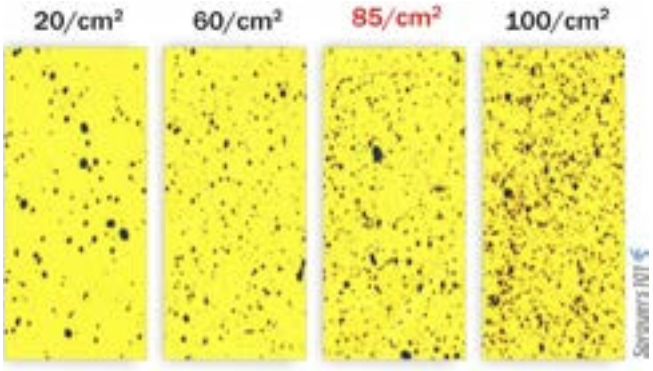


Figure 31. Water sensitive paper is an effective and economical means for diagnosing spray coverage. For most applications, 85 droplets per square centimetre and 10-15% coverage represent sufficient coverage.

What others have done

Researchers like Brad Higbee and Ken Giles have explored spray coverage and efficacy from different sprayer configurations to combat Naval Orange Worm in almond. What follows is a summary of their observations. This information comes from their presentations and conversations with Brad.

Ten years of trials spanned travel speeds of 3-6.5 km/h, volumes of 1,400-2,150 L/ha, and sprayer-generated airspeeds (measured at source) of 80-290 km/h. They looked at efficacy, residue levels and WSP coverage both in leaves and on the nuts themselves. When comparing sprayer configurations, the target almond tree was divided into four levels:

Level 1 = 1.8 m to 2.5 m (lower canopy)
Level 2 = 3.0 m to 3.7 m
Level 3 = 4.2 m to 4.9 m
Level 4 = >5.5 m (upper canopy).

Many configurations were tested, but Figure 32 shows the top four. Many are not shown, including the Bell 206 helicopter (280 L/ha at 50 km/h) and the Curtec AC 1000 Cross-Flow tower.

A. Air-O-Fan low profile axial D-240 (Also used Air-O-Fan 232)
B. Progressive Ag two-head 2650 electrostatic air-shear with 4 m tower (Also used 4.9 m three-head and 5.5 m four-head)
C. Low-profile axial airblast with two Sardi fans on mast. Upper fans set to 70% overall fan speed and spray volume. Axial fan and nozzles set to 30%.
D. Blueline Accutech 10-head air-shear tower.

Figure 32. Four (of many) sprayer configurations tested by Brad Higbee and Ken Giles in Californian almond trees.

- Spray coverage and residue deposition was weakest in the upper half (Levels 3 and 4) of the canopy. Tower sprayers tended to provide more uniform coverage across vertical levels. For low-profile axial sprayers, most of the residues were deposited in the lower half of the tree.
- The Air-O-Fan low-profile axial had the highest overall residues. However, above 3.7 m there was severe drop off in coverage. PTO-driven sprayers seemed as effective as engine driven. Incremental improvements were observed on this sprayer when using multiple banks of booms, full cone and hollow cone nozzles.
- The Progressive Ag tower provided the highest residue deposition above 3.7 m and modest deposition in the lower canopy. While tower sprayers tended to provide more uniform coverage, the Progressive Ag was not significantly better than the Air-O-Fan overall.
- Aerial application (280 L/ha) combined with the Air-O-Fan low-profile axial sprayer (1,870 L/ha) did increase residues in the upper canopy, but did not result in greater damage reduction relative to the Air-O-Fan alone.
- Slowing the Air-O-Fan low-profile axial sprayer from 4 to 3.2 km/h resulted in 30% more coverage and 47% higher residue deposition overall.
- Electrostatic treatments did not perform well on WSP (small droplet size was suspected), but they were among the best in residue deposition at full volume and "*delivered surprising residues at high speeds/low volumes*".

Brad has done remarkable work studying the impact of several sprayer configurations. While many were tested, there are still more that might be considered.

Learn more here: http://sprayers101.com/spray-equipment-from-the-great-lakes-expo/

Canopy management

When all else fails, we are left with only one alternative: canopy management. Hedging and pruning the trees to create sprayer clearance opens canopies to spray (and light and air) and is a critical part of crop protection.

Learn more here: http://sprayers101.com/canopy-management/

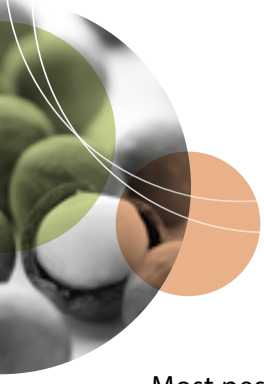
Topping trees to bring them to a manageable height to improve coverage and reduce drift may be the only viable option for protecting the crop. I acknowledge that a great deal of nut production takes place in the upper third of the canopy, and it is beyond the scope of this article to discuss production and yield economics. However, when the crop is left unprotected, the yield quality is negatively impacted and it has been shown that a reduction in harvest weight is offset by the improvement in overall quality.

In such an extreme case as macadamia, it is highly recommended that the orchardist engage a local crop expert and discuss a strategy for canopy management. There are many benefits, including:

- improved harvest quality
- fewer refills (saving time and water)
- less time to spray means more timely applications
- potential chemistry savings
- savings in fuel, noise and equipment wear and tear
- potential for reduced off target spray drift.

Take home points

- Adjust sprayer air settings first, using canopy penetration as your guide to travel speed.
- Distribute the 2/3 of the volume and coarser spray quality to the top 1/3 of the boom.
- Consider an air-assisted horizontal boom configuration to improve coverage uniformity and reduce drift.
- Use water sensitive paper for critical coverage feedback and make changes based on that feedback.
- Develop a canopy management strategy to improve spray coverage and yield quality.
- Visit www.sprayers101.com for more information on improving the efficacy, efficiency and safety of your spray applications.



Orchard pest and disease management priorities

Most pests and diseases of macadamia appear during specific growth stages of the crop. This guide lists (Table 6) the most common pests and diseases that growers should be on the lookout for during a typical growing season. It gives recommendations for control based on an integrated pest and disease management approach (IPDM). This approach also assumes that orchard pest and disease monitoring has indicated thresholds that require treatment. Guidance of action level by a pest scout or consultant is strongly recommended.

Resistance management

A fundamental aspect of any IPDM strategy is the pesticide or pesticides that are used. The primary consideration is to rotate applications so that the pest, disease or weed is not continually exposed to chemicals of the same group, thus reducing the risk of resistance to that chemical. To do this successfully, growers need to be able to identify chemical groups. You can do this by checking the activity group identification symbol, which all registered pesticides have on their labels, e.g. 1B, 11, 18.

Note that pesticide recommendations are based on NSW registrations, which are pest and crop specific. This is different from in Queensland, where regulations are for crops only. The recommendation made in this article are based on NSW regulations, however, they are relevant to the industry in Australia.

Table 6. Macadamia management guide (correct as at 30 May 2018).

Month	Reason	Treatment	Fungicide group	WHP days	Remarks
PRE-FLOWERING					
July	Macadamia flower caterpillar	Trichlorfon (S6)*	1B	2	Monitor crop for hot spot areas.
		OR			Apply in late evening when bees are not active or remove bees from orchard.
		Acephate (S6)	1B	NRD[1]	DO NOT SPRAY WHEN BEES ARE FORAGING.
		OR			Good coverage is essential for control.
		Methoxyfenozide (PS exempt)	18	28	Apply Bt at first sign of activity. Bt is best used in a routine program. It is not suitable for emergency treatment.
		OR			**Biological control**
		Tebufenozide (S5)	16A	28	Wasps (larvae parasite) *Agathis rufithorax*
		OR			*Brachymeria* sp., *Phanerotoma* sp.
		Bacillus thuringiensis (Bt) (PS exempt)	11C	NRD[1]	Egg parasitoids *Trichogrammatoidea flava*
					Parasitic bug *Termatophylum* sp.
					Syrphid fly larva *Melanostoma agrolas*

Month	Reason	Treatment	Fungicide group	WHP days	Remarks
July	Lace bug	Trichlorfon (S6) (See APVMA permit PER13689, expires 30 September 2021) OR Diazinon (S6) (See APVMA permit PER14276, expires 30 November 2020) OR Pyrethrin (NA) (See APVMA permit PER14852, expires 31 March 2019)	1B 1B 3A	2 14 1	Lace bug is generally not an issue in central Queensland but is becoming so in south-eastern Queensland. Monitor crop for hot spot areas. DO NOT SPRAY WHEN BEES ARE FORAGING. Apply late evening when bees are not active or remove bees from orchard. Good coverage is essential for control. NB: Apply Diazinon at pre-flowering due to residual and subsequent effect on bees. Diazinon residues on flowers can remain dangerous to bees for up to one week post application. Apply pyrethrin at first sign of infestation, pre-flowering, immediately before main flower opening. Repeat spray treatment (if required) before second flower opening, continuing to nut set if pressure persists. Apply a maximum of five applications of pyrethrum per crop with a minimum of seven days between applications.
July	Macadamia felted coccid	Petroleum oil (See APVMA Permit PER11635, expires 30 June 2020) (S5) OR Diazinon (S6) OR Methidathion (S7)	Unspecified 1B 1B	NRD[1] 14 21	Do not apply petroleum oil when temperatures exceed 32 °C or when soil is dry and trees are suffering from moisture stress. Products to be used are those referred to only as summer spray oils. BEWARE of repeated applications of methidathion as resistance may occur. **Biological control** Ladybird beetles and larvae *Midus pygmaeus, Rhizobius ventralis, Serangium maculigerum* Predatory moth *Batrachedra arenosella* Egg parasitoid *Aspidiophagus* sp., *Metaphcus* sp.
EARLY FLOWERING					
August	Macadamia flower caterpillar	Trichlorfon (S6) OR Acephate (S6) OR Methoxyfenozide (PS exempt) OR Tebufenozide (S5) OR *Bacillus thuringiensis* (PS exempt)	1B 1B 18 16A 11C	2 NRD[1] 28 28 NRD[1]	Late August peak flowering for some varieties. **Biological control** Wasps (larvae parasite) *Agathis rufithorax* *Brachymeria* sp, *Phanerotoma* sp. Egg parasitoids *Trichogrammatoidea flava* Parasitic bug *Termatophylum* sp. Syrphid fly larva *Melanostoma agrolas*
August	Lace bug	Trichlorfon (S6) (See APVMA permit PER13689, expires 30 September 2021) OR Pyrethrin (NA) (See APVMA permit PER14852, expires 31 March 2019)	1B 3A	2 1	An option is to leave at early flowering and then target pest at peak flowering due to some varieties still being harvested and residue concerns. Apply a maximum of five applications of pyrethrum per crop with a minimum of seven days between applications.

Month	Reason	Treatment	Fungicide group	WHP days	Remarks
August	Phytophthora	Phosphorous acid (See APVMA permit PER84766, expires 30 November 2022) OR Copper as cuprous oxide (S6) OR Metalaxyl (S5) OR Metalaxyl (S5) + copper oxychloride (S6)	33 M1 4 4/M1	14 1 28 28	**Maintenance** Foliar spray phosphorous acid. Apply at mature leaf flush during spring and autumn. Do not apply to young leaf flush as it can burn foliage. Apply to each leaf flush if disease persists during production period. Apply to point of run-off, ensuring all leaves and branches are covered. DO NOT apply to trees under severe water stress or during very hot weather (e.g. temperature >28 ℃). **Curative** Trunk application phosphorous acid. Apply to affected macadamia trees at root flush and 28 days after root flush. Dilute spray to point of run-off around trunk to approximately 1 metre above soil level, ensuring thorough coverage of trunk. Bark penetrant such as Pulse is to be applied at a rate of 2%.
PEAK FLOWERING					
September	Lace bug	Trichlorfon (S6) (See APVMA permit PER13689, expires 30 September 2021) OR Pyrethrin (NA) (See APVMA permit PER14852, expires 31 March 2019)	1B 3A	2 1	Monitor crop for hotspot areas. Apply in the evening when bees are not active or remove bees from orchard. Coverage is essential for control. Apply a maximum of five applications of pyrethrum per crop with a minimum of seven days between applications.
September	Macadamia flower caterpillar	Trichlorfon (S6) OR Acephate (S6) OR Methoxyfenozide (PS exempt) OR *Bacillus thuringiensis* (PS exempt) OR Tebufenozide (S5) OR Spinetoram (S5)	1B 1B 18 11C 16A 5	2 NRD[1] 28 NRD[1] 28 7	Monitor for eggs and very small larvae on flowers and apply control at threshold of 50–80% of racemes infested. **Biological control** Wasps (larvae parasite) *Agathis rufithorax* *Brachymeria* sp., *Phanerotoma* sp. Egg parasitoids *Trichogrammatoidea flava* Parasitic bug *Termatophylum* sp. Syrphid fly larva *Melanostoma agrolas*
September	Botrytis blight	Iprodione (S5)	2	0	Apply as a thorough cover spray to flower racemes when they open. A follow-up spray might be required one week later if wet conditions persist during flowering.

Month	Reason	Treatment	Fungicide group	WHP days	Remarks
NUT SET					
September–November	Husk spot	Pyraclostrobin (S5) OR Copper (S6) OR Carbendazim (S7) OR Difenoconazole (S5)	11 M1 1 3	NRD[1] 1 14 NRD[1]	First application when nuts are at match head size. Do not apply more than two consecutive sprays of the same product. At least two sprays 2–4 weeks apart and more sprays if: • weather is conducive for husk spot • variety is susceptible • infestation was severe in previous years. Try to remove sticktights from trees to reduce inoculum. Refer to husk spot risk assessment.
September–November	Macadamia twig girdler	Carbaryl (S6) OR Methidathion (S7) OR Spinetoram (S5)	1A 1B 5	NRD[1] 21 7	Monitor for leaf clumping and twig damage particularly on young trees. **Biological control** Parasitic wasp *Elachertus* sp.
September–November	Green vegetable bug (GVB)	Trichlorfon (S6) (See APVMA permit PER13689, expires 30 September 2021)	1B	2	Damage appears similar to fruit spotting bug. GVB will usually have more stings on fruit and they will be shallower than FSB stings. **Biological control** Parasitic wasp *Trissolcus basilis* and parasitic fly *Tricopoda giacomellii*.
September–November	Banana fruit caterpillar	Methomyl (S7) (See APVMA permit PER12796, expires 30 June 2021)	1A	NRD[1]	Problem only in Queensland. Blow out leaf litter before spraying. Ground surface treatment only using spray boom or equivalent application equipment. Apply one application only during late flowering–early fruit development. Time spray to coincide with initial observation of larvae activity. Ensure thorough coverage of all leaf litter and soil surface along tree line. Use higher rate when large larvae or higher numbers are present. DO NOT spray tree foliage, flowers or developing nutlets.
September–November	Sigastus weevil	Acephate (S6) (See APVMA permit PER81463, expires 31 January 2021)	1B	NRD[1]	Apply a maximum of three applications per season using an air-blast sprayer with a minimum re-treatment interval of 14–21 days. Apply first when nuts are at pea size using a spray volume of 500 to 1000 L/ha. Ensure thorough coverage. Sweep out affected nuts and expose in full sunlight. Mulch affected nuts. See NSW DPI factsheets: Sigastus weevil pest information and management options and Sigastus weevil life cycle and monitoring.

Month	Reason	Treatment	Fungicide group	WHP days	Remarks
PEA-SIZE NUT AND SPRING FLUSH					
November–December	Fruit spotting bug (FSB)	Trichlorfon (S6) (See APVMA permit PER13689, expires 30 September 2021) OR Azinphos-methyl (S7) OR Beta-cyfluthrin (S6) OR Acephate (S6) OR Methidathion (S7) OR Sulfoxaflor (S5)	1B 1B 3A 1B 1B 4C	2 7 7 NRD[1] 21 NRD[1]	Monitor crop for fallen nuts. Trap crops of *Murraya paniculata* are good indicator plants for FSB presence and can help determine pressure levels. Using chicken wire enclosures to prevent wildlife spreading berries is recommended. Monitor orchard boundaries, particularly if backing onto FSB host species. Use previous year's incidence to help predict incursion. Avoid applying more than two consecutive sprays of the same active to prevent resistance. Only apply beta–cyfluthrin once as it has been known to create mite and thrips flare ups. Monitor crop to prevent late FSB damage from mid-December onwards. **For Sulfoxaflor** DO NOT SPRAY WHEN BEES ARE FORAGING. DO NOT have more than two applications to any one crop in any one season. If making repeat applications, DO NOT reapply before 21 days after the first application. Apply as part of a season-long spray program targeting pests when active in the crop. The use of Transform early in the fruiting/flowering stage of the crop will conserve beneficials when used as part of an IPM system. Complete spray coverage is essential; concentrate sprays are not suitable for this pest. Addition of an adjuvant, although not critical, may improve control. Apply to the point of run-off. **Biological control** Egg parasitoids *Centrodora darwini, Anastatus* sp., *Ooencyrtus cauru, gryon* sp. Nymph and adult parasites *Pentatomophaga bicinta* (tachnid fly), *Pheidole megacephala* (coastal brown ants – beware of aphids), P*risthesancus papuensis* (assassin bug).

Month	Reason	Treatment	Fungicide group	WHP days	Remarks
November–December	Macadamia nut borer	Acephate (S6) OR Azinphos-methyl (S7) OR Beta-cyfluthrin (S6) OR Cabaryl (S6) OR Methoxyfenozide (PS exempt) OR Methidathion (S7) OR Tebufenozide (S5) OR Trichogramma wasp** OR Spinetoram (S5)	1B 1B 3A 1A 18 1B 16A 5	NRD[1] 7 7 NRD[1] 28 21 28 7	**Wasp release starting date can depend on region; early November for Bundaberg; mid-December for NSW. Wasps work well as an area-wide approach i.e. surrounding farms should incorporate wasps into their program as a control method. **Biological control** Parasitic wasps *Trichogrammatoidea cryptophlebiae, Apanteles briareus Nixon* *Bracon* sp. *Gotra bimaculatus* Parasitic fly.
November–December	Flower thrips (*Scirtothrip* spp.)	Acephate (S6) Abamectin (S6) (See APVMA permit PER81162, expires 31 October 2018)	1B 6	NRD[1] 28	**Biological control** Predatory thrips *Scolothrips sexmaculatus*
November–December	Flower thrips (*Scirtothrip* spp.) Broad mites (*Brevipalpus* spp.) Flat mites (*Polyphagotarsonemus* spp.)	Abamectin (S6) (See APVMA permit PER81162, expires 31 October 2018)	6	28	No more than one application per season. Do not apply in consecutive seasons without using a chemical from a different mode of action in between. Dangerous to bees.
November–December	Macadamia mussel scale, long soft scale and white scale	Methidathion (S7)	1B	21	Not an issue in Bundaberg **Biological control** Lacewings *mallada signata* (larva) and *Cryptolaemus.*
November–December	Macadamia leafminer	Diazinon (S6) OR Acephate (S6) OR Methidathion (S7)	1B 1B 1B	14 NRD[1] 21	Not an issue in Bundaberg and generally does not warrant control elsewhere. BEWARE repeating methidathion applications as resistance can occur.
November–December	Macadamia felted coccid	Petroleum oil (See APVMA permit PER11635, expires 30 June 2020). (S5) OR Diazinon (S6) OR Methidathion (S7)	Unspecified 1B 1B	NRD[1] 14 21	Do not apply petroleum oil when temperatures exceed 32 °C or when soil is dry and trees are suffering from moisture stress. Products to be used are those referred to only as summer spray oils. BEWARE repeating methidathion applications as resistance can occur. **Biological control** Ladybird beetles and larvae *Midus pygmaeus, Rhizobius ventralis, Serangium maculigerum* Predatory moth *Batrachedra arenosella* Egg parasitoid *Aspidiophagus* sp., *Metaphcus* sp.

Month	Reason	Treatment	Fungicide group	WHP days	Remarks
PEA-SIZE NUT AND SPRING FLUSH					
November–December	Macadamia kernel grub	See remarks			Can be an issue where variety has open micropyle. Control for macadamia nut borer and fruit spotting bug will prevent most kernel grub damage.
November–December	Sigastus weevil	Acephate (S6) (See APVMA permit PER81463, expires 31 January 2021)	1B	NRD[1]	Apply a maximum of three applications per season using an air-blast sprayer with a minimum re-treatment interval of 14–21 days. Apply first when nuts are at pea size. Ensure thorough coverage. Sweep out affected nuts and expose in full sunlight. Mulch affected nuts. Spray application for fruit spotting bug should control exposed adult weevil, however, larvae and egg in nuts will not be affected. See NSW DPI factsheets: Sigastus weevil pest information and management options and Sigastus weevil life cycle and monitoring.
SHELL HARDENING AND OIL ACCUMULATION					
January–February	Fruit spotting bug	Trichlorfon (S6) (See APVMA permit PER13689, expires 30 September 2021) OR Azinphos-methyl (S7) OR Beta-cyfluthrin (S6) OR Acephate (S6) OR Methidathion (S7) OR Sulfoxaflor (S5)	1B 1B 3A 1B 1B 4C	2 7 7 NRD[1] 21 7	Late season damage results in blind stings to macadamia nuts that are not easily visible from the outside. Monitoring for FSB damage after 25 December is difficult, as damaged nuts do not drop. A useful guide for the likelihood of pest pressure at this time is last season's factory results. Ensure adequate coverage of the whole tree as chemical must contact the insect to kill it. **Biological control** Egg parasitoids *Centrodora darwini, Anastatus* sp., *Ooencyrtus caurus* Nymph and adult parasites *Pentatomophaga bicinta* (tachnid fly), *Pheidole megacephala* (coastal brown ants – beware of aphids), *Pristhesancus papuensis* (assassin bug).
January–February	Macadamia nut borer	Wasps OR Acephate (S6) OR Azinphos-methyl (S7) OR Beta-cyfluthrin (S6) OR Cabaryl (S6) OR Methoxyfenozide (PS exempt) OR Methidathion (S7) OR Tebufenozide (S5) OR Spinetoram (S5)	 1B 1B 3A 1A 18 1B 16A 5	 NRD[1] 7 7 NRD[1] 28 28 28 7	Late January spray for FSB will require more wasps to be reintroduced into the orchard. Although other products are registered, an effective area-wide management approach of wasp releases should eliminate the need for spray applications unless a further FSB spray is required in January/February. **Biological control** Parasitic wasps *Trichogrammatoidea cryptophlebiae, Apanteles briareus Nixon Bracon* sp., *Gotra bimaculatus* Parasitic fly.

Month	Reason	Treatment	Fungicide group	WHP days	Remarks
January–February	Phytophthora	Phosphorous acid (See APVMA Permit PER84766, expires 30 November 2022) OR Copper as cuprous oxide (S6) OR Metalaxyl (S5) OR Metalaxyl (S5) + Copper oxychloride (S6)	33 M1 4 4/M1	28 1 28 28	**Maintenance** Foliar spray phosphorous acid. Apply at mature leaf flush during spring and autumn. Do not apply to young leaf flush as it might burn foliage. Apply to each leaf flush if disease persists during production period. Apply to point of run-off, ensuring all leaves and branches are covered. DO NOT apply to trees under severe water stress or during very hot weather (e.g. temperatures >28 ℃). **Curative** Trunk application phosphorous acid. Apply to affected macadamia trees at root flush and 28 days after root flush. Dilute spray to point of run-off around trunk to approximately 1 metre above soil level, ensuring thorough coverage of trunk. Bark penetrant such as Pulse is to be applied at a rate of 2%.
January–February	Phomopsis husk rot	Copper as cuprous oxide (S6)	M1	1	Injury to the macadamia fruit pericarp predisposes it to infection.

NUT MATURITY AND HARVEST

March–July	Rats	Coumatetralyl (S6)	NA	NA	Monitor rodent levels before baiting. Regularly check traps and top up bait. Remove nests. Concentrate baiting in outer three rows closest to scrubby habitat. Maintain ground cover at a low height. Promote owl boxes. Rat program should be continual all year round, clearing nests within trees and identifying burrows within the orchard. Bait when nuts are available.
	Phomopsis husk rot	Copper as cuprous oxide (S6)	M1	1	Injury to the macadamia fruit pericarp predisposes it to infection.

EMERGING

As required	Bark beetle	No registration exists for macadamia in NSW			Can be an issue with declining trees. Remove and destroy affected limbs and trees from the orchard. Maintain soil and tree health.
As required	Pinhole borer	No registration exists for macadamia in NSW			This is an issue in drier areas. Several species have been observed from Bundaberg to the Mid North Coast of NSW. It can become an issue if an affected nut makes it to a storage silo, so a careful belt sort is required if suspected.
As required	Dry flower	No registration exists for macadamia in NSW			Expressed as blight of the flower. Causes dieback of raceme and subsequent yield loss.
As required	Branch dieback	No registration exists for macadamia in NSW			Recently becoming more prevalent in older trees (>15 years old). Bark beetle is often seen as secondary to branch dieback infestation.

*Poison schedule: The second set of brackets. On the product label this will be seen as a signal heading whereby:

- Poison Schedule exempt (PS exempt)
- Schedule 5 (S5) Caution
- Schedule 6 (S6) Poison
- Schedule 7 (S7) Dangerous Poison.

The higher the number the greater the hazard and stricter labelling and regulatory requirements.

NRD[1]: Not required when used as directed.

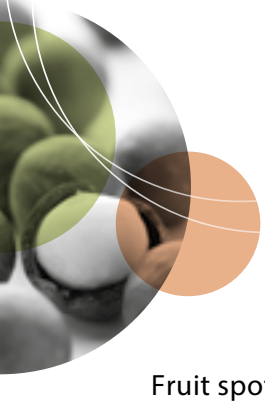
Always refer to product label and Safety Data Sheet (SDS)

Resistance strategies: No more than two consecutive sprays of a product within the same category e.g. Pyraclostrobin is category 11. So no more than two consecutive sprays with category 11. See Avoiding resistance to pesticides on page 71.

Refer to the AMS Communication Best practice guidelines for the application of chemicals in macadamia orchards when planning the spraying of your orchard.

Calibrate your spray machinery at least annually and before the season starts.

Ensure you are obtaining good coverage for complete crop protection.



Fruitspotting bug, its life cycle and control

Fruit spotting bug (FSB) has become the most significant pest of macadamias since an effective biological control option was established for macadamia nut borer. The Benchmarking the macadamia industry 2015-2018 project (MC15005) has reports from across all regions that late FSB insect damage is consistently the primary reason for nuts being rejected at factory stage. Two types of FSB are known in Australia; *Amblypelta nitida Stål (A. nitida)* and *Amblypelta lutescens lutescens (A. lutescens)*. Both feed on fruit and flowers of macadamia and have multiple plant species (Table 7). *A. nitida* is prevalent in Northern NSW and South East Queensland, while *A. lutescens* can be found from the Queensland border right through to Cape York in the north (Figure 33).

Table 7. Types of FSB in Australia.

Species	*Amblypelta nitida Stål (A. nitida)*	*Amblypelta lutescens lutescens (A. lutescens)*
Distribution	From 17°S to 35°S (Figure 33)	From 11°S to 27°S (Figure 33)
Number of host plant species	56	111
Diet	Feeds only on fruit and flowers	Generally feeds on fruit, shoots and flowers, although rarely on macadamia shoots
Days to develop from egg to adult at 20 °C	63	79
Days to develop from egg to adult at 25 °C	45	50

Figure 33. Distribution of fruit spotting bug in Australia.

Life cycle

Fruit spotting bugs pass through 3–4 generations a year; one in spring, one or two in summer and one in autumn (Figure 38). Adults of the autumn generation survive the winter, to begin a new generation in spring.

Key stages in the fruit spotting bug lifecycle

Figure 34. *A. nitida* 1st instar stage.

Figure 35. *A. nitida* 4th instar stage.

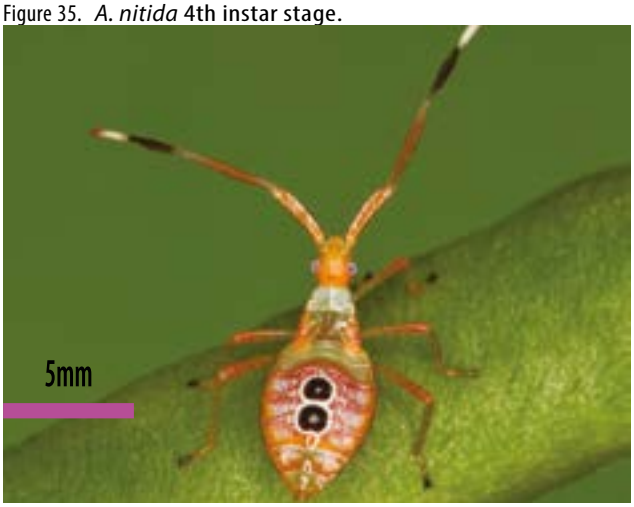


Figure 36. *A. lutescens* 4th instar stage.

Figure 37. *A. nitida* 5th instar stage.

Figure 38. *A. nitida* adult stage.

Damage to macadamia nuts

Very young fruit falls within a few days of an FSB attack. Some fallen fruit exhibit visible external symptoms in the form of slightly sunken black spots. Macadamia fruit can be dissected to detect and confirm that these lesions are the result of FSB feeding. Counts of fallen nutlets in October–November is the key monitoring tool that crop scouts use. The counts inform spray recommendations with the threshold for spraying in macadamias being 3% of nuts falling.

As the nuts become more mature later in the season (December onwards) they are less likely to fall to the ground once stung. However, they will be unmarketable. Nuts of all sizes and maturity levels can be damaged, although less frequently after shell hardening in January. Damage is visible as dark, slightly sunken spots on the husk; collapsed testa whilst it is soft; and misshapen, brown and shrivelled translucent kernels. Further damage can be caused by secondary disease causing organisms spread by FSB (Ironside 1981; Fay 2002).

Monitoring

Regular monitoring of FSB is essential to achieve effective management, but this is not always easy because the bugs:

- are very mobile
- only need a small number to cause significant damage
- are shy in nature
- lay eggs singularly
- do not congregate in large numbers
- tend to move around in the top half of trees.

Key steps in effective monitoring include:

- identifying entry points and natural harbours for FSB
- monitoring bordering vegetation (flowering and fruiting times in rainforest species)
- identifying hotspots in the crop (FSB often return to a damaged tree repeatedly)
- identifying hotspots in monitoring
- randomly check at least 10 trees in hotspots and 20 others
- understand timing and method of crop monitoring; importantly, searching for fresh damage:
    - start monitoring for FSB when small pea size nuts start dropping in October
    - after the initial shedding of nutlets, cut open 10 fresh green fallen nuts per tree and dissect the nuts
    - check for sting lesions in the husk and shell (see Figure 39)
    - identify other insect damage e.g. Macadamia nut borer (MNB) and Sigastus weevil (Figure 40)
    - repeat fortnightly until nut drop stops in December
    - late damage is difficult to detect as the nuts remain in trees.

Trap crop hedges, located in all macadamia growing regions, are in the early stages of being used commercially as a monitoring tool for FSB. A trap crop is a species planted in a hedge next to the macadamia crop that also attracts FSB. One of the best trap crop species is Murraya paniculata, or Mock Orange. Other proven trap crop species include Macadamia ternifolia and

longan. These three crop species are now being trialled for their effectiveness in predicting FSB movements as part of the HIA levy funded IPM project (MC16004).

The aim of trap crop monitoring is to predict when adult bugs start moving into an orchard. Ideally, a grower can time spraying to when populations are building in the crop. This limits production losses with minimal spray applications at better times.

There is a need to check the fallen nuts early in the season for fresh spotting bug damage up until mid-December. This ceases to be an accurate indicator of recent activity the further into the season you measure. Activity after the shell hardens from January onwards, particularly on the thinner shelled varieties (A4, 849), is hard to detect from the ground and if unchecked, can be very costly.

When monitoring nut drop in the spring months under macadamia crops, it is important to recognise and distinguish the common causes of nut drop. This includes Sigastus weevil (top left), macadamia nutborer (top right) and FSB feeding (bottom).

Figure 39. There is a need to check the fallen nuts early in the season for fresh spotting bug damage up until mid-December. This ceases to be an accurate indicator of recent activity the further into the season you measure. Activity after the shell hardens from January onwards, particularly on the thinner shelled varieties (A4, 849), is hard to detect from the ground and if unchecked, can be very costly.

Figure 40. When monitoring nutdrop in the spring months under macadamia crops, it's important to recognise and distinguish the common causes of nutdrop. This includes Sigastus weevil (Top left), macadamia nutborer (top right) and FSB feeding (below).

How to use a trap crop

During spring a 'hotspot' of FSB will appear within the trap crop before they move into the macadamia crop.

The FSB stay within the hedge once feeding starts, and monitoring aims to detect a build-up of large 5th instar nymphs.

A 5th instar nymph (see Figure 37) is typically almost adult size, with black antennae, black 'knees' and only wing buds rather than fully expanded wings.

Adult FSB flights out of the trap crop and into the macadamia crop occur approximately 10–14 days after 30% of the bugs in the trap crop reach the 5th instar nymph stage. This is the optimal time to spray for the first wave of FSB in the season. The hedge should then be continually monitored for the emergence of the next generation where stage 1 (Figure 34) nymph should be detected.

Control options

Cultural controls

Horticultural techniques that reduce the risk and extent of damage from FSB include:

- selecting appropriate varieties (avoiding thin-shelled macadamia varieties)
- reducing tree heights to improve spray coverage
- reducing canopy density by selective limb removal or new growing systems
- reducing tree density (tree removal)
- reducing the effect from out-of-season flowering in macadamias
- using cover crops in the inter-row
- managing bordering alternate FSB host vegetation better.

Chemical control

Future strategies will be based on an integrated pest management (IPM) approach. Programs will include cultural, biological and chemical controls based on monitoring using trap cropping and pheromone traps. Eventually area-wide management programs that reduce populations on a district basis might be developed.

The transition to IPM approaches will reshape chemical control practices through:

- using chemicals appropriately to reduce impacts outside the crop
- using less broad-spectrum chemicals that are safer on beneficial insects
- spraying hotspots to target problem areas, leaving unsprayed refuges in the crop
- improving timing to minimise the need for repeat sprays.

Biological controls

Use cover crops in the inter-row to provide habitat for natural enemies of FSB, such as:

- Egg parasitoids: Anastatus sp. near pentatomidivorus (Eupelmidae), Oocencyrtus caurus (Encyrtidae), Gryon sp. (Scelionidae) and Centrodora darwini (Aphilinidae). Nymph and adult parasitoids include the tachinid fly Trichopoda giacomellii.
- Predators: spiders, e.g. Ocrusiona sp., ants, e.g. green tree ant Oecophylla smaragdina, Pheidole sp., predatory bugs, e.g. assassin bug Pristhesancus pauensis, and lacewings, e.g. brown lacewing Micromus tasmaniae.

Sigastus weevil – the story unfolds

Entomologists at the NSW DPI have been on the trail of Sigastus weevil for a number of years, tracking its habits and investigating control methods. The following information is an update and summary of what the research has revealed about this serious pest.

Current distribution

Sigastus weevil is spread all across the NSW Northern Rivers and Atherton area of Far North Queensland. While there have been isolated incidences of Sigastus in the Gympie area, it has not yet been reported in Bundaberg, the Glasshouse Mountains or the Mid North Coast of NSW.

The NSW DPI has observed Sigastus weevil in Northern NSW over the past three years, improving our knowledge of the pest's habits and its control. Where Sigastus weevil is observed thriving, we generally see a number of elements that allow it to do so. These are outlined below:

Extended flowering and out-of-season nut set

Just as an extended flowering will support higher levels of lace bug, the same applies to Sigastus weevil. It is not so much the flowering that will support the weevil, rather, it is the following small, soft shell (Figure 41), out-of-season nut that allows the weevil to lay its egg (Figure 42) and increase in number.

Natural disasters (e.g. floods) in 2017 created higher pressure from multiple flowerings and nutset. Growers need to be aware that this run of out-of-season flowering will create a very high base population of not only Sigastus weevil, but also other insect pests. This means that growers need to ensure that their spray coverage and rates are adequate for what will be a very high pressure season. Key points to consider are:

- calibrate your sprayer now
- slow down: put a target up the tree and see whether you hit it at the normal speed you spray. In most cases spray operators are just going too fast to achieve adequate coverage
- timing: you need to be protecting your crop at the most efficient time. Delays will cause losses in production.

Figure 41. Sigastus lays its egg on a chewed patch of husk.

Figure 42. Typical mark left by sigastus weevil that indicates egg laying.

Figure 43. Sigastus larvae and pupae overwintering in nuts.

Neglected orchard

Orchard neglect is another issue, not only for controlling Sigastus weevil but also other pests. Neglected areas are breeding grounds for the weevil. While the crop is there for the weevil, there is no reason for it to move into neighbouring orchards. However, when the crop is limited, the weevil will migrate to other areas to sustain reproduction.

Orchard floor

Start early to avoid pest build up. Before fruit spotting bug (FSB) causes early nut drop, growers need to make sure that their orchard floor is clean. Figure 43 shows damage to the nuts caused by FSB overwintering in them. Treatment should be similar to a pre-harvest orchard floor clean up to ensure that developing larva within the dropped nut is controlled.

Old, damaged nuts left on the orchard floor will allow weevil populations to develop and increase, resulting in further damage to your crop and income. The positive case studies on Sigatus weevil control have all included regular orchard floor clean up, nut mulching, and, in some cases, eliminating infested nuts from the orchard altogether. Generally, growers can concentrate on hot spots in the orchard to maintain a clean floor.

Follow recommended control programs

Acephate is a key registered chemical (PER81463) to control Sigastus weevil and FSB. With FSB having a number of products within its arsenal, it is critical that growers use acephate at a time when it is most effective against FSB and Sigastus weevil. This is when the nuts have developed to pea size, which equates to around November in the Northern Rivers region of NSW. Before this spray, growers will have performed an orchard floor clean up as recommended. Another spray about 14–21 days later would be required to manage newly emerged weevils that were developing within the nutshell at the initial spray.

Missing a late spotting bug control spray

The problem with late spotting bug damage is that it is not seen in the orchard as it happens at the tops of the trees and is hard to monitor. As a result, the damage is generally recorded at the factory as a percentage of reject nuts.

Around January, most growers are releasing wasps for macadamia nut borer management and believe that their final insecticide spray has been applied for the season. FSB populations are still being seen as late as April. This means that they are still damaging nuts, especially thin-shelled varieties, while growers were harvesting. If spotting bug is responsible for high reject numbers in your factory reject report, then it might be appropriate to think about a late spray for this pest. This will have the additional benefit of also cleaning up the leftover weevil which, at this stage if there are no small nuts present, are susceptible to the pesticide.

Sigastus control: what you can do now

Pre-flower

Out of season flowering has meant that current on season flowering will have high pressure from built up populations that were supported by the early crop. Life cycle is dependent on degree days; with winter being quite late this season, pest development is heightened. Cold, wet weather will slow the progress of these pests but the need for diligence at pre-flowering for effective control is critical.

Pre-harvest clean up

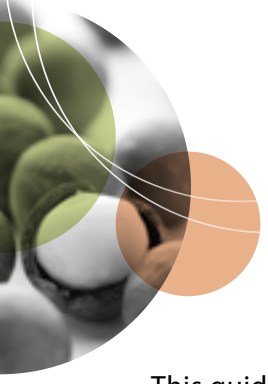
This generally occurs from January onwards and is especially important for Sigastus-infested orchards as this operation will minimise weevil populations if done thoroughly. We are seeing positive examples where a combination of good hygiene (removing infested nuts) with targeted spraying during spring, with the registered minor use permit chemical acephate, that effectively manages Sigastus weevil.

Take photos

If you see Sigastus weevil on other vegetation it would be useful to take a photograph, record the GPS location and report it to NSW DPI development officer Jeremy Bright. Previous literature has reported Sigastus using Ficus spp. as a place to breed. There are no other reports of Sigastus breeding in any crop other than macadamia.

Further information

Jeremy Bright
NSW DPI, Wollongbar
P: 0427 213 059
E: Jeremy.bright@dpi.nsw.gov.au



Controlling pests and diseases

This guide offers macadamia growers suggestions for managing pests and diseases through the responsible use of pesticides. Cultural controls help to reduce pest and disease pressures in the orchard, and should be used alongside chemical control programs. Neither pesticide nor alternative management systems alone will give consistently satisfactory results. Integrated management is required.

Weather has a large influence on the incursion of several pests and diseases. Growers should be aware of conditions that increase the risk of outbreaks. Wet weather can be a trigger for diseases such as husk spot, Botrytis and other fungal problems. High temperatures within and around the orchard can increase the speed at which insect pests develop through their lifecycle.

Maintaining an open canopy, or selecting varieties that accommodate an open canopy, supports pest and disease control. There is higher pest pressure within darker canopies. By opening up an orchard through canopy management, there can be substantial reductions in pests.

Reducing canopy height, and maintaining canopy height at or below the row width, can help to achieve better pest control. Higher canopies are harder to cover with crop protectant sprays. Sticktights (old nut husks that do not fall) are a source of infection across seasons and are more difficult to manage in taller trees. Removing dead and decaying branches is recommended. Sick trees can encourage pests such as bark beetle and trunk borer.

Working with neighbours in an area wide management (AWM) approach is another good strategy growers can pursue. AWM approaches recognise orchards as a large unit rather than individual farms. When pest incursions are detected anywhere within the area they are controlled strategically. This reduces the chances of the pest populations developing within the unit area. A good example of this is macadamia nut borer parasitism. By monitoring moth flights across the region, industry is able to co-ordinate release of wasps to control the pest.

Trees are more vulnerable to damage from pests and diseases when they are under stress. Tree health can be supported by maintaining good soil health, which includes erosion control, adequate soil pH, maintaining high levels of organic matter to cover exposed roots, and ensuring adequate nutrients are available to the tree. The following is an overview of the pests and diseases of macadamia in NSW.

Macadamia lace bug *Ulonemia* spp.

There are three species, with *U.decoris* being a species of NSW. Macadamia lace bug damages the flowers (Figure 44), starting at the tips where a blackening is seen (Figure 45). Left unchecked, the whole flower blackens and dies off. Shaking the head of infested flowers reveals the lace

Figure 44. Lace bug attacking macadamia florets.

Figure 45. Damaged florets.

bug. Nutset is prevented when lace bugs are not treated, causing 90%+ production loss on later varieties.

Numbers build up over successive seasons. Lace bug overwinters on the bark of trees. Monitoring should start when the flower raceme is green and unopened, particularly if lace bug was a problem the previous year. Taking action early will mean less damage later.

Lace bug damage worsens when multiple flower events extend throughout the season. Lace bug can trigger out of season flowering when the main flower set is destroyed. Ethrel has been used successfully to promote nut drop and put trees back into sync where out of season flowering occurs.

Macadamia flower caterpillar

Figure 46. Flower eating caterpillar.

The adult moth is most active during the main flowering period, i.e. July to October. Eggs are laid on flower buds and can be confused with immature scale insects. Larval feeding destroys buds and flowers, leaving the raceme covered by webbing.

Flower caterpillars (Figure 46) can severely reduce a nut crop if not controlled. Macadamia lace bug spray treatments should also eliminate flower caterpillar.

Fruit spotting bug

Ambypelta nitida (Figure 47) and Amblypelta lutescens lutescens (Figure 48)

Fruit spotting bug (FSB) damages nuts from pea size until ready to harvest. FSB has a strong preference for thinned-shelled varieties such as A4 later in the season. Early damaged nuts fall, but later damaged nuts remain in the tree, although they will be unmarketable once sent to a processor. Reviewing factory results for insect damage is a good way of determining how much FSB pressure the orchard has had, and how effective controls have been.

Figure 47. *Ambypelta nitida* nymph.

Figure 48. *Amblypelta lutescens lutescens* nymph.

Monitoring is the key to FSB control. Using a pest scout early and regularly throughout the production season is recommended. Later in the season, trap hedges can be used to predict FSB movement. FSB form hotspots rather than being

spread evenly through an orchard. Hotspots are often on the borders of the orchard, especially where it is next to forest or a neglected orchard. Two or three well-timed chemical sprays can limit the damage from this pest.

Husk spot

Husk spot is caused by a fungal pathogen. Most varieties of macadamia are prone to husk spot, (Figure 49) but it is more prevalent in specific varieties with sticktight husks. Rain splash easily spreads fungal spores from diseased sticktights to developing nuts in the tree canopy.

Figure 49. Husk spot damaged nut may be immature.

Cultural practices are important in limiting damage from husk spot. Growing varieties that do not support sticktights reduces the risk of infection. Pruning to open the tree canopy can increase ventilation and dry out nuts quicker. However, A38 has quite an open canopy and still suffers husk spot, which suggests that a combination of cultural and chemical controls is critical. Ideally we need to reduce favourable conditions for spore development. Removing sticktights, where possible, limits infection. Avoid moving husks with husk spot between farms as this can introduce husk spot to new orchards.

Sigastus weevil

Figure 50. Sigastus weevil.

Sigastus weevil (Figure 50) relies on out-of-season flowering and small soft-shell nuts for egg laying (Figure 51). Nuts will fall once the female has laid its egg inside the husk. These nuts should be mulched and destroyed to break the cycle. Hotspots areas should be noted and controlled. Ethrel has been used successfully to promote nut drop and put trees back into sync where out-of-season flowering has occurred.

Figure 51. Typical sigastus signature triangle on nut.

Macadamia nut borer

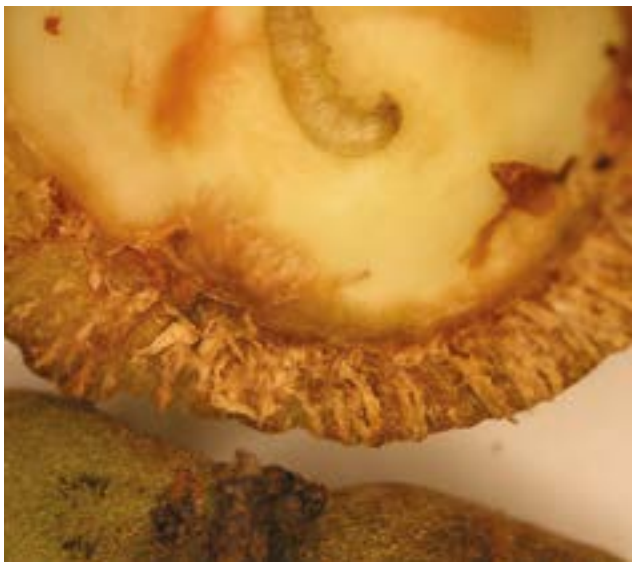


Figure 52. Macadamia nut borer in developing nut.

The nut borer lays its eggs on the husk, and the larvae burrow through the nut shell to eat out the kernel (Figure 52). Nut borer continues to cause problems after shell hardening, such as premature nut drop.

Cleaning up old nuts reduces carry over population between seasons. Biocontrol with parasitoid wasps is effective against nut borer and best co-ordinated in an area wide approach.

Thrips

Figure 53. Witches broom growth created by thrips damage.

Thrips attack flowers, new flush (Figure 53) and nuts. Bronze discolouration appears on damaged nuts and flowers. Leaf rossetting is seen on damaged new flush. Continual attacks on new flush is a concern as this leads to carbohydrate loss in the plant. It is important to protect at least one critical flush within the season. Yellow sticky traps, placed within the orchard, are useful for monitoring.

Mites

Figure 54. Broad mite on A16.

Damage from mites appears similar to thrips damage (Figure 54). Mites are becoming an issue due to overuse of 3A chemistry (synthetic pyrethroids including beta-cyfluthrin). Hot, dry weather is ideal for mite infestation. They are often seen on rows next to a dirt road. Ideally, introducing predatory mites would be a good control strategy, with consideration that later sprays for other pests would eliminate these biocontrol predators.

Phytophthora

Phytophthora disease is caused by the fungus *Phytophthora cinnamomi*, a soil-borne water mould. *Phytophthora* will offten appear at the bottom of slopes where water can pond, as well as on drainage lines and at the very tops of slopes where soil has been eroded away.

Figure 55. Ooze sap from a severe case of Phytophthora. Source: Olufemi Akinsanmi, University of Queensland.

Phytophthora appears to be worse where trees are suffering, e.g. nutritional or moisture stress. Although not always the case, generally soil management to achieve improved soil health and develop a healthy root system will help trees in their ability to prevent and recover from pest and diseases (Figure 55).

Kernel grub

Figure 56. Kernel grub.

Eggs are laid on the outside of the nut and through an open micropyle, or from damage caused by boring insects such as nut borer or fruit spotting bug, the grub is able to enter the nut (Figure 56). Kernel grub has become more of an issue in recent years. The problem is compounded if infested nuts are sent to the processors and stored in silos where the grub will continue to infest other nuts.

Unfortunately, the biological control for macadamia nut borer does not predate on kernel grub. Monitoring is key to controlling this pest. Previous work has shown that using navel orange weevil traps will be useful to monitor kernel grub. No product is registered to control the pest, but as it coincides with fruit spotting bug and Sigastus weevil, it should be an off-target control.

The beetles (general)

Figure 57. *Hypothenemus seriatus* (bark beetle) damage Bundaberg, Qld.

Figure 58. Ambrosia damaging macadamia trunk.

Figure 59. *Cryphalus subcompactus* damage from dead trees at Bundaberg, Qld.

Figure 60. Adult carpophilus beetle.

Many forms of beetles have become more prevalent within the macadamia industry. Since certain effective broad spectrum pesticides became no longer available, these beetles have become a very concerning issue around the world, particularly in the forestry industry. The generalised term of beetle can represent a number of species that can damage macadamia in different ways. The NSW DPI is still trying to get an accurate morphological taxonomy of these bark beetles to correctly identify them. In general they all sit under Scolytinae. As identification becomes more exact, we will split these beetles into their own categories.

Hypothenemus eruditrus (predominantly NSW) and *H. seriatus* (predominantly Bundaberg; Figure 57) can infect the nut in shell. The degree of damage can be influenced by the thickness of the shell, the duration fallen nuts are left on the ground between harvests, and how clean the orchard is as far as the residual out-of-season crop is concerned. Areas of Queensland have *Hypothenemus birmanus*, which feeds on avocado trunks as well as macadamia.

Ambrosia (Figure 58), which feed solely on fungus, use sick and dying trees to cultivate their fungal garden. Once the tunnel is created, they release the fungal spores into the xylem and feed on it. This fungus can further contribute to the plant's dieback. In 2016-17, we saw a number of single trees being destroyed through lightning strike. Secondary to the lightning strike was the appearance of euwallacea and cnestes solidis and xyleborus (spaghetti) ambrosia.

Bark beetle

The classic bark beetle, *Cryphalus subcompactus* (Figure 59), will feed on the cambium layer and can potentially ring bark branches causing significant dieback. In many cases, these trees are suffering from other issues.

Carpophilus beetle (Figure 60) inhabits nuts in shell that other pests have recently exposed. Carpophilus will feed on the kernel and can become a problem if allowed to enter silos where they will breed. Pheromone lures have worked well in controlling Carpophilus beetle in other crops.

Further reading on the taxonomy of these beetles includes:

Maddox C, Mitchell A and Dawes M. 2009. Identification of Australian Scolytid beetles in Macadamia tissue and the use of DNA barcodes for the rapid identification of exotic pest incursions. Australian Macadamia Society Bulletin, March 2009.

Mitchell A and Maddox C. 2010. Bark beetles (Coleoptera: Curculionidae: Scolytinae) of importance to the Australian macadamia industry; an integrative taxonomic approach to species diagnosis. Australian Journal of Entomology. 49(2) pp.104–113.

Lightning strike

Lightning strikes have been more frequent in the past 5 years. In nearly all cases the actual lightning strike has not been a direct hit, which would result in immediate damage to the tree, but rather a ground hit near the affected tree. Classic symptoms will not always be immediate, in most cases taking 3–6 months to show. However, if conditions are dry after the strike, symptoms will appear sooner. Classic symptoms are usually a centre tree with branch die back throughout and the bordering trees having die back on the side of the centre tree (Figure 61). In nearly all cases bark beetle infests the trees at a later stage due to the reduced sap flow which creates an opportunity for entry. Symptoms of xyleborus bark beetle include spaghetti-like formations along the trunk, refer Figure 62.

Figure 61. Lightning strike in a Macadamia orchard.

Figure 62. Symptoms of xyleborus bark beetle include spaghetti-like formations along the trunk.

Green vegetable bug *Nezara viridula*

Figure 63. Green vegetable bug damage is often confused with fruitspotting bug damage.

Green vegetable bug (Figure 63) adults and nymphs will feed on macadamia nuts at all stages and the damage can look similar to that caused by fruitspotting bugs. Damage from green vegetable bug (GVB) does not reveal any symptoms on the shell and it is not until the kernel is extracted that the damage becomes apparent. Generally, the control program for fruitspotting bug and banana spotting bug will control green vegetable bug also. Monitor for the full season. GVB eggs are frequently parasitised by Trissolus basalis and the GVB nymphs are attacked by ants, spiders and other predatory bugs. The fifth instar and adult can be parasitised by the tachinid fly *Trichopoda giacomellii*.

Red shoulder leaf beetle *Monolepta australis*

Figure 64. Red shoulder leaf beetle.

Red shoulder leaf beetles (Figure 64) are 6 mm long and yellow with a dark red band across the shoulder. The flaccid yellow eggs are small and oval. The larvae are white, slightly flattened with hard brown plates at both ends and reach 10 mm in length. The adult beetles will attack flowers and young leaves, often leaving just a network of veins. The leaves then desiccate and leave a scorched appearance to the shoot. These beetles are swarming pests, i.e. they will come in a swarm generally after a period of rain in spring and summer. Their duration is only a few days but their effect can be devastating, particularly for younger trees. Monitor frequently and if observed in large numbers direct spray to the hot spot areas. Hosts of this pest include legumes, avocado, corn, eucalypts, mango and kikuyu pastures.

Phomopsis husk rot

The incidence of husk rot appears to be increasing. It is caused by fungi *Diaporthe* spp. which are more prevalent after wet weather and warm temperatures. Symptoms of husk rot include soft and spongy black lesions up to 10 mm diameter on the green fruit pericarp (Figure 65). The lesions may form greasy decay of the entire fruit pericarp. Phomopsis husk rot is distinguishable from Anthracnose husk rot caused by *Colletotrichum* species by the absence of concentric rings on the lesion. It is thought that the wound to the husk predisposes the husk

to infection. Wounds created by insect pests also increase risk to Phomopsis husk rot. Currently no fungicide product is registered for the control of husk rot. Orchard hygiene and good insect control will assist in reducing the incidence.

Figure 65. Phomophis husk rot.

The flower blights

Raceme blight (Dry flower)

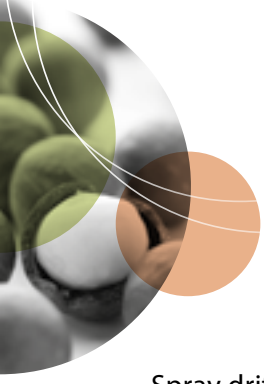
Figure 66. Rachis dieback and early dry flower from tip.

Dry flower (Figure 66) is caused by the fungal species in the *pestalotiopsis* and *neopestalotiopsis* complex. Not to be confused with Botrytis blight (next), symptoms appear from green raceme through to all development stages of flowering. Diseased flowers appear brown to dark brown and remain attached to the green rachis that later turns dark brown. Investigation of conditions necessary for infection and disease development is currently underway. Control of raceme blight may be required in orchards with recent history of occurrence. A further understanding of cultural practices to prevent this disease is also being investigated however, an open well ventilated canopy is generally less prone to infection.

Botrytis blight (Grey mould)

Figure 67. Botrytis blight.

Caused by the fungus *Botrytis cinerea*, botrytis blight (Figure 67) occurs mostly in mature flowers, especially during periods of wet, humid weather with temperatures between 18–22 °C. Diseased flowers appear dark brown and cluster together on the rachis with mycelial strands with greyish fungal spores, hence the grey mould appearance. Varieties are prone to botrytis blight when flowering peaks coincide with optimal infection conditions. Dense canopies may increase the risk to botrytis blight, therefore, ventilating the tree through opening up the canopy for better air movement will reduce risk of infection.



Managing spray drift

Spray drift is the airborne movement of agricultural chemicals onto a non-target area with the potential for risk of injury or damage to humans, plants, animals, the environment or property.

For information on managing chemical application to avoid and minimise spray drift, farmers and applicators should read label directions carefully and consult with their district agronomist or horticulturist. See NEVER SPRAY DURING A LOW-LEVEL INVERSION
Further information at the end of this section.

Successfully managing spray drift will require a range of complementary strategies to be adopted, including:

- identifying sensitive areas
- establishing appropriate buffer zones
- property planning
- developing effective communication between growers, spray contractors and neighbours.

Sensitive areas

Sensitive areas are those where spray drift is likely to have the greatest adverse impact, such as:

- lakes, ponds and waterways
- wildlife habitats and wetlands
- neighbouring houses
- public roads (particularly those used by school buses)
- schools and other public amenities
- travelling stock routes and reserves
- organic and alternative farming systems.

The potential adverse impact will depend on the exact nature of the sensitive area in relation to the toxicity and formulation of the chemical.

Buffer zones

Buffer zones help to minimise drift into sensitive areas. A buffer zone can consist of fallow, pasture, a non-sprayed strip of the crop or purpose-planted vegetation. Vegetative buffer zones should be sufficiently open to allow the spray to penetrate and of sufficient depth to trap the bulk of any drift.

Property planning

Property plans are a tool for communicating to others, such as spray contractors and neighbours, all the factors that need to be considered when applying chemicals on the property. A property plan would include:

- houses and farm buildings
- neighbouring properties
- sensitive areas
- roads and access points
- public roads and public places
- watercourses and storage
- cropping and grazing paddocks
- powerlines and other hazards to aircraft, such as transmitter towers.

Communication

Communicating with adjoining land users is critical in avoiding the conflict that can ensue from drift incidents. Communication can embrace:

- pre-season discussions with neighbours to identify the type and location of crops to be grown, chemicals to be used and potential adverse effects on neighbours' activities
- notifying neighbours before chemical application
- an agreement on the conditions in which chemical application will not proceed or be discontinued
- a clearly defined process and timetable for resolving any conflict that arises during the spraying season
- an agreed process for recourse to regulatory action, if required.

Reducing pesticide spray drift

Spraying during the night and early morning is common, especially for reaching the target and to minimise the amount reaching off-target areas. This results in:

- maximum pesticide effectiveness
- reduced damage and contamination to off-target crops and areas.

In areas where a range of agricultural enterprises co-exist, conflicts can arise, particularly from pesticide use. All pesticides are capable of drift.

People have a moral and legal responsibility to prevent pesticides from drifting and contaminating or damaging neighbours' crops and sensitive areas.

Some labels now carry spray drift management instructions including buffer zones. Read and follow all label instructions.

How to minimise spray drift problems

Before spraying

- Always check for susceptible crops in the area and sensitive areas such as houses, schools and riparian areas.
- Notify neighbours of your spraying intentions.
- Under the Records Regulation of the Pesticides Act it is essential that weather and relevant spray details are recorded. Forms are available from www.dpi.nsw.gov.au/agriculture/farm/chemicals/general/records.

During spraying

- Always monitor meteorological conditions carefully and understand their effect on drift hazard.
- Do not spray if conditions are not suitable, and stop spraying if conditions change and become unsuitable.
- Record weather conditions (especially temperature and relative humidity), wind speed and direction, pesticide and water rates, and operating details for each paddock.
- Supervise all spraying, even when a contractor is employed. Provide a map marking the areas to be sprayed, buffers to be observed, sensitive crops and areas.
- Spray when temperatures are less than 28 °C.
- Minimise spray release height (i.e. lowest possible boom height).
- Use the largest droplets that will give adequate spray coverage. Where droplet size is mentioned on the label, follow the label instructions.
- Always use the least-volatile formulation of pesticide available.
- Maintain a down-wind buffer that could be in-crop, e.g. keep a boom width from the downwind edge of the orchard. Where buffer zones are mentioned on the label, follow label instructions.
- If sensitive crops are in the area, use the least damaging herbicide.

How many types of drift are there?

Sprayed pesticides can drift as droplets, as vapours or as particles.

Droplet drift is the easiest to control because, under good spraying conditions, droplets are carried down by air turbulence and gravity to collect on plant surfaces. Droplet drift is the most common cause of off-target damage from pesticide application.

Particle drift occurs when water and other pesticide carriers evaporate quickly from the droplet leaving tiny particles of concentrated pesticide. This can occur with herbicide formulations other than esters. Instances of this form of drift have damaged susceptible crops up to 30 km from the source.

Vapour drift is confined to volatile herbicides such as 2,4-D ester. Vapours can arise directly from the spray or evaporation from the herbicide-sprayed surfaces. Use of 2,4-D ester in summer can lead to vapour drift damage of highly susceptible crops such as tomatoes, sunflowers, soybeans, cotton and grapes. This can occur hours after the herbicide has been applied.

Vapours and minute particles float in the airstream and are poorly collected on catching surfaces. They can be carried for many kilometres in thermal updraughts before being deposited.

Sensitive crops may be up to 10,000 times more sensitive than the crop being sprayed. Even small quantities of drifting herbicide can cause severe damage to highly sensitive plants.

What factors affect the risk of chemical spray drift?

Any herbicide, fungicide or insecticide can drift. The drift hazard, or off-target potential of a chemical in a particular situation depends on the following factors:

- Volatility of the formulation applied. Volatility refers to the likelihood that the chemical will evaporate and become a gas. Esters volatilise (evaporate) more readily than amine formulations.
- Proximity of crops susceptible to the particular chemical being applied and their growth stage.
- Method of application and equipment used. Aerial application releases spray at ~3 m above the target and uses relatively low application volumes, while ground rigs have lower release heights and generally higher application volumes, and a range of nozzle types. Misters produce large numbers of very fine droplets that use wind to carry them to their target.
- Amount of active ingredient applied: the more applied per hectare the greater amount available to drift or volatilise.
- Efficiency of droplet capture: bare soil does not have anything to catch drifting droplets compared with crops, erect pasture species and standing stubbles.
- Weather conditions during and shortly after application.

Use a low volatile formulation

Many ester formulations are highly volatile when compared with the non-volatile amine, sodium salt and acid formulations. Some low volatile ester formulations could have a proportion of high volatile esters present, so caution should be exercised when using these products.

The compromise between minimising drift and achieving ideal coverage

A significant part of minimising spray drift is equipment selected to reduce the number of small droplets produced. However, this in turn can affect target coverage, and therefore the possible effectiveness of the pesticide application.

This aspect of spraying needs to be carefully considered when planning to spray.

As the number of smaller droplets decreases, so does the coverage of the spray. The water rate might need to be increased to compensate for coverage.

Size of the area treated

When large areas are treated, relatively large amounts of active pesticide are applied and off-target risks increase due to the length of time taken to apply the herbicide. Conditions such as temperature, humidity and wind direction can fluctuate during spraying.

Applying volatile formulations to large areas increases the chances of vapour drift damage to susceptible crops and pastures.

Weather conditions to watch out for

Midday turbulence

Updraughts during the heat of the day cause rapidly shifting wind directions. Spraying should usually stop by 11.00 am during the summer months.

High temperatures

Avoid spraying when temperatures exceed 28 °C.

Humidity

- Avoid spraying under low relative humidity conditions i.e. when Delta T (the difference between wet and dry thermometers; Figure 68) exceeds 10 °C. Spraying when Delta T is between 8–10 °C is considered high risk.
- High humidity extends droplet life and can greatly increase the drift hazard from fine droplets under inversion conditions. This results from an increased life of droplets smaller than 100 microns.

Wind

- Avoid spraying under calm or still conditions. Under these conditions droplets are more likely to remain suspended in the air.
- Ideal safe wind speed for spraying is 7–10 km/hr. Leaves and twigs are in constant motion, considered a light breeze.
- 11–14 km/hr is suitable for spraying if using low drift nozzles or higher volumes application (80–120 L/ha). Small branches move, dust is raised and loose paper moving, considered a moderate breeze.
- If wind speed is >14 km/hr, do not spray.

Surface inversions

What are surface inversions?

Surface inversions are layers of the atmosphere at the earth's surface in which temperature increases with height. This is the opposite (inverse) of the normal temperature decrease with height.

Hazards of surface inversions

Surface inversions strongly suppress airborne pesticide (and similar) dispersion. Surface inversions can cause airborne pesticides to:

- remain at high concentrations for long periods over and close to the target
- travel close to the surface for many kilometres in light breezes
- move downslope and concentrate into low lying regions
- be transported often in unpredictable directions.

Radiation inversions – the most hazardous

Surface inversions usually begin to occur near sunset after heat energy through infrared radiation moves upward and causes the ground to cool (Figure 69). This radiation passes through clear air with little effect. As the ground cools, the air in contact with the ground begins to cool directly through conduction leading to the lowest layer of air being cooler than higher layers. This is referred to as radiation cooling.

Inversions caused by radiation cooling – called radiation inversions – are the most hazardous to pesticide applications because they are the most likely to severely restrict dispersion and promote transport (drift) at high concentrations of the airborne pesticides.

Radiation inversions occur most nights. Only when winds are strong enough to completely mix the lowest layers of the atmosphere and/or cloud cover severely restricts surface heating and cooling, is there a chance that surface radiation inversions will not form overnight.

Radiation inversions also form over sloping terrain when air in contact with the ground is cooled by terrestrial radiation. The cooled layer remains quite shallow over the slope and is typically only 2–10 m deep. This is because gravity continually pulls it downward causing drainage winds. Drainage-wind advection (horizontal convection) of cool air away from the slope and over or into lower lying regions can initiate a drainage inversion or intensify an existing radiation inversion. Once formed, drainage inversions have similar attributes to radiation inversions. Drainage winds can transport airborne pesticides long distances downhill, over flat terrain toward the lowest lying regions and into valleys.

Radiation and drainage inversions typically begin in the evening at about sunset as the ground surface cools and the air in contact with the surface loses sufficient heat by conduction to become colder than the air immediately above. With continued overnight cooling, inversions usually intensify and deepen up to the time of the overnight minimum temperature.

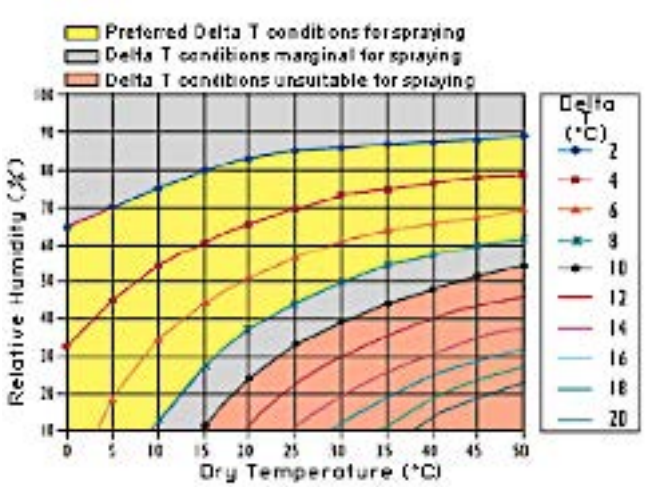
How to anticipate and recognise radiation inversions

The potential for inversions to occur and to adversely hold high concentrations of airborne pesticides near the surface should always be anticipated between sunset and up to an hour or two after sunrise; unless one or more of the following conditions occur:

- there is continuous overcast, low and heavy cloud
- there is continuous rain
- wind speed remains above 11 km/hr for the whole period between sunset and sunrise. Be mindful that established inversions can sometimes still occur when winds are in excess of 11 km/hr.

Source: APVMA. For more information on inversions, go to:

- the Cotton Map website fact sheet on temperature inversions (www.cottonmap.com.au/Content/documents/Temperature%20Inversions.pdf)
- the GRDC website page on inversions and spraying (https://grdc.com.au/Resources/Factsheets/2014/08/Surface-temperature-inversions-and-spraying)
- the Bureau of Meteorology (BOM) fact sheet: Weather for pesticide spraying (http://www.bom.gov.au/info/leaflets/Pesticide-Spraying.pdf).



NEVER SPRAY DURING A LOW-LEVEL INVERSION

Figure 68. Delta T.

Where to find helpful meteorological information

Real time data needs to be collected in the paddock at the time of spraying. This can be done with:

- handheld units that measure temperature, Delta T and wind speed
- on-farm weather stations, some can now be accessed by mobile phone.

Hourly data

Forecasts are available from a number of websites for parameters such as Delta T and wind speed, usually in three-hour blocks. Hourly data from the Bureau of Meteorology (BOM) weather stations including temperature, Delta T, wind speed and direction is available for the previous 72 hours from BOM. This data can help in planning spray activities and is useful for developing an understanding of the current daily patterns of meteorological conditions.

Meteograms™

Meteograms™ provide seven-day forecasts of:

- temperature
- relative humidity
- Delta T
- rainfall
- wind speed
- wind direction.

Meteograms™ are very helpful in planning spray programs for periods of lowest drift risk and highest pesticide efficacy.

Meteograms™ are mostly available by subscription. Some examples can be found at Weatherwise (http://www.weatherzone.com.au/models/meteogramdrill.jsp), or Spraywise (www.spraywisedecisions.com.au).

Source: M Scott, former Agricultural Chemicals Officer, NSW Department of Primary Industries, Orange.

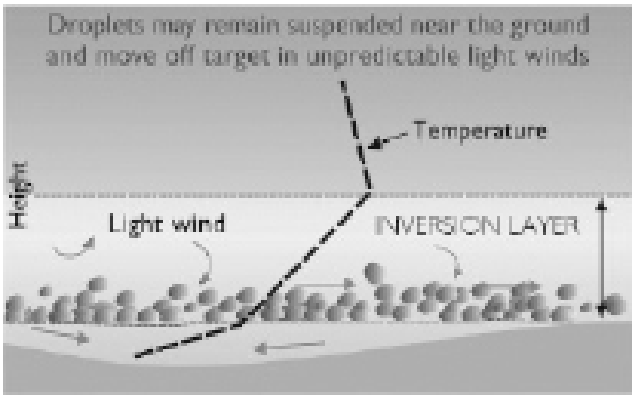


Figure 69. The relationship of air temperature and relative humidity to values of Delta T. Source: Bureau of Meteorology.

Further information

Further information about weather conditions and spraying can be found at:

- Practical tips for spraying (www.grdc.com.au/GRDC-FS-SprayPracticalTips)
- Weather essentials for pesticide application (www.grdc.com.au/Resources/Bookshop/2014/01/Weather-essentials-for-pesticide-application)
- Spray drift management principles, strategies and supporting information. 2002, CSIRO Publishing.(http://www.publish.csiro.au/Books/download.cfm?ID=3452)
- Reducing herbicide spray drift. http://www.dpi.nsw.gov.au/content/agriculture/pests-weeds/weeds/images/wid-documents/herbicides/spray-drift.

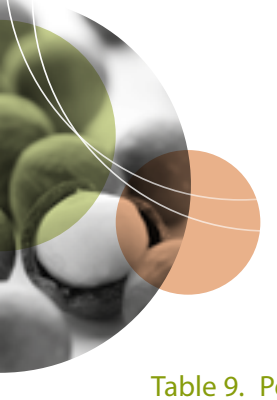
Non-bearing trees

Young trees that are not bearing nuts do not need the same intensive spray schedule as bearing trees, however, they still require continual monitoring for pests and disease (Figure 70). Below are the types of problems most likely to be encountered with young, non-bearing macadamia trees (Table 8).

Table 8. Problems most likely to be encountered with young non-bearing macadamia trees.

Pest or disease	Damage	Control
Macadamia felted coccid	Can cause severe setback to developing young trees. Can enter through infested nursery stock. Heavy infestation will stunt and distort growth.	Inspect nursery stock thoroughly before planting into orchard. Spray infested trees in the orchard and look at promoting natural enemies.
Macadamia twig girdler	Damage to branch forks and leaf whorls. Leaves skeletonised and webbed together.	Inspect and spray only affected plants. There are many natural enemies to twig girdler.
Macadamia leafminer	Appearance of tunnelling under the leaf surface. This causes the leaf to crinkle. Generally seen on fresh new flush, it can cause reduced photosynthetic capacity of the plant.	Softer sprays can be used if damage is widely spread across the orchard.
Scale	A number of scale can affect macadamia. Check nursery stock prior to planting. Look carefully along leaf stems and undersides. Also look for sooty mould.	Treat infected nursery stock. Only treat infested plants as blanket spraying will reduce beneficials within the orchard.
Red shouldered leaf beetle	Generally will swarm orchard. The affected leaves will appear scorched, causing premature leaf drop and poor tree establishment.	Monitor trees, especially after rain in spring and summer. Treat only affected trees.
Hares	Tree growth is reduced and tree may die from ring barking.	Protecting the tree with trunk guards and/or wire netting fence is the most reliable means of preventing attack.
Phytophthora	Leaves will take on a yellowing appearance. In severe cases, ooze sap will exude from trunk.	Ensure effective soil preparation before planting.

Figure 70. Young trees require continual monitoring for pests and disease.



Macadamia pesticides

Table 9. Pesticides – Chemicals registered[1] for managing macadamia pests and crop regulation in NSW.

For managing...		Pesticide common name	Comment[2]
Banana fruit caterpillar	3	Methomyl	Systemic and contact insecticide
Botrytis blight	1	Iprodione	Contact fungicide with protective and curative action
Broad mites, flat mites, flower thrips	3	Abamectin	Acaricide with stomach action and translaminar movement
	3	Acephate	Contact insecticide with stomach action
Fruit spotting bug	3	Acephate	Contact insecticide with stomach action
	3	Azinphos-methyl	Insecticide with contact and stomach action, moderate persistence
	3	Beta-cyfluthrin	Non-systemic and contact insecticide with stomach action
	3	Methidathion	Non-systemic insecticide, acaricide with contact and stomach action
	2	Sulfoxaflor	Systemic and contact insecticide with stomach action
	3	Trichlorfon	Insecticide and acaricide with contact and stomach action
Green vegetable bug	3	Trichlorfon	Insecticide and acaricide with contact and stomach action
Husk spot	2	Carbendazim	Protectant fungicide
	2	Copper hydroxide	Protectant fungicide
	1	Difenoconazole	Systemic fungicide with protectant and curative action
	1	Pyraclostrobin	Protective and curative fungicide
Lace bug	3	Diazinon	Non-systemic insecticide, acaricide with contact, stomach and respiratory action
	3	Pyrethrin	Contact insecticide with stomach action
	3	Trichlorfon	Insecticide and acaricide with contact and stomach action
Macadamia feltid coccid	3	Diazinon	Non-systemic insecticide, acaricide with contact, stomach and respiratory action
	3	Methidathion	Non-systemic insecticide, acaricide with contact and stomach action
	1	Petroleum oil	Insecticide and acaricide with ovicidal activity
Macadamia flower caterpillar	3	Acephate	Contact insecticide with stomach action
	1	Bacillus thuringiensis	Stomach poison
	1	Methoxyfenozide	Insecticide that lethally accelerates the moulting process
	2	Spinetoram	Insecticide with contact action
	1	Tebufenozide	Insecticide that lethally creates unsuccessful moulting process
	3	Trichlorfon	Insecticide and acaricide with contact and stomach action
Macadamia leaf miner	3	Acephate	Contact insecticide with stomach action
	3	Diazinon	Non-systemic insecticide, acaricide with contact, stomach and respiratory action
	3	Methidathion	Non-systemic insecticide, acaricide with contact and stomach action
Macadamia mussel scale and white scale	3	Methidathion	Non-systemic insecticide, acaricide with contact and stomach action
Macadamia nut borer	3	Acephate	Contact insecticide with stomach action
	3	Azinphos-methyl	Insecticide with contact and stomach action, moderate persistence
	3	Beta-cyfluthrin	Non-systemic and contact insecticide with stomach action
	3	Carbaryl	Contact insecticide with stomach action
	3	Methidathion	Non-systemic insecticide, acaricide with contact and stomach action
	1	Methoxyfenozide	Insecticide that lethally accelerates the moulting process
	2	Spinetoram	Insecticide with contact action
	1	Tebufenozide	Insecticide that lethally creates unsuccessful moulting process
	3	Trichlorfon	Insecticide and acaricide with contact and stomach action
	1	Trichogramma wasp	Predates on pest eggs
Macadamia twig girdler	3	Carbaryl	Contact insecticide with stomach action
	3	Methidathion	Non-systemic insecticide, acaricide with contact and stomach action
	2	Spinetoram	Insecticide with contact action
Phomopsis husk rot	1	Cu as cuprous oxide	Protectant fungicide
Phytophthora	1	Cu as cuprous oxide	Protectant fungicide
	1	Metalaxyl	Protectant fungicide with slow release activity
	2	Phosphorus acid	Systemic protectant fungicide
Sigastus weevil	3	Acephate	Contact insecticide with stomach action

[1] Source: APVMA Pubcris June 2016.

Coloured dots before the chemical common name denote that chemical's compatibility with IPM.

1 indicates that, when used with care, a chemical will have very little impact on beneficials and is recommended in an IPM program.

2 indicates that this pesticide can be used with caution in an IPM program, but the beneficials present and the likely impact of the chemicals should be assessed before application.

3 indicates that this chemical is likely to have a long-lasting, negative off-target impact (including an impact on beneficial arthropods) and it should only be used in an emergency where no alternative exists.

[2] Adapted from *The Pesticide Manual*, 14th Edition, British Crop Protection Council 2006.

Pollination with native stingless bees

Chris Fuller

Kin Kin Native Bees

New research on the pollination of macadamias in Australia has not only confirmed previous results, but also added to our knowledge on the topic. Horticulture Innovation Australia (HIA) engaged The New Zealand Institute for Plant and Food Research Ltd for the project. Trial sites were chosen in the Bundaberg, Gympie, Glass House Mountains and Northern Rivers regions and trial work commenced in June 2014. The paper, titled *Optimising pollination of macadamia and avocado in Australia* (Project Number MT13060), is now available on the HIA website.

Part of the trial work involved controlled self and cross pollination treatments using glass tubes to transfer pollen. These were then compared to open pollinated treatments which relied on pollinators to transfer pollen. In all cases, both open and cross pollinated treatments resulted in higher nut set than the self-pollinated treatments. Manual cross pollination resulted in greater nut set than open pollination. Manual cross pollination is a technique that growers can do themselves with minimal equipment. Although if this process is deemed necessary, then it probably indicates a lack of insect pollinators that should be doing the job. Introducing bees will increase pollen transfer and therefore increase orchard productivity.

An inventory of insects that visited macadamia flowers was compiled at the different trial sites. Stingless bees and honey bees were by far the most significant floral visitors during the trials, and of these, stingless bees were the most efficient pollinators. Consequently, growers could increase nut set by introducing hives of managed pollinators to their orchards.

There is a developing pollination industry based around using native stingless bees. Hives can either be rented or brought in for the flowering period, or alternatively, some growers are choosing to purchase their own hives (see Figure 71). When hives are kept on farm year round, growers should consider planting alternative forage from which bees can collect nectar and pollen when the macadamias are not flowering (see Figure 72 for an example). This is especially important in areas such as Bundaberg where many orchards have little surrounding natural forests. These forage areas also provide harbourage and food for beneficial predatory insects which help with pest insect control and add to the overall biodiversity on the orchard. Stingless bees are generalist foragers and are very good at finding feed provided it is in reasonably close proximity. Weeds such as Cobblers Pegs or Billy Goat weed (also known as Blue Top) can provide pollen and nectar over winter when little else is available.

Figure 71. As hive numbers grow on orchards, stands are created for multiple hives. This stand will eventually house 20 hives.

Figure 72. A mohawk of alternative forage for bees.

For further information on the availability and use of native stingless bees in macadamia orchards, please contact Chris Fuller at info@nativebees.com.au.

Biosecurity – it's your responsibility too

Rebekah Pierce
Plant Biosecurity Officer
NSW Department of Primary Industries

Good biosecurity practices are essential to protect your property and your industry against the entry, establishment and spread of exotic plant pests and their effects. Exotic plant pests can affect farmers and industry stakeholders as well as trade and communities. It is important that everyone plays their part in biosecurity by preparing for, and managing, biosecurity threats.

While Australia's geographic isolation and national quarantine systems provide some protection against harmful exotic pests being introduced, there will always be some risk of exotic pests entering Australia. Natural dispersal, such as wind, or assisted dispersal from tourism and imports, both provide pathways for exotic pests to be introduced to our shores.

Farm biosecurity

Newly introduced plant pests can easily be spread on plant material, clothing, vehicles and equipment. Always remember to '*come clean and go clean*' as vehicles, farm equipment and people can carry plant pests on and off your property, especially associated with soil or plant material. Clean down between farms, including vehicles and footwear, and use an on-farm vehicle where possible.

Signage (Figure 73) should be used to inform visitors that biosecurity practices are in place. Use signage to direct all traffic to a designated parking area where visitors can make themselves known and vehicles and clothing can be assessed for risk.

Monitor your orchard for plant pests and familiarise yourself and your employees with pests and diseases commonly seen in your orchard. Keep an eye out for any new or unusual pests or diseases and make sure employees know to whom they should report to if they spot something unusual.

Use pest-free propagation material sourced from reputable suppliers to avoid introducing new insects and diseases to your property.

Report suspect plant pests and diseases to the Exotic Plant Pest Hotline 1800 084 881.

An exotic plant pest is a disease-causing organism or an invertebrate not present in Australia and which threatens agricultural production, forestry or native and amenity plants.

Figure 73. Biosecurity signage alerts visitors to protect your property.

Macadamia biosecurity

Three of the most threatening exotic plant pests that affect macadamia orchards overseas are tropical nut borer, sudden oak death and bacterial leaf scorch. These have been identified as high priority exotic plant pests in the Macadamia Biosecurity Plan. Plant Health Australia prepared the Macadamia Biosecurity Plan in collaboration with industry and technical experts.

Awareness and early identification of these plant pests is essential for successful containment and eradication, should they be introduced to Australia.

Information on identifying these three high priority exotic macadamia pests is displayed in the following posters. These posters are available FREE from the Australian Macadamia Society and NSW DPI. Help protect your industry by ordering your free posters today and start encouraging awareness of biosecurity on your property.

If you think you have seen these, or any other exotic plant pest or disease call the Exotic Plant Pest Hotline on 1800 084 881.

UNWANTED:
TREE NUT PESTS
BACTERIAL LEAF SCORCH

Bacterial leaf scorch ***(Xylella fastidiosa)*** is an exotic plant disease **not present in Australia**.

Also known as 'almond leaf scorch' or 'golden death'.

Disease survives in sap and is **spread** between plants by sap feeding insects and grafting.

Be on the look out for symptoms on trees as well as the exotic insect vector **glassy winged sharpshooter,** also **not present in Australia**.

HIGH RISK TO:
ALMONDS, PECANS AND MACADAMIAS

Bacterial scorch of an almond leaf showing the yellow band between healthy and dead tissue
Courtesy of Sam Livingston, Department of Plant Pathology, California

Glassy winged sharpshooter – insect vector (12-14 mm)
Courtesy of Roy Niswanger, Texas

Infected almond tree
Courtesy of Franz Niederholzer, UC Cooperative Extension

Scorching of leaves
Courtesy of Sam Livingston, Department of Plant Pathology, California

Damage

- Delayed growth and flowering
- Stunted growth
- Reduced productivity
- May appear on one branch before spreading throughout the tree
- Eventual tree death

Identification

- Leaf margins appear scorched or burnt
- Golden yellow band between burnt edge and green leaf tissue
- Scorching usually progresses from leaf tip to base
- Infected leaves remain attached to tree
- Unlike salt burn, scorch symptoms are not uniform along the leaf margin

IF YOU SUSPECT BACTERIAL LEAF SCORCH CALL THE EXOTIC PLANT PEST HOTLINE

1800 084 881

OR EMAIL PHOTOS AND A DESCRIPTION TO
biosecurity@dpi.nsw.gov.au

NSW GOVERNMENT | Department of Primary Industries

AUSTRALIAN MACADAMIA SOCIETY

UNWANTED: TREE NUT PESTS

SUDDEN OAK DEATH

HIGH RISK TO:
CHESTNUTS, HAZELNUTS AND MACADAMIAS

Disease on leaves of rhododendron
Courtesy of Joseph OBrien, USDA Forest Service, Bugwood.org

Sudden oak death ***(Phytophthora ramorum)*** is an exotic plant disease **not present in Australia**.

This fungus infects the leaves, stems and trunks of over 130 tree and shrub species.

Spread occurs with rain splash, wind and the movement of infected host plant material.

Sudden oak death differs from phytophthora root rot by **infecting above ground parts of the plant**.

Bark discolouration and bleeding canker on oak trunk
Courtesy of Bruce Moltzan, USDA Forest Service, Bugwood.org

Canopy death of coast live oak
Courtesy of Joseph OBrien, USDA Forest Service, Bugwood.org

Damage

- Infected leaves prematurely die and fall
- Rapidly expanding cankers can girdle the tree leading to sudden death of the canopy

Identification

One or more of the following symptoms can occur:

- Brown to black sunken cankers beneath outer bark bordered by black 'zone lines'
- Red to black sap bleeding from cankers on trunk
- Dark brown disease lesions on leaves often spreading from the tip to cover the entire leaf
- Blackened shoots die back

IF YOU SUSPECT SUDDEN OAK DEATH
CALL THE **EXOTIC PLANT PEST HOTLINE**

1800 084 881

OR EMAIL PHOTOS AND A DESCRIPTION TO
biosecurity@dpi.nsw.gov.au

NSW GOVERNMENT | Department of Primary Industries

AUSTRALIAN MACADAMIA SOCIETY

UNWANTED:
TREE NUT PESTS
TROPICAL NUT BORER

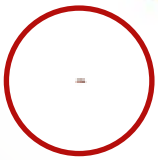
HIGH RISK TO:
MACADAMIAS

Tropical nut borer *(Hypothenemus obscurus)* is an exotic plant pest **not present in Australia**.

This beetle bores 0.5 mm holes into macadamia husks and tunnels through the husk, shell and edges of the kernel.

Up to 190 borers have been found in a single nut.

A heavy infestation of borers **can damage up to 60% of the crop**.



Actual size

Adult tropical nut borer (1.5 mm)
Courtesy of Pest and Diseases Image Library, Bugwood.org

0.5 mm holes bored into macadamia husk
Courtesy of Vincent P. Jones

Tunnelling of tropical nut borers inside a macadamia nut
Courtesy of C. Maddox , NSW Department of Primary Industries

Damage

- Numerous perfectly round holes (about 0.5mm diameter) in the husk
- Extensive tunnelling throughout the husk, shell and kernel
- Kernel is not consumed but is damaged and open to secondary infection

Identification

- Adult borers are 1.5 mm in size
- Numerous borers at all life stages present beneath the husk

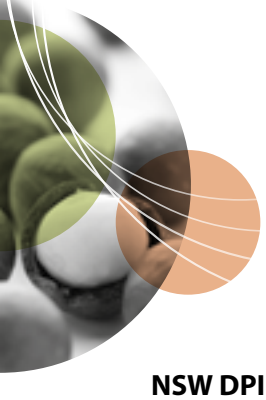
IF YOU SUSPECT TROPICAL NUT BORER CALL THE EXOTIC PLANT PEST HOTLINE

1800 084 881

OR EMAIL PHOTOS AND A DESCRIPTION TO
biosecurity@dpi.nsw.gov.au

NSW GOVERNMENT | Department of Primary Industries

AUSTRALIAN MACADAMIA SOCIETY



Publications and internet sites for macadamia growers

NSW DPI Primefacts/Agfacts are available free from NSW Department of Primary Industries website (www.dpi.nsw.gov.au/content/agriculture/horticulture/nuts).

NSW Macadamia plant protection guide (this book) is available for free download (www.dpi.nsw.gov.au/content/agriculture/horticulture/nuts).

Macadamia integrated orchard management practice guide introduces canopy, orchard floor and drainage management as the three pillars of integrated orchard management. It also introduces stages of orchard development and provides a framework for assessing orchard blocks across the three pillars. The guide encourages growers to recognise important 'red flags'; signs that production decline is imminent. It describes currently used management practices (Toolkits) in the macadamia industry and the appropriate circumstances for their use. This book can be collected from The NSW DPI office at Wollongbar or processors, and can also be downloaded free at (www.dpi.nsw.gov.au/content/agriculture/horticulture/nuts/growing-guides/macadamia-integrated-orchard-management).

*Macadamia integrated orchard management case studies 2016***.** A companion to the *Macadamia integrated orchard management guide 2016*. Where the guide details the 'what to do' and 'when to do it', the case study booklet details the 'how to do'. It is designed to give growers considering integrated orchard management (IOM) the confidence to start planning. The format involves 10 orchard case studies (two from each of the Australian macadamia growing regions). The book can be collected from the NSW DPI Wollongbar office, from processors and can also be downloaded free at (www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/667812/macadamia-iom-case-studies-2016.pdf).

Macadamia integrated orchard management drainage 2017

Effective orchard drainage systems keep productive soil in place. Successful orchard drainage systems create a synergy between the orchard layout and the landscape ensuring that:

- minimal soil movement occurs during rain
- concentrated water flows are managed away from macadamia trees
- blocks are protected from run-on water
- good conditions for macadamia feeder roots are maintained
- the orchard floor is trafficable and harvestable.

This book is available for free download (www.dpi.nsw.gov.au/content/agriculture/horticulture/nuts).

Spray Sense: a publication providing information on pesticide use. Topics covered include sprayer calibration, testing for residues, storing pesticides, disposal of empty containers, how to read a label and a number of other topics. The *Spray Sense* series of leaflets can be downloaded free (www.dpi.nsw.gov.au/agriculture/farm/chemicals/general/spray-sense-leaflet-series).

MacSmart: a range of more than 50 short and informative YouTube video interviews with growers and researchers covering topics including canopy management, innovative farm practices, orchard floor management, top performing farms, the latest research and other interesting topics. Go to www.macsmart.com.au.

Macadamia grower's handbook: This publication (2004) details what is involved from establishing a new planting right through to harvesting the crop. It gives useful technical information, key points and commonly asked questions.

Macadamia problem solver and bug identifier: An excellent reference for pest and disease identification. The book is available for purchase as a booklet or can be downloaded free with the grower's handbook several sections (era.daf.qld.gov.au/1964).

Macadamia variety identifier: A useful resource that assists in identifying specific varieties of macadamia. It covers 24 varieties. The publication is free to download (http://era.deedi.qld.gov.au/1964/14/mac-varieties.pdf).

Macadamia culture in NSW: a useful introductory resource to what is involved in growing macadamias. It is available for download free (www.dpi.nsw.gov.au/agriculture/horticulture/nuts/growing-guides/macadamia-culture-nsw).

Australian Macadamia Society FAQs and fact sheets: An up to date resource identifying current problems and issues within the industry and offering useful solutions and tips to overcome these. Compiled by the Australian Macadamia Society with the assistance of industry experts. Can be downloaded free (to members) (https://goo.gl/J8jfUd).

Establishing and managing smothergrass on macadamia orchard floors, 2008: A guide on how to establish smothergrass, including costs and management. Download for free (www.dpi.nsw.

gov.au/agriculture/horticulture/nuts/soil-nutrition/establishing-managing-smothergrass).

Reducing erosion and other soil degradation in macadamia orchards describes methods for reducing erosion from high rainfall. Looks at management practices that can be implemented to achieve this. Download for free (https://www.dpi.nsw.gov.au/agriculture/horticulture/nuts/soil-nutrition-floor-mgt/soil-macadamia).

The good bug book (second edition) is a valuable reference of the beneficial organisms commercially available for biological control in Australia. It includes illustrations of many of the beneficials as well as tables of information on their susceptibility to pesticides. It is published by Integrated Pest Management Pty Ltd for the Australasian Biological Control Association Inc. Can be purchased from Bugs for Bugs (www.goodbugs.org.au).

Internet sites for macadamia growers

Agricultural industry organisations

National Farmers' Federation (www.nff.org.au)

NSW Farmers' Association (www.nswfarmers.org.au)

Australian Macadamia Society (www.australianmacadamias.org/industry)

macSmart (www.macsmart.com.au)

Horticulture Innovation (HI) (www.horticulture.com.au)

International Nut and Dried Fruit Coun cil Foundation (INC) (www.nutfruit.org/)

Australian Nut Industry Council (www.nutindustry.org.au)

State government

NSW Department of Primary Industries www.dpi.nsw.gov.au

Department of Agriculture and Fisheries (Qld) www.daf.qld.gov.au/

WorkCover Authority of NSW (www.workcover.nsw.gov.au)

Workcover Queensland (www.worksafe.qld.gov.au)

Local Land Services NSW (www.lls.nsw.gov.au)

Rural assistance

NSW Rural Assistance Authority (www.raa.nsw.gov.au)

Qld Rural Assistance Authority (www.qraa.qld.gov.au)

Health NSW (www.health.nsw.gov.au)

Qld Health (www.health.qld.gov.au)

Centrelink (www.centrelink.gov.au)

Rural Skills Australia (www.ruralskills.com.au)

Federal government

ABC Rural Department (www.abc.net.au/rural)

Department of Agriculture and Water Resources (www.agriculture.gov.au)

Land & Water Australia (www.lwa.gov.au)

Australian Pesticides and Veterinary Medicines Authority (www.apvma.gov.au)

Australian Trade Commission (www.austrade.gov.au)

Plant Health Australia (www.planthealthaustralia.com.au)

Climate

Commonwealth Bureau of Meteorology (www.bom.gov.au)

Climate Outlook BOM (www.bom.gov.au/climate/ahead/)

National Centers for Environmental Prediction (wxmaps.org/pix/aus.vv.html)

The Long Paddock (www.longpaddock.qld.gov.au)

Environment

Office of Environment & Heritage (www.environment.nsw.gov.au)

Department of the Environment and Energy (www.environment.gov.au)

NSW Environment Protection Authority (www.epa.nsw.gov.au)

Qld Department of Environment and Heritage Protection (www.ehp.qld.gov.au)

Alternative systems (organics)

Organic Federation of Australia (www.ofa.org.au)

Australian Organic (www.austorganic.com/)

Australian Certified Organic (www.aco.net.au)

Australian Organic Certification and Grower Groups (www.nasaa.com.au)

Economic information

Department of Agriculture and Water Resources (www.agriculture.gov.au)

Australian Bureau of Statistics (www.abs.gov.au)

Integrated pest management

Bioresources (www.bioresources.com.au)

Australasian Biological Control Association Inc. (www.goodbugs.org.au)

Bugs for Bugs (www.bugsforbugs.com.au)

Quality assurance

Freshcare Australia (www.freshcare.com.au)

Processors

Macadamias Australia (www.macadamiasaustralia.net)

Macadamia Direct (www.macnut.com.au)

Macadamia Processing Company (www.mpcmacs.com.au)

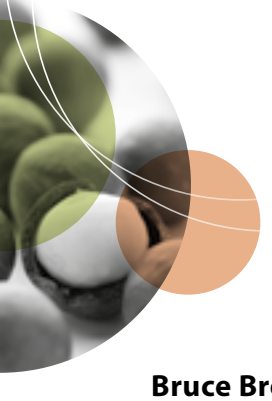
MWT Foods (www.mwtfoods.com)

Nambucca Macnuts (www.macnuts.com.au)

Pacific Farm Services (www.macadamia.com.au)

Stahmann Farms (www.stahmann.com.au)

Suncoast Gold Macadamia (Aust) Ltd (www.suncoastgold.com.au)



Managing your legal responsibilities in applying pesticides

Bruce Browne

Farm Chemical Officer, Plant Biosecurity
Orange

The main national and NSW government agencies involved in legislation related to pesticides are the Australian Pesticides and Veterinary Medicines Authority (APVMA), NSW Environment Protection Authority (EPA) and Safe Work NSW.

Australian Pesticides and Veterinary Medicines Authority (APVMA)

Pesticides are controlled in Australia through an inter-governmental arrangement known as the National Registration Scheme for Agricultural and Veterinary Chemicals. Under this scheme, the APVMA is the Commonwealth agency responsible for assessment and registration of pesticides in Australia and their regulation up to and including the point of sale under the Agricultural and Veterinary Chemicals Code Act 1994. The States and Territories are responsible for controlling the use of pesticides beyond the point of sale, that is, for their use, handling, storage and disposal.

Before registering a product, the APVMA is required to conduct an assessment of the potential impacts of the pesticide on the environment, human health and trade, and of the likely effectiveness of the pesticide for its proposed uses. When a pesticide contains an active constituent not previously used in Australia, the APVMA must seek public comment before registering the product.

Only registered pesticides can be used in NSW. Registration includes approval of label directions for each pesticide product. Label directions specify how, and under what circumstances, the pesticide may be used to treat the relevant target pest or pests. Labels also give directions on clean-up, storage and disposal, and personal and environmental safety.

The APVMA's Chemical Review Program reviews the registration of existing agricultural and veterinary chemicals if new information regarding a higher risk to human health, the environment or trade becomes available. The public, the Office of Chemical Safety and the Australian Department of Environment can report problems known as 'adverse events' regarding specific chemicals or products to the APVMA. The new and existing information is reviewed by the Office of Chemical Safety, the Department of Environment and the APVMA. The APVMA also invites public comment for chemicals under review as part of the process.

Permits for off-label use

Special provisions exist under legislation administered by the APVMA to allow people to use pesticides in a way that is not described on the approved label. The APVMA can approve off-label use of the pesticide by issuing a minor use permit. In NSW off-label use is not allowed unless a permit has been issued. A permit is similar to a label in that all instructions must be strictly followed.

Permits

A permit is issued for a limited use over a specified period of time if the Australian Pesticides and Veterinary Medicines Authority (APVMA) are convinced that such a use is justified. Justification is usually on the grounds that a suitable registered alternative is not available, it is required as part of an emergency management response program or to manage a pest or resistance management strategy.

In addition the pesticide:

- will not cause undue hazard to the safety of people exposed to it, during handling the pesticide or anything containing its residues,
- should not have an unintended effect that is harmful to animals, plants or the environment,
- will not unduly prejudice export trade and
- the use of the product as proposed would be effective against the intended pest.

Permits may be granted during the course of the 2018–19 season. Consult the APVMA for information about new permits. Growers wishing to use a chemical in the manner approved under a permit should obtain a copy of the relevant permit from the APVMA and must read and comply with all the details, conditions and limitations on the permit. Current permit and registration details are available on the APVMA web site: http://apvma.gov.au/

Industry bodies, organisations and corporations can apply for permits for off-label use. Inquiries should be made through: the APVMA

PO Box 6182

Kingston ACT 2604

Phone: 6210 4700

Web: http://apvma.gov.au/

The EPA – The Pesticides Act 1999 and Regulation 2009

The Pesticides Act 1999 and the Regulation 2009 are two of the primary legislative instruments controlling the use of pesticides in NSW. They control the use of pesticides after the point of sale. They aim to reduce the risks associated with the use of pesticides to human health, the environment, property, industry and trade. It also aims to promote collaborative and integrated policies for the use of pesticides. The Environment Protection Authority (EPA) enforces the proper use of all pesticides in NSW.

The underlying principle of the Pesticides Act is:

Pesticides must only be used for the purpose described on the product label and all the instructions on the label must be followed.

The Act and Regulation 2009 require all commercial pesticide users to:

- only use pesticides registered or permitted by the APVMA
- obtain an APVMA permit if they wish to use a pesticide in a way not covered by the label
- read the approved label and/or APVMA permit for the pesticide product (or have the label/permit read to them) and strictly follow the directions on the label
- only keep registered pesticides in containers bearing an approved label
- prevent injury to people, damage to property and harm to non-target plants and animals, the environment and trade through the use of a pesticide
- undertake approved training in pesticide application and renew this qualification every 5 years. Keep records of their pesticide application.

Compulsory training in pesticide use

Since 1 September 2003 training in the use of pesticides has been compulsory in NSW. If you use pesticides in your job or business you must now achieve and maintain a specific level of competency in pesticide use.

There is a range of training available to suit all types of pesticide users. In most cases the training involves a two-day course, based on competencies from the Agriculture, Horticulture and Conservation and Land Management (AHCIO) Training Package. You can also become qualified by demonstrating to a registered training organisation that you know how to use pesticides in your job or business.

The minimum prescribed training qualification is the AQF2 unit of competency, 'Apply chemicals under supervision'. Owner-applicators are encouraged to train and be assessed in the two higher AQF3 competencies, 'Prepare and apply chemicals' and 'Transport, handle and store chemicals'.

Note: the lower level AQF2 competency will provide a minimum qualification that satisfies the Regulation.

For more information on compulsory training in pesticide and a full list of training providers go to the EPA website.

These training requirements do not apply where the pesticide is all of the below:

- ordinarily used in the home or garden
- widely available to the general public at retail outlets
- being applied by hand or using hand-held equipment only
- being used in small quantities:
    - for outdoors use, in quantities of no more than 5 litres/5 kilograms of concentrated product or 20 litres/20 kilograms of the ready-to-use product
    - for indoors use, in quantities of no more than 1 litre/1 kilogram of concentrated product or 5 litres/5 kilograms of the ready-to-use product.

Pesticide record keeping

Adapted from the NSW Environment Protection Authority.

The EPA's Pesticides Regulation 2009 makes it compulsory for all people who use pesticides for commercial or occupational purposes, to make a record of their pesticide use (Spray Diary). Pesticides include herbicides, fungicides, insecticides, fumigants, nematicides, defoliants, desiccants, bactericides and vertebrate pest poisons. A small use exemption, similar to that for training, applies to record keeping.

To comply with the record keeping rules set out in the Regulation you must record:

- date, start and finish time
- the operator details – name, address and contact details
- the crop you treated e.g. macadamia. The property address and a clear delineation of the area where the pesticide was applied – you can mark this on a rough sketch or map of your property if this is easiest for you
- type of equipment used to apply the pesticide e.g. knapsack, air blast sprayer, tractor mounted boom- spray
- the full product name of the pesticide applied (e.g. Cabrio 250 g/L not just Cabrio). If you mixed two pesticides together, you can record both on the same form
- the total amount of concentrate product used

- the total amount of water, oil or other things mixed in the tank with concentrated product
- size of block sprayed
- order blocks were treated
- an estimate of the wind speed and direction at the start of spraying. You can use a wind meter (anemometer) or the Beaufort scale to help estimate the wind speed
- Beaufort scale available from BOM (http://www.bom.gov.au/lam/glossary/beaufort.shtml)
- if other weather conditions are specified on the label as relevant to the proper use of that pesticide (such as temperature, humidity, rainfall etc.) you must record a description of these weather conditions at the start of the application
- if wind and weather conditions change significantly while you are spraying you need to record these changes
- records must be made in English.

The EPA's Pesticides Regulation 2009 requires you to make a record within 24 hours of applying the pesticide

If you already keep records for other purposes (e.g. for the processor you are supplying), you can simply add to that record any of the requirements listed above that are not already in that record.

Records must be kept for three years. If you are the owner or the person who has the management or control of the property on which you, your employees or a contractor applied the pesticide, you are responsible for keeping the record.

Note: If you applied the pesticide yourself, then it is your responsibility to make the record. You can get someone else to write it down for you but it is up to you to make sure the record is made and that it is accurate. If you employed someone to apply the pesticide then that person must record their name as well as your name, address and contact details as their employer. If the pesticide was applied by a contractor, the contractor must record their own name, address and contact details, the name, address and contact details of the owner or the person who has the management or control of the land where the pesticide was applied. You only have to record this additional information if the person who owns or manages the property and the person who applied the pesticide are different. Refer to page 74 for the EPA's example record keeping form (Spray Diary).

Dangerous goods and hazardous substances (chemicals)

Dangerous goods are substances, mixtures or articles that, because of their physical, chemical (physicochemical) or acute toxicity properties, present an immediate hazard to people, property or the environment. Types of substances classified as dangerous goods include explosives, flammable liquids and gases, corrosives, chemically reactive or acutely (highly) toxic substances.

The criteria used to determine whether substances are classified as dangerous goods are contained in the Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG Code).The ADG Code contains a list of substances classified as dangerous goods.

Hazardous substances (chemicals) are those that, following worker exposure, can have an adverse effect on health. Examples of hazardous substances include poisons, substances that cause burns or skin and eye irritation, and substances that may cause cancer.

A substance is deemed to be a hazardous substance if it meets the classification criteria specified in the Approved Criteria for Classifying Hazardous Substances [NOHSC:1008(2004] (Approved Criteria).

Substances that have been classified according to the Approved Criteria are provided in the online database called the Hazardous Substances Information System (HSIS).

Many hazardous substances are also classified as dangerous goods.

Safe Work NSW

Under the Work Health and Safety Act 2011 (WHS Act), Safe Work NSW seeks to protect workers in the workplace. Regulations under the WHS Act control hazardous substances including most pesticides. The Work Health and Safety Regulation 2011 is the most recent and important of these. It covers identification of hazardous substances in the workplace and the assessment and control of risks associated with their use.

- Work Health and Safety Act 2011
- Work Health and Safety Regulation 2011

The Act and accompanying Regulation are intended to protect workers from both the short and long term health effects of exposure to hazardous chemicals and to improve current health and safety practices by:

- provision of health and safety information to workers (including a list or register of all hazardous chemicals and an SDS (Safety Data Sheet) for each hazardous chemical)
- consultation with workers
- training of workers
- minimising the risks arising from hazardous chemicals exposure
- health surveillance (if organophosphates are used).

Pesticides: Example record keeping form

Note: It is not compulsory to use this format. If you use a short name for something in filling out this form, you must write the full name somewhere else such as a book or farm diary.

Pesticides application record sheet. Record the name, address and contact details of the owner or occupier of the land where the pesticide was applied:

Date, start and finish time	Operator details	Crop or place where pesticide was applied	Type of equipment used	Name of pesticide used	Amount of concentrated product used	Total quantity applied	Size of block sprayed	Order blocks were treated	Estimated wind speed and direction		Other weather details
	Name, address and contact details	*Also record spraying of fallow and any pesticides used in and around crops**		*Record all the pesticides you used.*	*If you mixed two Pesticides together, you can record both on the same form.*	*Total amount of water, oil or other things mixed with concentrated product.*	*Refer to your farm map***	*Write which block was sprayed first, second, third, etc.*	*If these conditions change significantly during spraying then also record the changes.*		*Only if they are specified on label the label or APVMA permit*
									Speed	Direction	

* It is not compulsory to record the pest or disease but it is recommended as part of good operating practices.

** A farm map is recommended because it would make recording this information easier.

(Records must be in English)

Form reproduced with the permission of NSW EPA

To help industries implement the Act and Regulation, Safe Work NSW developed a code of practice: Safe Use and Storage of Chemicals (Including Pesticides and Herbicides) In Agriculture 2006. This does not replace the WHS laws, but can help understanding what you have to do.

Note: this code of practice is the 2006 edition. The Pesticides Regulation 2009 and the Work Health and Safety Act and Regulation 2011 have been enacted after this code of practice was published. Safe Work's statement on this issue, on their web site, is:

"These codes of practice were developed based on the Occupational Health and Safety Act and Regulation (or older laws) which were replaced with the Work Health and Safety Act and Regulation in NSW from 1 January 2012. These codes are taken to have been made under the Work Health and Safety Act, which means they are current and can still be used to help you meet your WHS requirements, however to ensure you comply with your legal obligations you must refer to the appropriate legislation."

For further guidance see – Managing risks of hazardous chemicals in the workplace July 2014.

The WHS Regulations 2011 include specific responsibilities of a person conducting a business or managing risks to health and safety associated with handling and storing hazardous chemicals at a workplace. These include:

- correct labelling of containers, using warning placards and outer warning placards and displaying of safety signs
- maintaining a register and manifest (where relevant) of hazardous chemicals and providing notification to the regulator of manifest quantities if required
- identifying risk of physical or chemical reaction of hazardous chemicals and ensuring the stability of hazardous chemicals
- ensuring that exposure standards are not exceeded
- provision of health monitoring to workers
- provision of information, training, instruction and supervision to workers
- provision of spill containment system for hazardous chemicals if necessary
- obtaining the current Safety Data Sheet (SDS) from the manufacturer, importer or supplier of the chemical
- controlling ignition sources and accumulation of flammable and combustible substances
- provision and availability of fire protection, firefighting equipment, emergency and safety equipment
- preparing an emergency plan if the quantity of a class of hazardous chemical at a workplace exceeds the manifest quantity for that hazardous chemical
- stability and support for containers of bulk hazardous chemicals including pipework and attachments
- decommissioning underground storage and handling systems
- notifying the regulator of abandoned tanks in certain circumstances.

NSW dangerous goods and hazardous substances transport legislation

Not all pesticides are dangerous goods or hazardous substances but many are. If a pesticide is a dangerous goods or hazardous substance it will say so on the label and SDS.

Prior to the implementation of the Work Health and Safety Regulations 2011 (WHS), workplace storage, handling and use of hazardous chemicals were regulated under separate instruments for hazardous substances and for dangerous goods.

The new WHS Regulations cover workplace hazardous substances and dangerous goods under a single framework for hazardous chemicals and introduce a new hazard classification and hazard communication system based on the United Nations' Globally Harmonised System of Classification and Labelling of Chemicals (GHS). The specific requirements of the ADG Code for the transport of dangerous goods do not usually apply to the transport of chemicals on a farm because they are normally small quantities.

Large operations should check the amounts for which marking of the vehicle and other special conditions are required by the ADG code.

The following rules apply to small quantities of pesticides

When obtaining chemicals from a supplier in the original unopened containers:

- keep them in a compartment of the vehicle separate from persons or foodstuffs
- the vehicle must be locked to prevent public access to chemicals when parked near a public road
- do not leave your loaded vehicle unlocked or unattended
- protect the load from the weather
- do not accept or load damaged or leaking containers. Secure the load and limit its movement.

When transporting chemicals once the container has been opened observe the following precautions:

- keep in a separate airtight compartment, or on the rear section of an open vehicle (ute, truck or trailer)

- personal protective equipment, a change of clothes, food and drink, should be carried in clean containers preventing contact with any chemical pest control equipment and chemicals carried on the vehicle should not be in contact with porous surfaces
- the internal and external surfaces of the vehicle, chemical containers and spray equipment should be kept clean
- protect the load from the weather
- do not leave your loaded vehicle unlocked or unattended
- do not load damaged or leaking containers
- secure the load and limit its movement

Re-entry intervals

The re-entry interval is the time which must elapse between applying the pesticide and re-entry into the sprayed crop, unless the person is wearing the personal protective equipment specified for re-entry on the label. The reason for setting a re-entry interval is that pesticides sometimes remain on crops in the form of foliar aerosol particles. Residues can be dislodged by contact with the crop and absorbed through the skin by those working in the crop.

Re-entry intervals only appear on the label of a small number of newer products and older products that have recently been reviewed by the Australian Pesticides & Veterinary Medicines Authority (APVMA). If there is no re-entry period on the label, the general rule is to wait 24 hours after application or until the crop is dry, whichever is the longer.

Crops should not be re-entered when wet from dew or light rain within the re-entry period unless appropriate personal protective equipment, as described on the label, for handling the pesticide, is worn.

Pesticides and the environment

Many insecticides are toxic to aquatic organisms, bees and birds. Fungicides and herbicides are relatively safe to bees in terms of their active ingredients, but their carriers and surfactants may be toxic. The risk to organisms can be managed by following label instructions.

Protecting bees

Many pesticides are toxic to bees, however this risk can be reduced by following label instructions. The label provides the following special statement:

Dangerous to bees. DO NOT spray any plants in flower while bees are foraging.

Protecting birds

Organophosphate and carbamate insecticides can be toxic to birds, especially in granular formulations. See label for details on how to minimise the danger to birds.

Managing residues resulting from pesticide application

Withholding periods (WHPs)

The withholding period (WHP) is the minimum time which must elapse between the last application of a pesticide and harvest. The purpose of the WHP is to avoid residues in raw agricultural commodities and in foods for consumption by humans and animals.

- pesticides used on crops may have WHPs for both harvest and grazing
- WHPs are specific to use patterns, i.e. to chemical, crop and pest
- WHPs are also product specific
- harvest WHPs may vary with formulation (e.g. ULV or EC), rate (which may vary with the pest controlled), and whether or not the crop can be harvested green or dry
- not all labels include all registered use patterns for a particular active ingredient. Consequently, not all labels carry the same information on WHPs. On some labels the WHP is contained within the tables giving Directions for Use; on other labels the WHP appears separately below the Directions for Use
- where no WHP is given on the label, it will carry a statement to the effect that no WHP is necessary if label directions are followed
- where appropriate, growers are advised to contact the chemical manufacturer or the winery they are supplying for advice on managing chemical residues in the crop or in stock.

Export requirements

Some export markets have a lower maximum residue limit (MRL) than Australia or no MRL. Contact your processor to determine their requirements.

Managing spray drift

Spray drift is the airborne movement of agricultural chemicals onto a non-target area. There may be a risk of injury or damage to humans, plants, animals, the environment or property. If you are responsible for spray drift that causes off-target damage you may be fined or required to pay compensation. See Managing spray drift section elsewhere in this publication.

Buffer zones

Buffer zones assist in minimising drift into sensitive and non-target areas. A buffer zone may consist of fallow, pasture, a non-sprayed strip of the crop or purpose planted vegetation such as a crop or wind break. Vegetative buffer zones should be sufficiently open to allow the spray to penetrate and of sufficient depth to trap the bulk of any drift.

Analytical laboratories

In some situations a chemical analysis of fruit may be required. Listed below are some laboratories which undertake this type of work.

Agrisearch Analytical
Level 1, 48 Victoria Road
Rozelle 2039
Phone 02 9810 3666
Fax 02 9810 3866
E-mail: contact@agrisearchanalytical.com.au

National Measurement Institute
36 Bradfield Road
Lindfield NSW 2070
Phone 02 8467 3600
Fax 02 8467 3610
Email: info@measurement.gov.au

National Association of Testing Authorities
PO Box 7507
Silverwater NSW 2128
Phone 02 9736 8222
Fax 02 9743 5311

More labs can be found at National Association of Testing Authorities.

Poison Schedules

Pesticides are classified into four categories in the Poisons Schedule based on the acute health hazard to the user of the pesticide. They are either Unscheduled or Schedule 5, 6 or 7 (Table 10). Each schedule has a corresponding signal heading which appears in large contrasting lettering on the label of the pesticide product, generally above the brand name on the front of the label.

NOTE: Some active ingredients can appear under more than one schedule, generally because the carrier is more hazardous than active ingredient or due to the concentration of active e.g. parathion is a schedule 6 poison if the concentration of the active ingredient is 45% or less of the total formulation Penncap-M which contains 240 g/L parathion is schedule 6, on the other hand, the product Folidol M500 which contains 500 g/L parathion, is a schedule 7.

The Safety Directions specify what personal protective equipment should be worn, and what safety precautions should be taken, e.g. 'do not inhale spray mist'. The First Aid Instructions specify what action should be taken in the event of a poisoning. Safety Directions and First Aid Instructions may be different for different formulations of the same pesticides.

Note: Before opening and using any farm chemical, consult the label and the Safety Data Sheet (SDS) for specific safety directions.

Applying pesticides by aircraft

Additional legal obligations apply if the pesticide is to be applied by aircraft. More information on the legal requirements for aerial application is available on the EPA website: http://www.epa.nsw.gov.au/pesticides/aerialapplicators.html

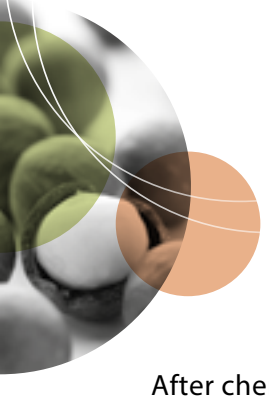
Acknowledgements

Thanks to Jenene Kidston, Technical Specialist Farm Chemicals NSW DPI; Brian McKinnon Non Graduate Lecturer Farm Mechanisation NSW DPI and Natalie O'Leary, Profarm Trainer NSW DPI for reviewing this article.

Authors contact details
T: 02 6391 3154 E: bruce.browne@dpi.nsw.gov.au

Table 10. Poisons Schedule.

Schedule 1	This Schedule is intentionally blank
Schedule 2	Pharmacy medicine
Schedule 3	Pharmacist only medicine
Schedule 4	Prescription only medicine, or prescription animal remedy
Unscheduled	Very low toxicity
Schedule 5	Slightly toxic. Caution – Substances with a low potential for causing harm
Schedule 6	Moderately toxic. Poison – Substances with a moderate potential for causing harm
Schedule 7	Highly toxic. Dangerous Poison – Substances with a high potential for causing harm at low doses. Requires special precautions during manufacture, handling or use. Access is by authorised users only. Schedule 7 poisons are not permitted for domestic use
Schedule 8	Controlled drug restricted access to minimise misuse. Restricted access to minimise misuse
Schedule 9	Prohibited substance. Substances required for research



Disposal of farm chemicals and their containers

After chemicals have been applied as per label directions, empty chemical containers and any unused chemicals have to be disposed of in an environmentally responsible manner.

drumMUSTER

AgStewardship Australia Limited has been established to develop and implement stewardship programs that reduce and manage waste for Australia's agricultural sector. Its member organisations are the National Farmers' Federation, CropLife Australia, Animal Health Alliance, the Veterinary Manufacturers and Distributors Association and the Australian Local Government Association.

AgStewardship Australia Limited is responsible for managing two of the most successful voluntary product stewardship programs in Australia: drumMUSTER® and ChemClear®, which collect and dispose of used agricultural chemical containers and unwanted crop protection and animal health chemicals. Agsafe Limited, who previously managed these programs, has been contracted by AgStewardship to continue delivering them on its behalf.

drumMUSTER is the national, industry-driven program for collecting and recycling eligible, empty, cleaned, non-returnable crop protection and animal health chemical containers. drumMUSTER is funded through a levy on the purchase price of crop protection and animal health chemical products sold in eligible, non-returnable, rigid plastic and steel containers over 1 kg or 1 L in size up to 205 L. The levy of 4 cents per litre or kilogram started in February 1999 and is paid by manufacturers into a fund administered by AgStewardship Australia Limited. This is then passed on to distributors and retailers who, in turn, pass the levy on to consumers.

Local councils and other collection agencies, either individually or in groups, enter into an agreement with drumMUSTER. Farmers are then able to deliver clean, free of chemical residue (i.e. triple or pressure rinsed) containers to designated collection points run by the participating councils and collection agencies. At these collection points, delivered containers are inspected for eligibility including cleanliness and either accepted or rejected.

Only containers with the drumMUSTER sticker (attached as part of the label, stickered or embossed into the container), for which the levy has been paid, will be accepted.

Cleaning containers for collection

When rinsing chemical containers, the personal protective equipment (PPE) specified on the label for application and/or mixing and loading the pesticide should be worn. This is because the chemical remaining in a container is the concentrate, the most toxic form of the chemical, even though it is diluted during the rinsing process.

There are two main ways to clean a container; triple cleaning or pressure rinsing. Triple rinsing is only suitable for small containers, such as those up to 20 L. To triple rinse a container up to 20 L to meet drumMUSTER standards:

- remove the cap, invert the container and allow it to drip drain into the mixing tank for 30 seconds
- add rinse water – 20% (1 L per 5 L) of container volume
- replace cap and shake vigorously for 1 minute
- remove cap, invert and drip drain into mixing tank for 30 seconds
- repeat twice
- wash cap separately and replace on container.

Rinsing is most effective while the containers are still moist inside. The longer the residues have to dry on the inside of containers, the more difficult they are to remove. This is the reason for rinsing during mixing and loading because it enables the rinsate to be emptied into the spray or mixing tank of the application equipment where it can be disposed of for its desired application. Using the rinsate in this way avoids the necessity for having to dispose of the container residues separately (see page Disposal of rinsate or dilute chemical on page 69).

An alternative to manually triple rinsing small containers is a pressure rinsing nozzle. There are two main types. One type has a rotating

spray head which can be used either to rinse an inverted container in the induction hopper or directly over the tank. The other type has a hardened, pointed shaft to pierce drums and the hollow shaft itself has four holes at 90° to spray the water around the container.

To pressure rinse a container up to 20 L:

- remove the cap, invert the container and allow it to drip drain into the mixing tank for 30 seconds
- ensure clean rinse water is at 35–60 psi
- insert pressure rinsing probe either through container opening or through pierced base of the container (depending upon type of nozzle)
- invert container over mixing tank and rinse for 30 seconds or longer if the water coming from the container neck is not clear, moving the probe about to ensure all inner surfaces are rinsed
- wash cap in clear rinse water from container
- turn off water, remove probe and drip drain container into mixing tank for 30 seconds
- replace lid on container.

Large containers, e.g. 200 L, are best rinsed with a chemical transfer probe that has a flushing cycle as well as the primary suction cycle. Such probes are standard on many boom sprays, and options on most others. The drums might have to be slightly inclined to ensure all rinsate is removed. Typical rinse time for a 200 L drum would be 3–5 minutes.

Non-rigid containers, i.e. bags and cartons, have to be buried (see Disposal of rinsate or dilute chemical in the next column). Plastic bags should be rinsed first, and paper bags punctured or shredded. Cartons are also required to be punctured or shredded before burial.

Burning is specifically prohibited.

Visit www.drummuster.com.au for program information free call 1800 008 707.

ChemClear®

ChemClear® is the national industry stewardship program set up under the Industry Waste Reduction Scheme (IWRS). The program collects and disposes of unwanted agricultural and veterinary (agvet) chemicals. The ChemClear® and drumMUSTER programs are funded through a joint levy under the Industry Waste Reduction Scheme which is applied by participating manufacturers of agvet chemicals and passed on to the chemical user at the point of sale.

There are two categories of agvet chemicals ChemClear® collects:

- Group 1 chemicals are currently registered products manufactured by participating companies signed to the Industry Waste Reduction Agreement. These products are collected free of charge.
- Group 2 chemicals are products manufactured by non-participating companies, or, deregistered, unknown, mixed or out of date products (by 2 years). A per litre/kilogram fee for disposal applies.

Visit www.chemclear.com.au for information.

Register for the program by calling 1800 008 182.

Disposal of rinsate or dilute chemical

Labels contain a prohibition on disposing of concentrate on-site or on-farm, as per state environmental legislation. Unused chemical has first to be diluted and, if not applied in terms of the label use pattern, has to be disposed of in an environmentally responsible manner, such as an evaporation pit.

The pit should be a metre deep, lined with plastic sheeting over which has been spread hydrated lime, and any wastes covered with at least half a metre of soil. Disposal pits are only suited to small volumes and for diluted chemicals. In the case of a concentrate spill, the chemical would have to be diluted to at least standard label rates before transfer to the disposal pit.

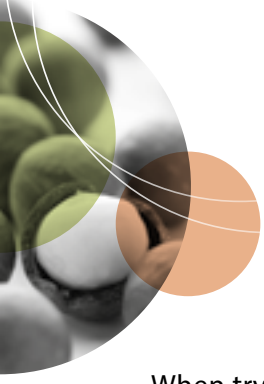
Accreditation and training

Most importantly, the Drummuster and ChemClear® websites have been incorporated into the one-stop website www.agsafe.com.au

This site is dedicated to supporting the safe and compliant handling, supply and disposal of agvet chemicals and their containers through these industry programs.

The available accreditation and training supports the safe storage, handling, transport and sale of agricultural and veterinary chemicals for rural merchandise businesses. You can enrol online (http://aat.agsafe.com.au/) for this training.

The program trains and accredits staff and businesses in handling and providing responsible advice in the safe and effective use of agvet chemicals. The aim of this program is to ensure that there is responsibility and compliance with government regulations and industry standards throughout the supply chain.



Timing, calibration and coverage for macadamia

When trying to achieve adequate pest and disease control it is important to understand the significance of timing, calibration and coverage when spraying. Each of these is individually essential and if any one is missing, the strategy of pest and disease control will fail.

Timing is understanding the life cycle of the pest and identifying the correct time to spray in order to suffer the least amount of loss.

Calibration is making sure that once you achieve the right coverage you calibrate to ensure the right amount of product is hitting the target.

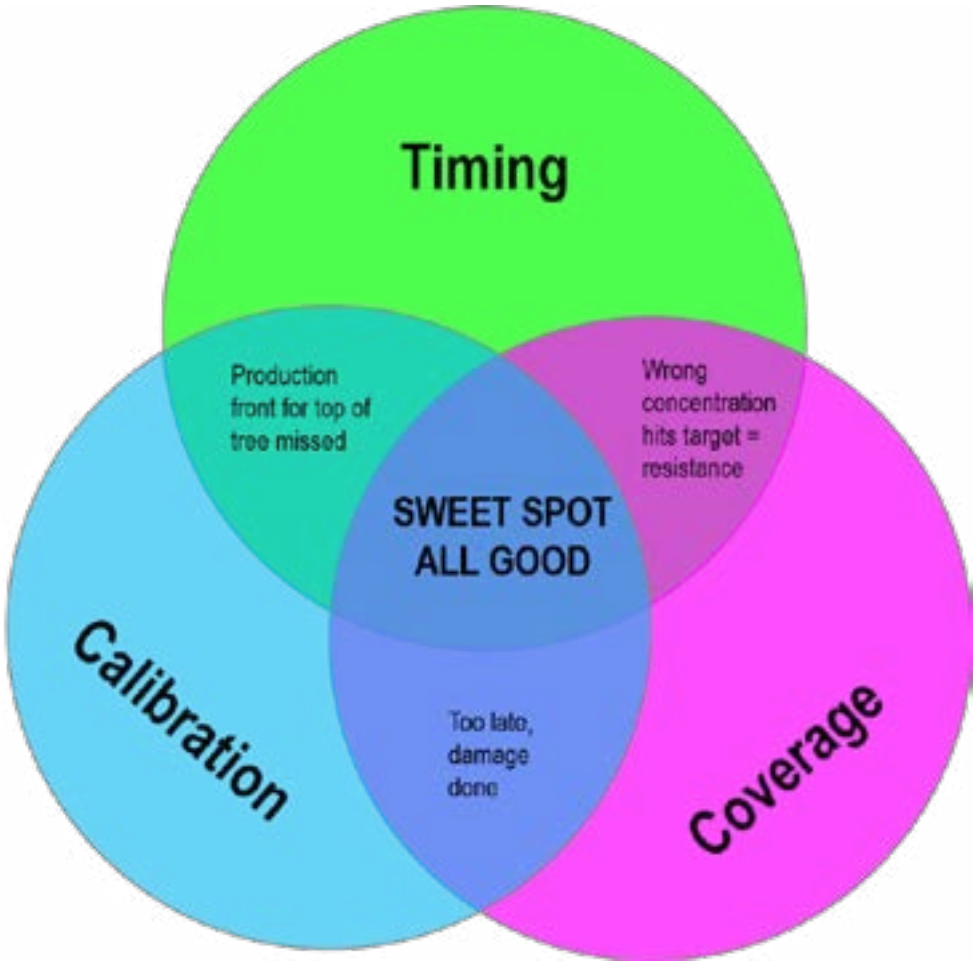
Coverage is about ensuring that your spray application covers the whole target area, including the high production front at the tops of the trees.

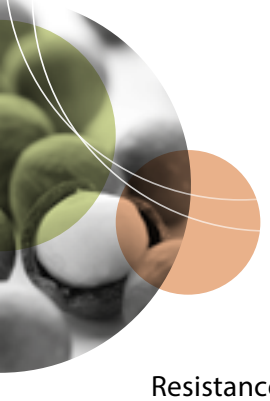
Where all three elements align we achieve good control and production. If any of the three are missing or not effective, then there are potential threats to the system not being effective.

We need to physically check our coverage to ensure it is reaching the tops of the trees. This is where our production front predominantly is and this is what needs to be covered.

We need to frequently check our orchards at susceptible times and look for pest and disease activities. No one knows the orchard better than the person working the orchard. A pest scout will also complement this information.

Finally, we need to ensure we calibrate the spray equipment. Just as we check other machinery, (e.g. your car every 10,000 km and tractor every 1,000 hours) we also need to check our sprayer every year. When we calibrate we can be sure that the right amount of chemistry is hitting our target pest.





Avoiding resistance to pesticides

Resistance in an insect, mite or disease to a specific chemical has occurred when the chemical no longer provides the control it did previously. Populations of pests and diseases that are repeatedly sprayed with a particular chemical group can develop resistance to it. All populations contain a very small number of individuals that are resistant to a given pesticide. Continuing to use the pesticide kills susceptible individuals, but in doing so selects a strain that is increasingly composed of resistant forms. Once a critical proportion of a population is resistant, lack of control ultimately renders the chemical useless.

Resistance management

Managing resistance for all pesticides is now an important consideration when choosing a control strategy. One strategy used in resistance management is to rotate the chemical groups so that the weed, fungus, insect or mite is not being continually treated with the same type of chemical. Repeated treatment with the same chemical group could lead to the organism developing resistance to that group.

In the past, it has often been difficult for growers to distinguish between chemical groups and their different modes of action, a factor important in successful rotation. An identification scheme now exists for both herbicides and fungicides.

All registered pesticides have an activity group identification symbol on the label. This helps growers to choose a product from a different chemical activity group when seeking to rotate chemicals in a program.

Case study: Mites in macadamia

Other industries have shown that mites are particularly successful in developing pesticide resistance and have overcome virtually every miticide produced since the 1950s. This is certainly the case for macadamia whereby mites have recently become an issue due to certain effective broad spectrum chemicals becoming unavailable. The NSW DPI, funded by Horticulture Innovation Australia Limited, has been successful in achieving a permit for the industry for use on mites. The product active ingredient is Abamectin, which has a different mode of action (6) from other chemistry that will also have some effect on mite control. In order to achieve control and long-term value out of Abamectin, we need to consider chemical rotation of products used for other pests. i.e. regularly changing the mode of action. As an industry, we are limited for choice on miticides, which means that growers need to be more strategic about when to apply the product.

Decisions such as which flush would be most useful to protect? How bad is the damage and what are the other pests that might be targeted? become important options when considering long-term effective control.

Insecticides

Unfortunately the macadamia industry relies heavily on a limited number of chemistry of the same groups, being predominantly 1A and 1B. So the option of chemical rotation is limited. However, the option is there and must be used to prevent resistance to the few chemicals that are available to the industry. In the early stages of tree production, such as pre-flowering and flowering, pest options are limited to a range of 1B products. There should be a conscious decision at the later stages of nut development to use the available alternative options to 1B.

A typical scenario could be to spray lace bug early with a 1B product. Continue monitoring regularly for pests at this critical stage; there could be another requirement for a 1B product to be used around later flowering time. Then at premature nut drop, continue monitoring for fruit spotting bug. At this stage there is an opportunity to use a different chemical group, being 3A. Suggestions in the remarks column of the table in the Orchard pest and disease management priorities on page 24 help growers decide how to rotate their chemicals to avoid resistance. Ideally the industry needs to use available researchers to continually screen new chemical formulations as they become available. Not only will this screen the effectiveness of new formulations but will also identify ways that the new chemistry can be incorporated into the spray program system to achieve better IPM strategies.

Fungicides

Fungicide resistance arises because most of the newer fungicides are very specific in their effects on fungal cells. In any collection of spores, a very low number will be resistant to a specific fungicide. If we use the same fungicide over and over again, we allow these spores to multiply, while killing those which are susceptible to the chemical, until almost all of the spores are resistant to, and unaffected by, the fungicide. If we then use a fungicide with a different mode of action, we can control the new strain but damage to the crop is already done.

Avoiding fungicide resistance

Generally horticultural crops have a variety of fungicides from different chemical groups to prevent resistance build up. Unfortunately, in

macadamia there are limited options to prevent husk spot, which is the industry's main fungal concern.

Management strategies for husk spot control, including which chemicals should be used when to maintain resistance, have been developed by Olufemi Akinsanmi, plant pathologist at the University of Queensland. These strategies are outlined in Table 11.

The clear message is that there should be no more than two consecutive applications of the same chemical group in a row. This includes within season sprays one to four, and between season e.g. 4th spray to 1st spray the following year. Also, never rely solely on one type of fungicide for whole of season disease control, no matter how effective it seems; use at least two fungicides with different modes of action.

Specific recommendations for avoiding fungicide resistance are now shown on many labels and chemicals are now classified into groups. The principal groups adopted by the agrochemical industry through APVMA and CropLife Australia are shown in Table 12 and Table 13. Only fungicides recommended in this guide are shown.

Table 11. Spray strategy for the control of husk spot to avoid resistance.

Spray strategy	1st spray (match-head stage)	2nd spray (2–4 weeks after 1st spray)	3rd spray (2–4 weeks after 2nd spray)	4th spray (2–4 weeks after 3rd spray)
1	Carbendazim + copper	Carbendazim + copper	Cabrio only OR copper only	Copper only
2	Cabrio only	Cabrio only	Copper only OR Carbendazim + copper	Copper only OR Carbendazim + copper
3	Cabrio only	Carbendazim + copper	Cabrio only OR Carbendazim + copper OR copper only	Copper only
4	Carbendazim + copper	Cabrio only	Cabrio only OR copper only OR Carbendazim + copper	Copper only OR Carbendazim + copper

Table 12. Insecticide[1,2.]

Group	Chemical class	Common name	Example trade name*
1A	Carbamate	Carbaryl	Bugmaster Flowable®
		Methomyl	Lannate L®
1B	Organophosphate	Azinphos-methyl	Gusathion®
		Diazinon	Diazinon®
		Methidathion	Suprathion®
		Acephate	Lancer®
		Trichlorfon	Lepidex®
3A	Pyrethroid	Beta-cyfluthrin	Bulldock®
4C	Sulfoximines	Sulfoxaflor	Transform
5	Spinosyn	Spinetoram	Success Neo®
6	Acermectin	Abamectin	Vertimec®
11	Microbial	Bacillus thuringiensis	DiPel®
16A	Hydrazide	Tubufenozide	Mimic®
18	Diacylhydrazine	Methoxyfenozide	Prodigy®

Table 13. Fungicide groups[1,2.]

Group	Chemical class	Common name	Example trade name*
1	Benzimidazole	Carbendazim	Spin Flo®
2	Dicarboximide	Iprodione	Rovral®
3	Triazole	Difenoconazole	Score®
4	Phenylamide	Metalaxyl	Ridomil®
7	Pyrazole carboxamide	Penthiopyrad	Fontelis®
8	Hydroxypyrimidine	Bupirimate	Nimrod®
9	Anilinopyrimidine	Cyprodinil	Chorus®
		Fluquinconazole (3) + pyrimethanil	Vision®
11	Strobilurin	Pyroclostrobin	Cabrio
12	Phenylpyrrole	Fludioxonil	Scholar®
33/Y	Ethyl Phosphonate	Phosphoric acid	Phospot®
M1	Inorganic	Copper fungicides	Kocide®

[1] Trade names which include the common name are not listed. Source: www.apvma.gov.au and CropLife Australia.

[2] The information in the table shows insecticide groups based on mode of action only. For a chemical's compatibility with IPM please see the chemical listings for individual crops.

* Example only. Other products are registered.

Compatibility

Scott Herd

Northern AgriServices Casino

Hitting the target, the importance of understanding tank mixing and compatibility

Controlling pests and diseases well can mean the difference between producing a valuable, successful crop or a mediocre, disappointing outcome. Applying pesticides effectively requires some understanding of the pest, the product you are applying and the sprayer's ability to hit the target.

Many growers believe they can save money by applying a number of products in the one tank mix. However, this can present problems if the products are not compatible or compromise the efficacy of the products applied. A chemical applied to control macadamia lace bug can be compromised by adding fungicides and foliar fertilisers (which defeats the purpose of applying the insecticide in the first place).

You have to ask yourself, what am I trying to achieve? Do you want to do one or two things well, or simply tick the boxes and hope for the best? Better growers pay attention to detail.

If you are a farm manager, contractor or advisor, the grower will not measure your success by the number of products you have applied; they want a protected crop that produces a good yield.

It is critical that all growers and contractors read the label of the products they apply. Be aware that over time the instructions on product labels can change.

Checking spray tank water:

- what is the water source?
- is the pH (the measure of acidity/alkalinity) of the water stable?
- do you check it regularly? (simple pool test kits or pH test strips can be used).
- do you have adequate agitation in your spray tank?

When mixing products, a series of steps should be followed in order (Table 14) and remember 'dilution is the solution', always:

- add the product to water under agitation
- never add water to the product
- never mix products before adding to water.

If you are unsure about the compatibility of products (can they be mixed together and in what order should you put them in) you should read the label, ask your chemical supplier or contact the manufacturer.

A simple jar test (Table 15) can give some indication of whether products are physically compatible, but does not guarantee that you will not cause injury to the plant or that the mix will be effective against the desired targets. Once again, chemical suppliers, consultants or manufacturers might need to be contacted.

To conclude, remember to prepare well and understand:

- the target pest
- your equipment
- your use of products and techniques.

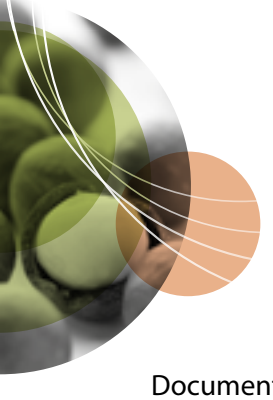
Always read product labels and adhere to the instructions.

Table 14. Multiple tank mix solutions guide.

Step 1	Fill the spray tank to at least 70% full. Run agitation
Step 2	Add any water conditioners e.g. acidifier
Step 3	Add any water-dispersable granualar products and allow 10 minutes or more for complete dispersion
Step 4	Add any suspension concentrate products
Step 5	Add any emulsifiable concentrate products
Step 6	Add any soluble liquid products
Step 7	Fill the spray tank to nearly full
Step 8	Add any adjuvants
Step 9	Fill the tank

Table 15. A simple jar test to check for compatibility.

	Final quantity	Option one	Option two	Option three	Option four
Tank mix	50 L	8 L	20 L	500 mL	40 mL
Jar test	1 L	160 mL	400 mL	10 mL	0.8 mL
Tank mix	100 L	8 L	20 L	500 mL	40 mL
Jar test	1 L	80 mL	200 mL	5 mL	0.4 mL
Tank mix	200 L	8 L	20 L	500 mL	40 mL
Jar test	1 L	40 mL	100 mL	2.5 mL	0.2 mL
Tank mix	500 L	8 L	20 L	500 mL	40 mL
Jar test	1 L	16 mL	40 mL	1 mL	0.08 mL
Tank mix	1000 L	8 L	20 L	500 mL	40 mL
Jar test	1 L	8 mL	20 mL	0.5 mL	0.04 mL



Example of spray record document

Documents are required by quality assurance (QA) programs to provide evidence that the produce is safe and of acceptable quality. Types of documents include records of pesticide applications, orchard sprayer calibration and a spray diary.

How to fill out your pesticide application record

Records must be kept for three years. Records should be made within 24 hours of the application. Records must be in English.

General information

Operator

The operator, or person applying the pesticide, must fill in their contact details. If the operator is not the owner, e.g. a contractor or employee, then the owner's details also have to be filled in. In the case of a contractor, one copy of the record should be kept by the applicator and another given to the owner.

Date of application, start time, finish time

You must record the date, the time of the day you started and the time when you finished.

Crop details

Crop sprayed

Adding details such as crop variety and growth stage are often important for QA schemes, but might also be necessary to positively identify the area treated.

Block/area name and size of block sprayed

Identify the block/area and order of treatment (if there is more than one) in the 'Block/area' and 'Size of block sprayed' boxes on the form. This should be filled in before starting application, along with the residential address. If using a contractor or an employee, this information should also be given to them before they start the job. Applicators using GPS could include a GPS reading as well as the block number/name.

Product/application details

Pest/disease targeted

It is desirable to identify the targeted pest or disease. It is helpful to provide as much detail about the pest or disease as possible, e.g. for a grub: 3rd instar/10 mm.

Equipment used

As a minimum, you have to fill in what equipment you used. Specifying the settings (e.g. nozzle type and angle, pressure) used will help identify the equipment used. The nozzle type will usually include the angle. With pressure, the reading should be as close to the nozzle as possible. Other details are useful as a reminder for future use; as a check on your set-up should you have a treatment failure, e.g. date of calibration and water quality. Water quality is important for herbicide efficacy. At the most basic level, water quality can be described in terms of its source, e.g. rainwater, dam water, bore water.

Product used

The product name and rate/dose should be transcribed from the label. For tank mixes, include all products in the mixture. If the use pattern is on permit, you must read the permit. It is recommended you include the permit number and expiry date as well as the label details. The permit rate/dose can vary from that on the label. Do not forget to include the label product name.

Amount of concentrate used and total quantity of spray applied

The water rate might come from the label, from your standard practice or as a result of your calibration. If additives or wetters are included in the mixture, it is helpful to note these. The total L or kg can be calculated when the application is finished.

Weather conditions

Wind speed and wind direction (changes to wind speed direction)

As a minimum, you need to record wind speed and direction. This is better measured with instruments than estimated. Record any changes during application. Weather records have to be made for all equipment that distributes pesticide through the air.

Other comments

Rainfall should be recorded for the 24 hours before and after application, unless a different figure is given in the restraints or critical comments section of the label. Rainfall before or after application can affect efficacy.

Temperature and relative humidity should also be recorded, particularly if either or both are referred to in the restraints or critical comments sections of the label. Temperature and relative humidity can affect efficacy, increase the risk of off-target drift or can damage the host (e.g. phytotoxicity) or a combination of all three.

If there are sensitive areas, either on the property or land adjoining, these should be identified in advance, and marked on a sensitive areas diagram that should be appended to the Pesticide application record sheet, together with any precautions or special instructions. When using a contractor or giving the job to an employee, this section should be filled in and given to the person doing the application before the job starts. The property map with sensitive areas marked should be shown to them, and the job fully discussed.

CUT HERE

Pesticide Application Record Sheet

(To be completed within 24 hours of spraying and kept for 3 years)

General information		
Operator (See note at bottom of sheet):*		
Date of application:	*Start time:*	*Finish time:*
Crop Details		
Crop sprayed:	*Block/Area name and address:*	*Size of block sprayed:*
Product/Application Details		
Product used:		
Pest/Disease targeted:	*Equipment used:*	
Amount of concentrate used (indicate either the label rate or the total amount used):	*Total quantity of spray applied (in ha or m^2):*	*Total area of application:*
Weather Conditions		
Wind speed:	*Wind direction:*	
Did weather conditions change during spraying? ☐ *No* ☐ *Yes (Give details)*		
Other comments:		

*Operator: If it is the property owner you need to record name, address and contact details. For an employee you need to record name and employer details and for a contractor you need name, address and contact detalis. On this record you can record the name only, as long as you have the other details recorded elsewhere.

Sample pesticide record sheet

On the previous page is an example of a pesticide record sheet. It includes all categories that should be filled out when applying agricultural chemicals.

We encourage you to cut out this sheet and photocopy it ready for filling in each time you spray. The filled in sheet can then be filed as a record of your spray activity.

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Permits

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT

FOR PROMOTION OF NUTFALL IN MACADAMIAS

PERMIT NUMBER - PER11462

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 7 MAY 2009 TO 30 JUNE 2020.

Permit Holder:
AUSTRALIAN MACADAMIA SOCIETY LTD
Suite 1/113 Dawson St
LISMORE NSW 2480

Persons who can use the product under this permit:
Persons generally.

CONDITIONS OF USE

Products to be used:
ETHIN GROWTH REGULATOR
K-ETHEPHON GROWTH REGULATOR
Plus OTHER REGISTERED PRODUCTS
Containing: 480g/L ETHEPHON as their only active constituent.

Directions for Use:

Crop	Purpose	Rate
MACADAMIAS (DO NOT use on variety Teddington)	PROMOTE NUTFALL AFTER MATURITY REACHED	65 - 250 mL /100 L water Refer critical use comments below

Critical Use Comments:

- DO NOT spray trees if they are stressed.
- DO NOT spray close to flowering or after flower buds have begun to expand.
- Spray at the first sign of natural nut drop. Ethephon is more effective if used when natural abcission has begun. Applications should be made before the end of May.
- Add a non-ionic wetter at 20 mL / 100 L (e.g. *Agral Spray Adjuvant*). As an alternative to non-ionic wetter, an adjuvant such as *Spraytech Oil Multipurpose Spray Adjuvant* can be added at 125 mL/100 L-water. Addition of urea at 70 g/100 L-water can be useful for some varieties.
- Many varieties require 150 - 200 mL/ 100 L. However, cultivars 842 and 814 seem to be more sensitive and so require a lower rate of 65 - 100 mL / 100 L. The higher rates may be required for colder climates and less responsive cultivars such as A16.

Withholding Period:
DO NOT harvest for 7 DAYS after application.

Jurisdiction:
NSW, QLD, NT & WA only.

Additional Conditions:

This PERMIT provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.

To Avoid Crop Damage:
The sensitivity of some varieties to be treated under this permit has not been fully evaluated. It is advisable, therefore, to only treat a small number of plants to ascertain their reaction before treating the whole crop.

Issued by the Australian Pesticides and Veterinary Medicines Authority

Note:
17/04/2015. Permit expiry date extended to 30/06/2020. Issued as version 2.

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT

FOR CONTROL OF FELTED COCCID IN MACADAMIA NUT PLANTATIONS

PERMIT NUMBER – PER11635

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 01 JULY 2010 TO 30 JUNE 2020

Permit Holder:
AUSTRALIAN MACADAMIA SOCIETY LTD
Suite 1/113 Dawson St
LISMORE NSW 2480

Persons who can use the product under this permit:
Persons generally

CONDITIONS OF USE

Product to be used:
(NOTE: PRODUCTS TO BE USED INCLUDE ONLY THOSE REFERRED TO AS SUMMER SPRAY OILS.)

ALL REGISTERED PRODUCTS CONTAINING BETWEEN 763 AND 861 g/L PETROLEUM OIL AS THEIR ONLY ACTIVE CONSTITUENT.
INCLUDING THOSE DESCRIBED AS PARAFFINIC OIL AND MINERAL OIL.

Directions for Use:

RESTRAINTS

- **DO NOT** apply when temperatures exceed 32 degrees Celsius or when soil is dry and trees are suffering from moisture stress.
- **DO NOT** apply product during flowering.
- Tank agitation is required to ensure product remains in suspension.
- Thorough coverage in essential. Apply to the point of run off ensuring thorough coverage.
- Apply only as dilute spray application using ground based application equipment.

Crop	Pest	Rate
Macadamia Nut (*Macadamia* species)	Macadamia Felted Coccid (*Eriococcus ironsidei*)	Apply 1 L product per 100 L water

Withholding Period:
Not required when used as directed.

Jurisdiction:
QLD and NSW only.

Additional Conditions:

This PERMIT provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.

PERSONS who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the DETAILS and CONDITIONS of this permit.

To Avoid Crop Damage:
The sensitivity of some species and varieties of the crops to be treated under this permit has not been fully evaluated. It is advisable, therefore, to only treat a small number of trees to ascertain their reaction before treating the whole crop.

Issued by the Australian Pesticides and Veterinary Medicines Authority
Note: 17/04/2015 – permit expiry date extended to 30 June 2020, issued as version 2

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT

FOR CONTROL OF BANANA FRUIT CATERPILLAR IN MACADAMIA ORCHARDS

PERMIT NUMBER - PER12796

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 22 JULY 2011 to 30 JUNE 2021

Permit Holder:
AUSTRALIAN MACADAMIA SOCIETY LTD
Suite 1/113, Dawson Street
LISMORE NSW 2480

Persons who can use the product under this permit:
Persons generally.

CONDITIONS OF USE

Product to be used:
DUPONT MARLIN INSECTICIDE
Plus ALL OTHER REGISTERED PRODUCTS
Containing: 225 g/L METHOMYL as their only active constituent.

Directions for Use:

Crop	Insect Pest	Rate
MACADAMIA	Banana Fruit Caterpillar (*Tiracola plagiata*)	1.5-2.0 L/ha Spraying ground mulch/soil surface up to treelines only

Critical Use Comments:
- Ground surface treatment only using spray boom or equivalent application equipment.
- Apply one application only during late flowering/early fruit development.
- Time spray to coincide when larvae activity is initially observed.
- Ensure thorough coverage of all leaf litter and soil surface along treeline.
- Use higher rate when large larvae or higher numbers are present.
- DO NOT spray tree foliage, flowers or developing nutlets.

Withholding Period:
Not required when used as directed.

Jurisdiction:
QLD only.

Additional Conditions:

THIS PERMIT provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.

PERSONS who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the details and conditions of this permit.

Export of produce:
To allow treated produce to be supplied or otherwise made available for human consumption the APVMA has established a temporary Maximum Residue Limit (MRL) at T1.0 mg/kg for methomyl on macadamia nuts. This temporary MRL applies only to produce marketed and consumed in Australia. Therefore if treated produce is to be exported, due account should be taken of the residue definition and residue limits/import tolerances of importing countries and that any residues must not exceed those requirements of the importing country.

Issued by the Australian Pesticides and Veterinary Medicines Authority

Note:
09/02/2016. Expiry date extended to 30/06/2021. Issued as version 2.

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT FOR THE CONTROL OF AUSTRALIAN PLAGUE LOCUST IN TREE NUT ORCHARDS

PERMIT NUMBER - PER13642

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 1 SEPTEMBER 2012 TO 30 JUNE 2025.

Permit Holder:
AUSTRALIAN NUT INDUSTRY COUNCIL
C/O Horticulture Innovation Australia Limited
87 Wickham Terrace
Spring Hill, QLD 4000

Persons who can use the product under this permit:
Persons generally

CONDITIONS OF USE

Product to be used:
CONQUEST CHLORPYRIFOS 500 INSECTICIDE
LORSBAN 500 EC INSECTICIDE
NUFARM CHLORPYRIFOS 500 EC INSECTICIDE
DAVID GRAYS CHLORPYRIFOS 500
PLUS OTHER REGISTERED PRODUCTS
Containing: 500 g/L CHLORPYRIFOS as their only active constituent.

FYFANON 440 EW INSECTICIDE
PLUS OTHER REGISTERED PRODUCTS
Containing: 440 g/L MALDISON as their only active constituent.

NUFARM MALDISON 500 INSECTICIDE
PLUS OTHER REGISTERED PRODUCTS
Containing: 500 g/L MALDISON as their only active constituent.

FYFANON 1000 EC INSECTICIDE
PLUS OTHER REGISTERED PRODUCTS
Containing: 1000 g/L MALDISON as their only active constituent.

HY-MAL INSECTICIDE
PLUS OTHER REGISTERED PRODUCTS
Containing: 1150 g/L MALDISON as their only active constituent.

Directions for Use:

Crops	Pest	Rate	Critical Use Comments
TREE NUTS Including: almonds, chestnuts hazelnuts, macadamias pecans, pistachio and walnuts	**AUSTRALIAN PLAGUE LOCUST** (*Chortoicetes terminifera*)	Chlorpyrifos 500 g/L product: 350 mL/ha Maldison 440 g/L product: 1.4 or 1.9 L/ha Maldison 500 g/L product: 1.2 or 1.7 L/ha Maldison 1000 g/L product: 600 or 850 ml/ha Maldison 1150 g/L product: 520 or 750 mL/ha	**All Tree nuts:** Apply to pasture, soil, crop edge or inter row ONLY using ground-based boom spray rig or equivalent application equipment. Concentrate on spraying large pest numbers at the nymph stage, commonly located in roadside areas and headlands. Use the lower rates for small hoppers and the higher rates for large hoppers and adults. DO NOT use misters or aerial application. DO NOT spray tree foliage or spray in close proximity to tree apron. DO NOT spray near beehives or if bees are foraging. If grazing is to occur in treated areas, the withholding periods outlined below must be observed. **Hoppers** – spray (ground only) a swath in advance of marching band and then spray along the dense marching front. Continue spraying until all hoppers have been contacted. **Adults** – spray (ground only) area in and around crop infested with locusts. Repeat applications as necessary. **Almonds, Pecans, Pistachio and Walnuts:** DO NOT apply to the orchard floor between the beginning of hull split and end of the harvest period. **Chestnuts:** DO NOT apply to the orchard floor between the beginning of burr split and end of the harvest period. **Hazelnuts:** DO NOT apply to the orchard floor if shells have cracked or between the beginning of nut fall and end of the harvest period. **Macadamia:** DO NOT apply to the orchard floor between the beginning of nut fall and end of the harvest period.

Jurisdiction:

ACT, NSW, NT, QLD,SA, TAS,WA only.

Note: Victoria is not included in this permit because their 'control-of-use' legislation means that a permit is not required to legalise this off-label use.

WITHHOLDING PERIODS
(HARVEST, GRAZING, EXPORT INTERVALS)

HARVEST (ALL CROPS)

CHLORPYRIFOS: DO NOT HARVEST FOR 30 DAYS AFTER APPLICATION.
Note: This withholding period is enforced where chlorpyrifos products are used to spray the orchard floor (i.e. inter-rows only). A withholding period does not apply where spray treatment is restricted to the perimeter of the orchard (i.e. perimeter fence lines, roadside verges and headlands). The critical use comments listed in Directions for Use for spray treatment of the orchard floor must be adhered to where the specified period exceeds 30 days.
MALDISON: NOT REQUIRED WHEN USED AS DIRECTED.

GRAZING TREATED AREAS FOR DOMESTIC & EXPORT MARKETS & FOR LIVESTOCK PRODUCING MILK FOR HUMAN CONSUMPTION

LIVESTOCK DESTINED FOR THE DOMESTIC MARKET & LIVESTOCK PRODUCING MILK FOR HUMAN CONSUMPTION:
CHLORPYRIFOS & MALDISON: DO NOT GRAZE OR CUT FOR STOCK FOOD TREATED AREAS FOR TWO (2) DAYS AFTER APPLICATION.
OR
If over-spraying of grazing livestock is unavoidable and does occur, withhold stock from slaughter until the Export Grazing Interval (EGI) or Export Slaughter Interval (ESI) is met.

LIVESTOCK DESTINED FOR EXPORT MARKETS:
The above withholding periods for grazing or cutting for stock food only applies to stock slaughtered for the domestic market. Some export markets apply different standards. To meet these standards, ensure that the Export Slaughter Interval (ESI) or the Export Grazing Interval (EGI) stated below for the relevant chemical product used is observed before stock are sold or slaughtered.

EXPORT SLAUGHTER INTERVALS[1] (ESI):
CHLORPYRIFOS: Livestock that have been grazing on or fed treated material from treated areas and/or over-sprayed with products containing chlorpyrifos should be placed on clean feed for 56 days (8 weeks) prior to export slaughter.

EXPORT GRAZING INTERVAL[2] (EGI):
CHLORPYRIFOS: Livestock that have been grazing on treated crops and/or over-sprayed with products containing chlorpyrifos should not be sold for export slaughter for 56 days (8 weeks) after application of the chemical product, unless the Export Slaughter Interval has been observed.

No ESI or EGI are available for areas treated with MALDISON and livestock management MUST adhere to the requirements of the above withholding periods.

Note 1. The ESI is the minimum period that must elapse between removal of grazing livestock to clean pasture or clean feed and slaughter.

Note 2. The EGI is the minimum period that must elapse between the application of the chemical product and slaughter of the stock, where grazing has continued on the crop from the time that the chemical product was applied.

ADDITIONAL INFORMATION:

These chemicals may persist on dry pasture (or in harvested and stored animal feed, e.g. hay) for long periods. Livestock fed on pastures that were treated when drying off or while dry, may have residues at levels unacceptable to our overseas markets. Similarly, feeds harvested from pastures or crops treated when drying off or while dry, may have unacceptable levels of residues. The pasture, or crop, must be regarded as contaminated until such time as there has been substantial re-growth (i.e. following good rains or the autumn break).

Livestock grazing or receiving contaminated feed should be managed in accordance with the Export Intervals described above. If further advice is required, contact your local State Department of Agriculture or Primary Industries, or the Australian Pesticides and Veterinary Medicines Authority (APVMA).

VENDOR DECLARATION:

Vendors may use Question 9 on the NVD (Cattle) or Question 7 on the NVD (Sheep) to confirm to buyers that the stock have been managed in accordance with the requirements of Permit PER13075.

Additional Conditions:

THIS PERMIT provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label, including:

- Mixing
- Application
- Protection of Livestock
- Protection of Wildlife, Fish, Crustacea & Environment
- Restraints
- Storage & Disposal
- Safety Directions
- First Aid

PERSONS who wish to prepare for use and/or use the products for the purposes specified in this permit must read, or have read to them, the permit particularly the information included in Details of permit and Conditions of Permit.

Issued by the Australian Pesticides and Veterinary Medicines Authority

Version 2: issued 24/4/15 extending expiry date until 30 June 2025 to align duration with other current locust eradication permits

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT TO CONTROL, LACE BUG, FRUIT SPOTTING BUG, BANANA SPOTTING BUG AND GREEN VEGETABLE BUG ON MACADAMIAS

PERMIT NUMBER - PER13689

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 14 MAY 2013 TO 30 SEPTEMBER 2021.

Permit Holder:
AUSTRALIAN MACADAMIA SOCIETY LIMITED
C/- HORTICULTURE INNOVATION AUST LTD
PO BOX 12996, GEORGE STREET
BRISBANE QLD 4003

Persons who can use the product under this permit:
Persons generally.

CONDITIONS OF USE

Products to be used:
DIPTEREX 500 SL INSECTICIDE
PLUS OTHER REGISTERED PRODUCTS
Containing: 500 g/L TRICHLORFON as their only active constituent.

Directions for Use:

Crop	Pest	Rate
Macadamia nut	Macadamia Lace Bug, Fruit spotting bug, Banana spotting bug and Green vegetable bug.	200 mL/100 L

Critical Use Comments:

- Monitor crops and commence applications once local thresholds are reached
- Apply a maximum of 4 applications at a minimum of 14 day intervals
- Apply to point of run off ensuring complete penetration and coverage of the tree canopy
- DO NOT apply to plants in flower, while bees are foraging. Treat in the late afternoon after bees have finished foraging.

Withholding Period:
DO NOT HARVEST FOR 2 DAYS AFTER APPLICATION

Jurisdiction:
NSW, QLD only.

Additional Conditions:
THIS PERMIT provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.

PERSONS who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the details and conditions of this permit.

Issued by the Australian Pesticides and Veterinary Medicines Authority.
Version 2: issued 5 August 2013 to include lace bug.
Version 3: issued 14 May 2014 to reduce WHP from 14 weeks to 2 days
Version 4: issued 30th August 2016 to extend expiry date and update products to include all registered 500g/L Trichlorfon products.

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT

FOR CONTROL OF MACADAMIA LACE BUG IN MACADAMIA PLANTATIONS

PERMIT NUMBER - PER14276

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 1 DECEMBER 2013 TO 30 NOVEMBER 2020.

Permit Holder:
AUSTRALIAN MACADAMIA SOCIETY LTD
c/- HORTICULTURE AUSTRALIA LIMITED
PO Box 12996 George St
BRISBANE QLD 4003

Persons who can use the product under this permit:
Persons generally.

CONDITIONS OF USE

Product to be used:
FARMOZ DIAZOL 800 INSECTICIDE
COUNTRY DIAZINON 800 INSECTICIDE
PLUS OTHER REGISTERED PRODUCTS
Containing: 800 g/L DIAZINON as their only active constituent

Directions for Use:

Crops	Insect Pests	Rate
MACADAMIA Plantations	Macadamia Lace Bug (*Ulonemia concava* and *Physatochelia spp*)	120 mL product / 100 L

Critical Use Comments:

- Apply at pre-flowering, immediately prior to main flower opening. Repeat spray treatment (if required) prior to second flower opening.
- Ensure spray application provides thorough coverage of all foliage and racemes.
- Ground-based application only, using suitable air-blast sprayer or equivalent.
- Diazinon is HIGHLY TOXIC to bees and other beneficial insects. DO NOT spray trees while bees are actively foraging. Apply spray in the late-afternoon or early evening.
- Diazinon residues on flowers can remain dangerous to bees for up to 1 week post-application.
- Refer to the diazinon label for further precautions that need to be observed to ensure safe and effective use of the product.
- Use in accordance with current Integrated Pest Management (IPM) strategies and in accordance with best practice.

Withholding Period:
Harvest: DO NOT harvest for 14 DAYS after final application.
Grazing: DO NOT graze or cut treated areas for stockfeed for 14 DAYS after final application.

Jurisdiction:
NSW, QLD and WA only.

Additional Conditions:

THIS PERMIT provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.

PERSONS who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the details and **CONDITIONS** of this permit.

Other matters:
Approval is granted on the condition that it is subject to any relevant outcomes from the diazanon review. Users should be aware that the APVMA will take steps to apply relevant review outcomes to any approved permits.

Issued by the Australian Pesticides and Veterinary Medicines Authority.
Note: 30 September 2015; Version 2 issued; expiry date extended until 30 November 2020.

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT

FOR THE CONTROL OF MACADAMIA LACE BUG IN MACADAMIA

PERMIT NUMBER - PER14852

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 21 AUGUST 2014 TO 31 MARCH 2019.

Permit Holder:
AUSTRALIAN MACADAMIA SOCIETY LIMITED
C/O HORTICULTURE AUSTRALIA LIMITED,
Suite 2, Level 5
87 Wickham Terrace
BRISBANE QLD 4000

Persons who can use the product under this permit:
Persons generally.

CONDITIONS OF USE

Product to be used:
PYGANIC ORGANIC INSECTICIDE
Containing: 13 g/L PYRETHRINS as its only active constituent.

Directions for Use:

Crop	Pest	Rate
Macadamia nuts	Macadamia lace bug (*Ulonemia* spp.)	200 mL/100 L Apply to the point of runoff to a maximum of 4 L/ha

Critical Use Comments:

- Apply at first sign of infestation, pre-flowering, immediately prior to main flower opening. Repeat spray treatment (if required) prior to second flower opening, continuing to nut set if pressure persists. Commonly July-October.
- Apply a maximum of 5 applications per crop with a minimum of 7 days between applications.

Withholding Period:
Harvest: Do not harvest for 1 day after application.

Jurisdiction:
ALL States except VIC.
Note: Victoria is not included in this permit as that State's *Control of Use* legislation does not require a permit to be issued to cover this use.

Additional Conditions:
This Permit provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.

Persons who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the details and conditions of this permit.

Export of Produce:
Exported produce must have appropriate residue tolerance limits established in the importing countries and any residues must not exceed the tolerance limits. Growers are advised that before using this product that tolerances established in export markets should be verified to ensure that any residues resulting from use under this permit do not exceed tolerances established in export markets.

Issued by

Delegated Officer

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT

FOR CONTROL OF MITES AND THRIPS IN MACADAMIAS

PERMIT NUMBER – PER81162

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 28 OCTOBER 2015 TO 31 OCTOBER 2018

Permit Holder:
AUSTRALIAN MACADAMIA SOCIETY LIMITED
Suite 1/113 Dawson Street
LISMORE NSW 2480

Persons who can use the product under this permit:
Persons generally.

CONDITIONS OF USE

Products to be used:
VERTIMEC MITICIDE/INSECTICIDE
PLUS OTHER REGISTERED PRODUCTS
Containing: 18 g/L ABAMECTIN as their only active constituent.

VANTAL UPGRADE MITICIDE/INSECTICIDE
PLUS OTHER REGISTERED PRODUCTS
Containing: 36 g/L ABAMECTIN as their only active constituent.

Directions for Use:

Crop	Insect Pest	**Rate**
MACADAMIAS	Thrips (*Scirtothrips* spp.) Broad mites (*Brevipalpus* spp.) Flat mites (*Polyphagotarsonemus* spp.)	18 g/L abamectin product: 750 mL product / ha Plus 5 L summer spray oil / ha 36 g/L abamectin product: 375 mL product / ha Plus 5 L summer spray oil / ha

Critical Use Comments:
- Make no more than one (1) spray application per season. Abamectin should not be applied in two (2) consecutive seasons without a chemical from a different MoA Group being used in between.
- Apply in July as protection for the spring flush, or in December as protection for the summer flush.
- Apply via orchard airblast/mister sprayer applying sufficient water to obtain thorough and uniform coverage of foliage and branches. May be applied in dilute or concentrate sprays, but in not less than 1,000 L/ha.
- Use in accordance with existing insecticide resistance management strategies and in accordance with best practice.
- DO NOT use if rainfall is expected before spray has dried as this may result in reduced efficacy.
- Dangerous to bees. DO NOT spray trees during flowering, while bees are foraging.

Withholding Period:
DO NOT harvest for 28 DAYS after application.

Jurisdiction:
ALL STATES, except VIC.
Note: Victoria is not included in this permit, as their *Control-of-Use* legislation does not require a permit to legalise this off-label use in this state.

Additional Conditions:

This PERMIT provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.

PERSONS who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the details and conditions of this permit.

To Avoid Crop Damage:
The sensitivity of some macadamia nut varieties to be treated under this permit has not been fully evaluated under all growing conditions. It is advisable, therefore, to only treat a small number of trees to ascertain their reaction before treating the whole crop.

Export of Treated Produce:
To allow treated produce to be supplied or otherwise made available for consumption, the following Temporary Maximum Residue Level (TMRL) has been established for abamectin:

Macadamia nuts T*0.01 mg/kg

This TMRL limit applies only to produce marketed and consumed in Australia. Where abamectin treated produce is to be exported, due account should be taken of the residue definition and residue limits/import tolerances of importing countries, and that any residues must not exceed those requirements of the importing country.

Issued by the Australian Pesticides and Veterinary Medicines Authority

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT

FOR THE CONTROL OF SIGASTUS WEEVIL IN MACADAMIA

PERMIT NUMBER - 81463

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 24 DECEMBER 2015 TO 31 JANUARY 2021.

Permit Holder:
AUSTRALIAN MACADAMIA SOCIETY LTD.
C/- HORTICULTURE AUSTRALIA LIMITED
SUITE 1/113
DAWSON STREET
LISMORE NSW 2480

Persons who can use the product under this permit:
Persons generally.

CONDITIONS OF USE

Product to be used:
LANCER 970 INSECTICIDE
PLUS OTHER REGISTERED PRODUCTS
Containing: 970 g/kg ACEPHATE as their only active constituent.

LANCER 750 DF INSECTICIDE
Containing: 750 g/kg ACEPHATE as their only active constituent.

Directions for Use:

Crop	Pest	Rate
Macadamia nuts	Sigastus weevil (*Sigastus* spp.)	**970 g/kg product** 80 g/100 L **750 g/kg product** 100 g/100L

Critical Use Comments:

- Apply a maximum of 3 applications per season using an air-blast sprayer with a minimum re-treatment interval of 14-21 days.
- Make the first application when nuts are pea sized using a spray volume of 500 to 1000 L/ha.
- Apply with sufficient water to obtain thorough and uniform coverage of foliage and branches.

Withholding Period:
Harvest: Not required when used as directed.

Jurisdiction:
NSW and QLD only.

Additional Conditions:
This Permit provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.

Persons who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the details and conditions of this permit.

Issued by the Australian Pesticides and Veterinary Medicines Authority

Australian Government
Australian Pesticides and Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT

TO CONTROL PHYTOPHTHORA TRUNK CANKER IN MACADAMIA TREES

PERMIT NUMBER – PER84766

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 30 NOVEMBER 2017 TO 30 NOVEMBER 2022

Permit Holder:
AUSTRALIAN MACADAMIA SOCIETY LIMITED
c/- HORTICULTURE INNOVATION AUSTRALIA LTD
Level 8, Chifley Square
SYDNEY NSW 2000

Persons who can use the product under this permit:
Persons generally.

CONDITIONS OF USE

Products to be used:

COUNTRY PHOSPOT 400 SYSTEMIC FUNGICIDE
Plus other REGISTERED PRODUCTS
Containing: 400g/L PHOSPHOROUS ACID as their only active constituent.

AGRI-FOS 600 SYSTEMIC FUNGICIDE
Plus other REGISTERED PRODUCTS
Containing: 600g/L PHOSPHOROUS ACID as their only active constituent.

SPRAYPHOS 620 SYSTEMIC FUNGICIDE
Plus other REGISTERED PRODUCTS
Containing: 620 g/L PHOSPHOROUS ACID as their only active constituent.

AGRI-FOS 625 SYSTEMIC FUNGICIDE
Plus other REGISTERED PRODUCTS
Containing: 625 g/L PHOSPHOROUS ACID as their only active constituent.

Directions for Use:

Crop Type	Plant Disease	Product & Application Rate
MACADAMIA TREES	Phytophthora root rot and Trunk (stem) canker (*Phytophthora cinnamomi*)	**Foliar Spray** 400 g/L product: 250 - 300 mL / 100 L 600 g/L product: 170 - 200 mL / 100 L 620 g/L product: 160 – 190 mL / 100 L 625 g/L product: 160 – 190 mL / 100 L
		Trunk Application 400 g/L product: 500 mL / 1 L 600 g/L product: 334 mL / 1 L 620 g/L product: 323 mL / 1 L 625 g/L product: 320 mL / 1 L + Bark penetrant such as Pulse applied at a rate of 2 % v/v with trunk application.

Critical Use Comments:

Foliar Application

- Apply to affected macadamia trees at mature leaf flush during Spring and Autumn.
- Apply to each leaf flush if disease persists during the production season.
- DO NOT apply to young leaf flush, as phosphorous acid may burn young foliage.
- Apply spray to the point-of-runoff, ensuring all leaves and branches are covered.
- Apply a maximum two (2) applications per crop with a minimum re-treatment interval of 28 days.
- Apply using a spray volume of 2,000 – 3,000 L/ha for mature trees (depending on tree size) OR 7.5 – 10 L of solution per tree.
- Apply using air-blast sprayer or equivalent equipment.
- DO NOT apply to trees under severe water stress or during very hot weather.

Trunk Application

- Apply to affected macadamia trees at root flush and 28 days after root flush.
- Apply a maximum two (2) applications per crop with a minimum re-treatment interval of 28 days.
- Apply by dilute spray to the point-of-runoff around the trunk to approximately 1 m above soil level, ensuring thorough coverage around the entire trunk.
- Trunk is to be wet at the time of application.
- Apply using knapsack sprayer or equivalent equipment.
- Bark penetrant such as Pulse or similar is to be applied at a rate of 2 % v/v.

Withholding Period:
Harvest: DO NOT harvest for 14 DAYS after application.

Jurisdiction:
NSW, QLD and WA only.

Additional Conditions:

This Permit provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.

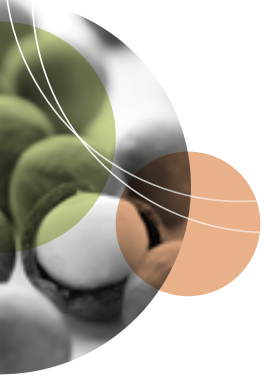
Persons who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the Details and Conditions of this permit.

RESIDUES:
To allow produce from treated plants or animals to be supplied or otherwise made available for human or animal consumption the APVMA has established the following temporary maximum residue limits (TMRLs):

TN 0085 Tree nuts T3000 mg/kg

EXPORT OF PRODUCE:
The use of phosphorous acid may result in detectable residues in macadamias and export markets may not have suitable residue tolerances in place.

Issued by the Australian Pesticides and Veterinary Medicines Authority
Note: Permit amended to change maximum no. of applications, the TMRL and permit holder address. Permit version 3 issued 28 August 2017.



Keeping glyphosate resistance rare in Australian orchards and vineyards

Table 16. Tip the scales in your favour to minimise the risk of glyphosate resistance.

	Risk increasing	Risk decreasing
Orchards and Vineyards	Continuous reliance on glyphosate knockdown as a control agent under tree or under vine	Strategic use of alternative knockdown groups
	Lack of use of alternative herbicide modes of action, including residual herbicides	Use of alternate herbicide modes of action including residual herbicides
	Lack of non herbicide weed control methods e.g. mowing, mulching, tillage or grazing	Using a double knock – full glyphosate rate followed by tillage or a full label rate of paraquat (Group L)
	Allowing weed control escapes to set seed	Adoption of non-herbicide practices for weed control e.g. mowing, mulching, tillage or grazing
	Entering the cropping phase with high weed numbers	Preventing weed control escapes from setting seed
	Poor farm hygiene (machinery and stock coming onto farm) which leads to movement of resistant seed	Entering the cropping phase with low weed numbers
	Lack of crop competition on weeds	Ensuring that all machinery and stock coming onto farm are 'clean'
		Utilising cover crops to compete with weeds
All group M herbicides are glyphosate herbicides		

AUSTRALIAN Glyphosate Sustainability Working Group

If you suspect glyphosate resistance, further information, industry contacts and testing services are detailed on the website of the Australian Glyphosate Sustainability Working Group (www.glyphosateresistance.org.au)

This information on glyphosate resistance has been produced by the Australian Glyphosate Sustainability Working Group, a collaborative initiative aimed at promoting the sustainable use of glyphosate in Australian agriculture.

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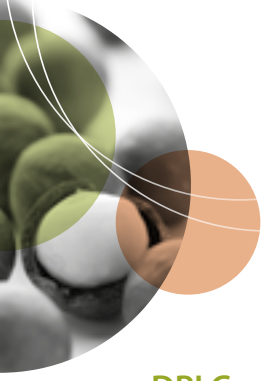


Key Contacts

DPI Contacts

Coffs Harbour
Anne Webster (Senior Inspector, Regulatory)
p: 6650 3111 m: 0427 102 253 f: 6651 2780
Coffs Harbour District Office (Agriculture)
76 Harbour Drive COFFS HARBOUR NSW 2450

Grafton
Stephen Green
p: 6640 1618 m: 0438 977714
Private Mail Bag 9002 Grafton NSW 2460

Tocal
David Deane
p: 4939 8944 m: 0411 108 961 f: 4939 8961

Genevieve Leonard
p: 4939 8955 m: 0427 208 615 f: 4939 8961

Tocal Agricultural Centre
Tocal Road PATERSON NSW 2421

Wagga Wagga
Adrian Knobel
p: 6938 1977 m: 0427 022 579 f: 6938 1995
Wagga Wagga Agricultural Institute
Pine Gully Road WAGGA WAGGA NSW 2650
(Private Mail Bag Wagga Wagga NSW 2650)

Wollongbar
Kathy Goulding
p: 6626 1345 m: 0407 175 043 f: 6626 1122
Wollongbar Primary Industries Institute
1243 Bruxner Highway Wollongbar NSW 2480

Blueberries
Melinda Simpson, Development Officer
e: melinda.simpson@dpi.nsw.gov.au
p: 6626 1350 m: 0447 081 765 f: 6628 1744
Wollongbar Primary Industries Institute
1243 Bruxner Highway WOLLONGBAR NSW 2477

Macadamias
Jeremy Bright, Development Officer
e: jeremy.bright@dpi.nsw.gov.au
p: 6626 1346 m: 0427 213 059 f: 6628 1744
Wollongbar Primary Industries Institute
1243 Bruxner Highway WOLLONGBAR NSW 2477

Temperate Fruits
Kevin Dodds, Development Officer
e: kevin.dodds@dpi.nsw.gov.au
p: 6941 1405 m: 0427 918 315 f: 6947 4149
Tumut District Office
64 Fitzroy Street TUMUT NSW 2720

Southern Horticulture Leader
Myles Parker, Leader, Southern Horticulture
e: myles.parker@dpi.nsw.gov.au
p: 6391 3155 m: 0419 217 553 f: 6363 7878
Orange Agricultural Institute
1447 Forest Road ORANGE NSW 2800

Northern Horticulture Leader
Mark Hickey, Leader, Northern Horticulture
e: mark.hickey@dpi.nsw.gov.au
p: 6626 1277 m: 0427 401 474 f: 6628 1744
Wollongbar Primary Industries Institute
1243 Bruxner Highway WOLLONGBAR NSW 2477

Director Horticulture
Dr Shane Hetherington, Director Horticulture
e: shane.hetherington@dpi.nsw.gov.au
p: 6391 3860 m: 0409 314 894 f: 6391 3605
Orange Agricultural Institute
1447 Forest Road ORANGE NSW 2800

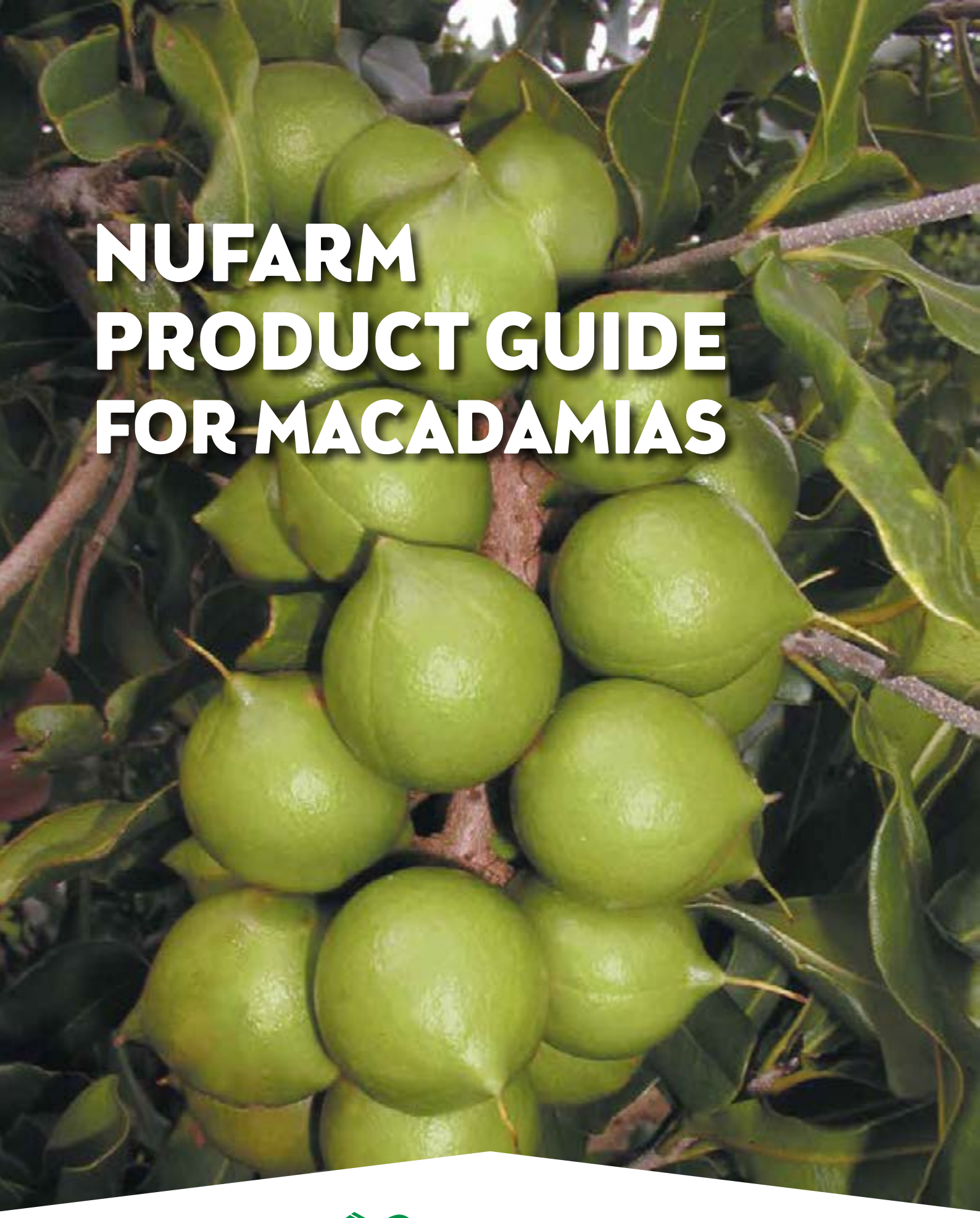
Sub-tropical Bananas
Matt Weinert, Development Officer
e: matt.weinert@dpi.nsw.gov.au
p: 6626 1352 m: 0438 644 136 f: 6628 1744
Wollongbar Primary Industries Institute
1243 Bruxner Highway WOLLONGBAR NSW 2477

Temperate Nuts
Jacquelyn Simpson, Research Horticulturist
e: jacquelyn.simpson@dpi.nsw.gov.au
p: 6391 3824 m: 0439 206 248
Orange Agricultural Institute
1447 Forest Road ORANGE NSW 2800

Local Land Services Contacts

Coffs Harbour
Julie Dart
Senior Land Services Officer
NC Operations Unit (South)
p: 6650 9406 m: 0427 007 501
Suite 33, 361 Harbour Drive COFFS HARBOUR NSW 2450

North Coast
Kelvin Langfield
Senior Land Services Officer
e: kel.langfield@lls.nsw.gov.au
p: 6623 3927 m: 0429 773 289
w: www.lls.nsw.gov.au/northern
79 Conway Street LISMORE NSW 2480



NUFARM PRODUCT GUIDE FOR MACADAMIAS

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NUFARM PRODUCT GUIDE FOR MACADAMIAS

HERBICIDES

		WEED		CROP STAGE						PRODUCT DETAILS			
PRODUCT	ACTIVE	Broadleaf	Grass	Pre-flowering	Flowering	Nut let growth	Nut growth and oil accumulation	2nd leaf flush	Nut drop	Group	Adjuvant required	WHP	Use rate
WEEDMASTER ARGO	540g/L glyphosate	✔	✔	Apply as a directed or shielded spray or using wiper equipment#						M	*	Not required when used as directed	1.35-6.00L/ha
WEEDMASTER DST	470g/L glyphosate	✔	✔	Apply as a directed or shielded spray or using wiper equipment#						M	*	Not required when used as directed	1.5-6.8L/ha
RIFLE 440	440g/L pendimethalin	✔	✔	Apply as residual herbicide, soil surface should be free of weeds						D	-	-	6.75-9L/ha
BIFFO	200g/L glufosinate ammonium	✔	✔	Apply as a directed or shielded spray						N	*	-	1-5L/ha
EXERT	520g/L haloxyfop	**	✔	Spray should be directed to the base of the tree						A	✔	-	200mL-800mL/ha
NAIL 600	600g/L carfentrazone ethyl	✔	-	Apply only as a tank mix with recommended rates of knockdown herbicides						G	✔	-	10- 30mL/ha
ALLIANCE	250g/L amitrole + 125g/L paraquat	✔	✔							Q+L	*	-	3L-4L/ha
REVOLVER	135 g/L paraquat + 115 g/L diquat	✔	✔							L	*	-	2.4-3.2L/ha
SHIRQUAT	250g/L paraquat	✔	✔							L	*	-	1.6L-3.2L/ha

* Additional surfactant is not required but may assist in improved weed control. Please consult label for specific recommendation. #DO NOT allow spray or spray drift to contact green bark or stems canes, laterals, suckers, fresh wounds, foliage or fruit. ** Exert does provide control of Erodium spp.

FUNGICIDES

		DISEASE						CROP STAGE						PRODUCT DETAILS			
PRODUCT	ACTIVE	Anthracnose (*Colletrichicum* spp)	Husk spot (*Pseudocercospora macadamiae*)	Pink limb blight (*Corticium salmonicolor*)	Phytophthora root rot	Phytophthora trunk canker	Phytophthora stem canker	Pre-flowering	Flowering	Nut let growth	Nut growth and oil accumulation	2nd leaf flush	Nut drop	Group	Max no. applications	WHP	Dilute use rate
CHAMP DRY PRILL	375g/kg present as cupric hydroxide	✔	✔	✔										M1	-	Do not harvest for 1 day after application	140g/100L
DIGGER	250g/L difenoconazole		✔											3	2	Not required when used as directed	50mL/100L
SPIN FLO	500g/L carbendazim		✔											1	2	14 days (H) 4 weeks (G)	50mL/100L
MEDLEY 50G	50g/kg metalaxyl				✔	✔		Before summer wet season and repeat at 3 to 6 months intervals.						4	-	4 weeks	25g to 50g/m²
TRI-BASE BLUE	190g/L copper present as tribasic copper sulphate						✔	Stem application						M1	-	Do not harvest for 1 day after application	140mL/L of water or water based paint
CHAMP 500WG	500g/kg copper (Cu) present as cupric hydroxide	✔	✔	✔										M1	-	Do not harvest for 1 day after application	105g/100L

INSECTICIDES/MITICIDES

		INSECT/MITE PEST	CROP STAGE	PRODUCT DETAILS

PRODUCT	ACTIVE	Macadamia nut borer	Banana spotting bug	Lace bug	Leaf-miner	Fruit spotting bug	Macadamia flower caterpillar	Flower thrips	Macadamia leafminer	Redshouldered leaf beetle	Pre-flowering	Flowering	Nut let growth	Nut growth and oil accumulation	2nd leaf flush	Nut drop	Group	Max no. applications	WHP	Dilute use rate
LEPIDEX 500	500g/L trichlorfon		✔	✔		✔	✔										1B	-	-	200mL/100L
DIPTEREX 500	500g/L trichlorfon		✔	✔		✔	✔										1B	-	-	200mL/100L
LANCER DF	970g/kg acephate	✔	✔		✔	✔	✔	✔	✔	✔							1B	-	Not required when used as directed	80g/100L

Please consult the APVMA website for current permits for control of various pests in macadamias.

ADJUVANTS		FOR USE AS									CROP STAGE						PRODUCT DETAILS		
PRODUCT	ACTIVE	Water conditioning			Compatibility agent	Droplet management/ drift	Deposition aid/drift	Spreading	Penetration	Rainfastness	Pre-flowering	Flowering	Nut let growth	Nut growth and oil accumulation	2nd leaf flush	Nut drop	Max no. applications	WHP	Dilute use rate
		High pH	Hardness	Anti-foaming															
PRIMABUFF	266.2g/L nonoxinol-9, 375.1g/L phosphoric acid derivatives	✔✔✔	✔✔	✔			✔	✔✔	✔								-	-	see label
BANJO	725g/L methyl esters of canola oil					✔✔	✔	✔✔	✔✔✔	✔✔✔							-	-	see label
DU-WETT	500g/L trisiloxane ethoxylate 255g/L synthetic latex					✔	✔✔✔	✔✔✔✔✔	✔✔	✔✔							-	-	see label
ACTIVATOR	900g/L non-ionic surfactants			✔✔✔		✔	✔	✔✔	✔	✔							-	-	see label
BOND	450g/L synthetic latex 100g/L surfactant					✔	✔✔✔	✔		✔✔✔✔✔							-	-	see label
COLLIDE 700	350g/L soyal phospholipids 350g/L propionic acid	✔✔✔			✔	✔✔	✔	✔✔	✔✔	✔✔✔							-	-	see label
PULSE	1000g/L polydimethylsiloxane					✘	✔✔	✔✔✔✔✔	✔✔✔	✔✔✔							-	-	see label
LIASE	417g/L ammonium sulfate	✔	✔✔✔		✔✔												-	-	see label
SUPERCHARGE ELITE	471g/L paraffin oil					✔✔	✔	✔✔	✔✔✔	✔✔✔							-	-	see label
SHIRWET 600	600g/L nonyl phenol ethylene oxide					✘	✔	✔✔	✔								-	-	see label

✔ Better effects indicated by higher number of ticks. ✘ Indicates that the adjuvant has a negative effect on the outcome.

This brochure does not replace the product directions for use label. Please ensure the product label is always consulted prior to using any product.

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Notes

For more information, visit **nufarm.com.au**

The information and recommendations set out in this brochure are no substitute for professional or expert advice and are based on tests and data believed to be reliable at the time of publication. Results may vary, as the use and application of the products is beyond our control and may be subject to climatic, geographical or biological variables, and/or developed resistance. To the maximum extent permitted by law, Nufarm Australia Limited disclaims all warranties of any kind, whether express or implied, including but not limited to any warranty that the information is up-to-date, complete, true, legally compliant, accurate, non-misleading or suitable.

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"So glad we reported it!

We noticed these plants covering the lake that weren't there before...

...we called Council and it turned out to be frogbit, a new weed that ruins waterways! They acted fast and our call helped save the lake."

Always contact your local council weeds officer if you notice unusual plants, or call the NSW Invasive Plants and Animals Enquiry Line **1800 680 244**

For more information search 'frogbit' in NSW WeedWise at **weeds.dpi.nsw.gov.au**

NSWWeedWise

NSW GOVERNMENT

Biosecurity Act 2015

By law biosecurity is everybody's business. Weeds threaten our biosecurity and come under the new Biosecurity Act in NSW

Every person and organisation needs to do their bit to protect the economy, environment and community from the risks posed by weeds. This is now part of your "general biosecurity duty"

WHAT CAN YOU DO?

- use NSW WeedWise to find out about the biosecurity duties for weeds in your area (go to **weeds.dpi.nsw.gov.au** or get the app)
- talk to your local council weeds officer about weeds on your property
- control and prevent weeds spreading on and from your property

For more information about the *Biosecurity Act 2015* visit **www.dpi.nsw.gov.au/biosecuritylegislation** or email **biosecuritylegislation@dpi.nsw.gov.au**