

Orchard Biosecurity Manual

for the Mango Industry

Reducing the risk of new pests
impacting on your orchard

Version 1.0





Plant Health Australia (PHA) is the national coordinator of the government-industry partnership for plant biosecurity in Australia. As a not-for-profit company, PHA services the needs of Members and independently advocates on behalf of the national plant biosecurity system. PHA's efforts help minimise plant pest impacts, enhance Australia's plant health status, assist trade, safeguard the livelihood of producers, support the sustainability and profitability of plant industries and the communities that rely upon them, and preserve environmental health and amenity.

www.planthealthaustralia.com.au



Biosecurity Queensland and Agri-Science Queensland, services of the Department of Employment, Economic Development and Innovation (DEEDI), are working to promote profitable primary industries for Queensland. This is achieved by providing expertise and support to assist the state's food and fibre industries to increase productivity, improve sustainability, grow markets and adapt to change.

DEEDI is committed to delivering world-class research and development, providing leadership on industry policy, protecting industries against pests and diseases, maintaining animal welfare standards and managing fisheries sustainably.

www.deedi.qld.gov.au



The Australian Mango Industry Association (AMIA) is the national organisation that represents mango growers and associated businesses.
www.industry.mangoes.net.au

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Six easy ways to protect your property

2 You have an important role to play in protecting your property and the entire mango industry from biosecurity threats.

Here are six easy ways you can reduce the threat of new pests impacting on your livelihood. Each of these practices should be embedded in your orchard's everyday management as they make good business sense by reducing the risk of spreading pests. Don't put your livelihood at risk by neglecting orchard biosecurity.

1. Be aware of biosecurity threats

Make sure you and your orchard workers are familiar with the most important exotic mango pest threats. Conduct a biosecurity induction session to explain required hygiene practices for people, equipment and vehicles in your orchard.

2. Use pest-free propagation material

Ensure all propagation material is from trusted sources and orchard inputs are fully tested, pest-free and preferably certified. Keep good records of your orchard inputs.

3. Keep it clean

Practicing good sanitation and hygiene will help prevent the entry and movement of pests onto your property. Workers, visitors, vehicles and equipment can spread pests, so make sure they are clean before entering and leaving your property. Have a designated visitor's area and provide vehicle and personnel wash-down facilities.

4. Check your orchard

Monitor your trees frequently. Knowing the usual appearance of your orchard and trees will help you recognise new or unusual events and pests. Keep written and photographic records of all unusual observations. Constant vigilance is vital for early detection of any exotic plant pest threat.

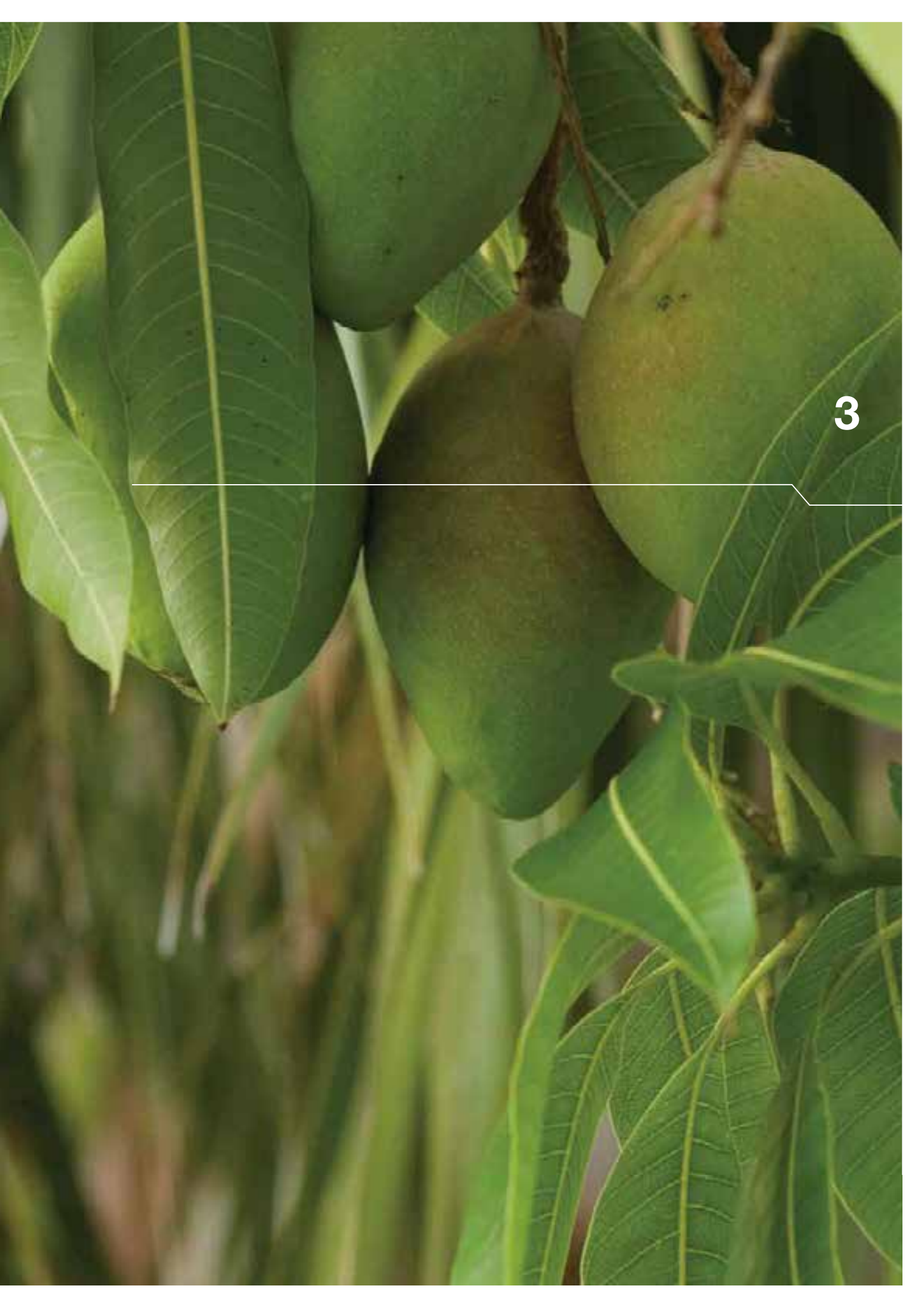
5. Abide by the law

Respect and be aware of laws and regulations established to protect the mango industry, Australian agriculture, and your region.

6. Report anything unusual

If you suspect a new pest – **report it immediately to the Exotic Plant Pest Hotline.**

EXOTIC PLANT PEST HOTLINE
1800 084 881



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Biosecurity overview

4

This manual is designed to assist you in protecting your property and the mango industry from new and invasive pests. By implementing the recommended measures in your day-to-day operations, you will improve your own biosecurity and that of your region, while minimising produce losses and unnecessary costs.

What is biosecurity?

Biosecurity is about the protection of livelihoods, lifestyles and the natural environment, which could be harmed by the introduction of new pests.

Biosecurity is a national priority, implemented off-shore, at the border and on-farm. Biosecurity is essential for your business.

Australia's geographic isolation has meant that we have relatively few of the pests that affect plant industries overseas. Freedom from these exotic pests is a vital part of the future profitability and sustainability of Australia's plant industries. Biosecurity allows us to preserve existing trade opportunities and provide evidence to support new market negotiations.



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The definition of a **pest** used in this manual covers all insects, mites, snails, nematodes, pathogens (diseases) and weeds that are injurious to plants, plant products or bees. **Exotic** pests are those not currently present in Australia, while **established** (and **endemic**) pests are those present within Australia.

What is orchard biosecurity?

Orchard biosecurity is a set of measures designed to protect a property from the entry and spread of pests. Orchard biosecurity is your responsibility, and that of every person visiting or working on your property.

Through the implementation of orchard biosecurity measures, growers play a key role in protecting the Australian mango industry from exotic pests. If a new pest becomes established in your orchard, it will affect your business through increased orchard costs (for monitoring, cultural practices, additional chemical use and labour to apply them), reduced productivity (yield and/or quality reductions) or loss of markets.

Early detection and immediate reporting of an exotic pest increase the chance of effective and efficient eradication.

Regional biosecurity

To strengthen the biosecurity measures implemented on your property, consider including biosecurity issues and activities in community or regional meetings. Through this collaborative approach, biosecurity threats to all properties in your region can be minimised.

Potential sources of biosecurity threats may be neighbouring orchards (operating or abandoned), nurseries, other commercial plantings, native vegetation and/or peri-urban residential or amenity plantings.

Promotion of biosecurity at the regional level is enhanced through broad engagement of the community, understanding the region's vulnerability, the source and nature of threats, knowledge of the expertise base and resources available to the region, together with a commitment from stakeholders to implement biosecurity measures, surveillance and reporting.

Implementation of orchard biosecurity underpins regional biosecurity, which in turn underpins national biosecurity. If orchard measures are supported by community based measures, a regional framework for biosecurity can be coordinated and is achievable.

Pests

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High priority exotic pest threats of the mango industry

The following are some key exotic pest threats for the Australian mango industry as identified through the development of the Mango Industry Biosecurity Plan (IBP). Any of these pests would have serious consequences should they enter and become established in Australia. For a complete list of identified exotic pest threats for the mango industry, refer to the Mango IBP, available from www.phau.com.au/biosecurity/mango

Oriental fruit fly complex (*Bactrocera* spp.)

OVERALL RISK – HIGH

- Can cause up to 100% fruit loss
- Adults 6-8 mm long with a narrow brown band along the edge of the wings
- Abdomen has a distinctive black T-shaped mark, which is similar to a number of other endemic species
- Larval feeding can result in rotting of fruit and may cause fruit to drop
- Long range dispersal through movement of larvae-infested fruit



Scott Bauer

Mango pulp weevil (*Sternuchetus frigidus*)

OVERALL RISK – HIGH

- Causes high economic losses to mango industries in Asia
- Adults are 6-9 mm long, stout, and dark brown with paler patches
- Unlike the Mango seed weevil, larvae only feed on the pulp
- Circular exit holes appear in the fruit when adult weevils emerge
- Long range dispersal through movement of infested fruit



Dr Mohd. Shamsudin Osman,
MAFDI, Malaysia

Mango malformation disease (*Fusarium* spp.)

OVERALL RISK – HIGH

- Found in India, Egypt, Africa, Central America, Brazil, Mexico, Malaysia, Pakistan
- Most important floral disease of mangoes worldwide
- Causes malformed shoots and inflorescences
- Panicles are thickened with large flowers and inflorescences appear crowded
- Long range dispersal via infected plant material and pruning equipment



Barry Conde, DoR, NT

Mango gall midges (*Procontarinia* spp.)

OVERALL RISK – HIGH

- Found in India, Africa, Malaysia
- Eggs laid on leaves cause small red spots
- Wart-like galls form quickly and extend up to 3-4 mm in diameter
- Heavily galled leaves can curl up and drop off prematurely, causing dieback of whole branches in susceptible cultivars
- Long range dispersal through movement of infested plant material



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The climate of Australian mango production regions would allow each of these pests to survive, spread and establish, should they be introduced. Additional information on each of these pest threats is included in the fact sheets at the back of this manual.

Remain observant for anything unusual in your orchard and storage facilities.

If a pest is found that is not normally present on your property, it may be new not only to your property, but to the region, state or even Australia.

Red banded mango caterpillar (*Deanolis sublimbalis*)

OVERALL RISK – HIGH

- Found in Southeast Asia, Papua New Guinea, Torres Strait Islands and quarantined on the tip of Cape Peninsula
- Larvae have distinctive red and white bands plus a black collar
- Damaging to all stages of fruit development, feeding on both flesh and seed
- Caterpillar entry holes lead to sap stain on fruit
- Long range dispersal through movement of infested plant material



PaDIL (Glynn Maynard)

Blue-striped nettle grub (*Parasa lepida*)

OVERALL RISK – HIGH

- Found in Vietnam, Indonesia, China, Papua New Guinea
- Larvae have thick, green fleshy bodies with three pale blue longitudinal stripes
- Cocoons are buried in soil or among leaf litter
- Grubs chew holes in leaves; larger infestations lead to defoliation of entire trees
- Long range dispersal through movement of infested plant material



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Mango fruit borer (*Citripestis eutrapphera*)

OVERALL RISK – HIGH

- Found in India, Indonesia and parts of the Northern Territory
- Larvae are reddish violet, and turn dark blue as they develop
- Larvae feed on pulp
- Causes premature fruit drop, particularly in young fruit
- Long range dispersal through movement of infested fruit



Lanni Zhang, DoR, NT

Mango sudden death syndrome (*Ceratocystis* spp.)

OVERALL RISK – HIGH

- Found in Brazil, Pakistan, Oman
- Symptoms vary depending on which species of *Ceratocystis* is present
- Causes parts or all of the tree to wilt and die
- Blue-grey to brown staining of vascular tissue
- Lifecycle not well understood but likely spread with the Mango bark beetle



Al Obaid Al-Adawi, Ministry of Agriculture, Sultanate of Oman



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Pest surveillance

Orchard monitoring and surveillance involves looking for and recording the presence, absence and population levels of pests. Conducting regular monitoring is a fundamental part of orchard management practices and gives the best chance of spotting a new pest soon after it arrives.

Pest surveillance is necessary to improve:

- **Market access:** Export destinations for mangoes can require 'evidence of absence' data for exotic and some established pests of concern. The Australian mango industry, in collaboration with governments, must prove through surveillance that exotic pests have been looked for and found to be absent.
- **Exotic pest eradication:** Early detection of exotic pests improves the chance of eradication or containment within a region. Even if eradication or containment is not feasible, early detection, in conjunction with contingency planning and preparedness by government and industry bodies (e.g. preparing emergency chemical registrations, permits for importation of biocontrol agents, awareness material and training in pest diagnostics) assists with a more rapid and effective response.
- **Pest management:** Regular inspections of orchards to determine pest presence and population levels will inform management practices.

- **Pest status information:** Surveillance at the orchard level contributes essential information to regional biosecurity efforts and ultimately to the national status (presence/absence) of a pest.

All pest (exotic and established) surveillance activities on your property should be recorded. These records can be used in the response to a pest incursion and provide support to industry surveillance activities. The addition of exotic pests to current data sheets used by consultants is an effective recording mechanism. An example pest surveillance data sheet is included in this manual (see page 23).

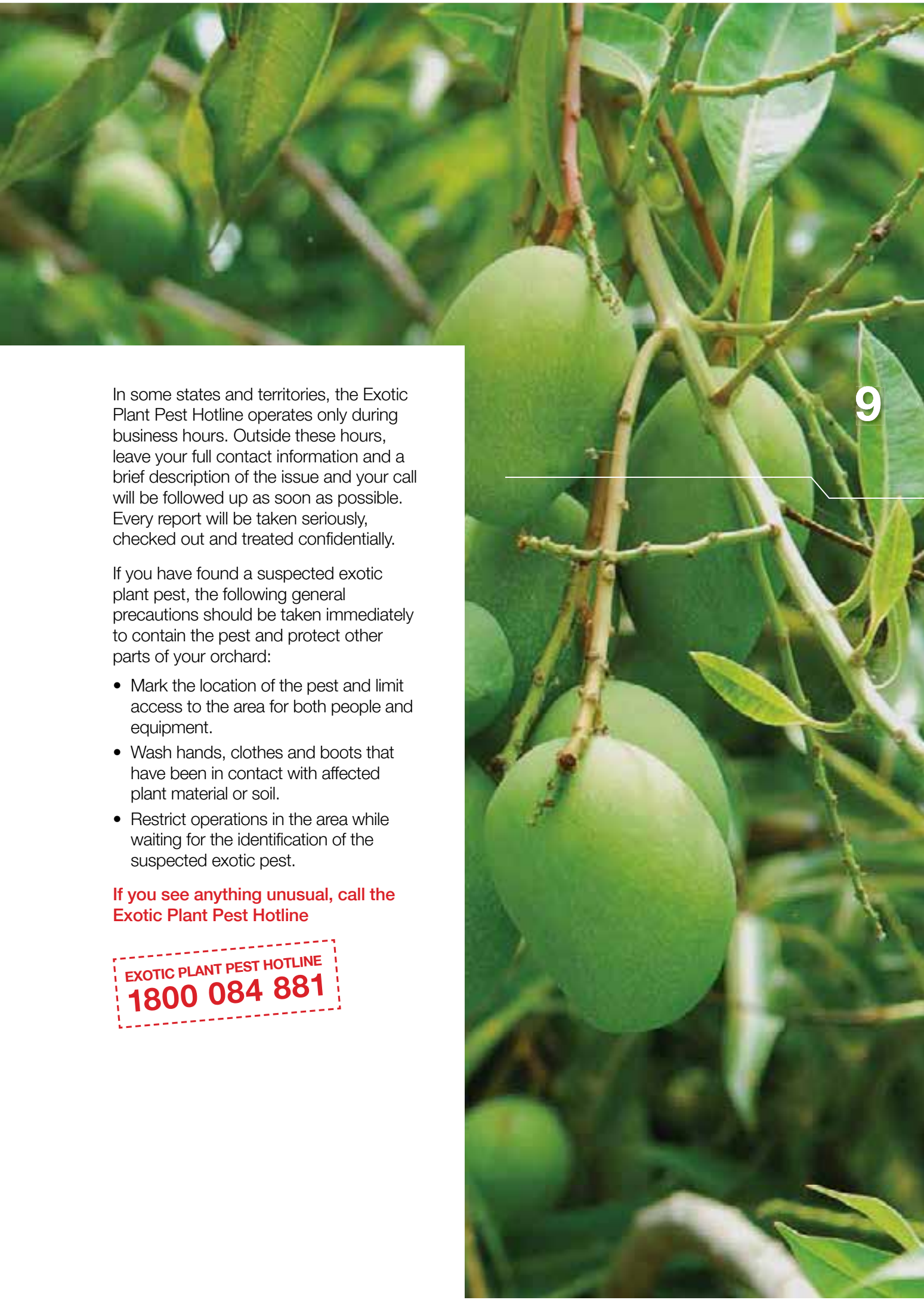
Report suspect pests

Early detection and reporting may prevent or minimise long-term damage to, or the quarantine period of, your orchard and the mango industry.

Report any unusual or suspect plant pest immediately via the **Exotic Plant Pest Hotline on 1800 084 881**.

Calls to the Exotic Plant Pest Hotline will be forwarded to an experienced person in your state or territory government, who will ask some questions about what you have seen and may arrange to collect a sample.

Do not send samples without first speaking to someone from the state department, who can discuss the correct type of sample, its packaging, handling and transport to the laboratory assigned for diagnosis.



In some states and territories, the Exotic Plant Pest Hotline operates only during business hours. Outside these hours, leave your full contact information and a brief description of the issue and your call will be followed up as soon as possible. Every report will be taken seriously, checked out and treated confidentially.

If you have found a suspected exotic plant pest, the following general precautions should be taken immediately to contain the pest and protect other parts of your orchard:

- Mark the location of the pest and limit access to the area for both people and equipment.
- Wash hands, clothes and boots that have been in contact with affected plant material or soil.
- Restrict operations in the area while waiting for the identification of the suspected exotic pest.

If you see anything unusual, call the Exotic Plant Pest Hotline

**EXOTIC PLANT PEST HOTLINE
1800 084 881**

10 The Emergency Plant Pest Response Deed (EPPRD)

The EPPRD is a formal, legally binding document between Plant Health Australia (PHA), Australian and state/territory governments, and plant industry signatories. As a signatory to the EPPRD, the Australian Mango Industry Association (AMIA) has a seat at the decision making table and also contributes to funding if an approved Response Plan is implemented to eradicate an Emergency Plant Pest (EPP).

Under the EPPRD, the mango industry has a responsibility to report suspect pests. The earlier a new pest is detected, the greater the chance an eradication response will be mounted and the more likely it will be successful.



Owner Reimbursement Costs

An underlying principle of the EPPRD is that growers are neither better nor worse off as a result of reporting a suspect EPP. As a result, grower reimbursement payments (Owner Reimbursement Costs; ORCs) may be included for direct costs incurred as a result of the implementation of an approved Response Plan. ORCs may cover direct grower costs or losses through such actions as the destruction of crops, enforced fallow periods, replacement of trees and additional chemical treatments.

Calculation of ORCs is prescribed in the EPPRD, including the different formulae used to accommodate the wide range of crops grown by Industry signatories. Mango ORCs are calculated using the "Perennial Trees" formula. To ensure that these calculations are accurate, growers should keep records of key value information (example record sheet provided on page 24).

It is important to remember that ORCs only apply to approved Response Plans aimed at eradication, which are more likely to be developed following early reporting of new pests.

For more information on the EPPRD and ORCs refer to www.phau.com.au/epprd





Product management

12 Planting and propagating material

Use only clean planting and propagation material (i.e. tested with no pest detections). Obtain these only from nurseries that will provide you with reliable records of the material's source and testing history.

You cannot visually assess the health of your planting material. Viruses, viroids and phytoplasmas will not display symptoms under some circumstances.

To minimise the risk:

- Purchase plant material only from a nursery that takes biosecurity, hygiene, health testing and record keeping seriously.
- Check your nursery and planting material thoroughly.
- Maintain a register of your orchard's propagation material, including its source (with contact details), cultivar/rootstock combinations, specific planting locations, numbers of plants and date planted.
- Request information on the source of budwood, mother tree health testing regime and timetable, location of foundation material of new imports and the Quality Assurance scheme or certification status of the nursery itself and the planting material provided.

Chemical residues

Chemical residues on mango produce can result in rejection from export and domestic markets, particularly as these residues can pose a risk to human health.

Appropriate training and advice on the safe use of pesticides should be obtained prior to chemical control of pests and always follow label regulations and withholding periods. Don't put your livelihood or the industry at risk through poor or illegal practice.

In most states and territories, growers and contractors who apply pesticides must complete an accredited chemical training course (e.g. ChemCert or SMARTtrain) to gain the appropriate knowledge base on the safe use of pesticides and the legal requirements.

Details about regulations for agricultural and veterinary chemicals can be obtained from the Australian Pesticides and Veterinary Medicines Authority (APVMA) **www.apvma.gov.au** or from relevant state agencies. Consult these sources frequently for information regarding chemical regulations as these may change.



Waste fruit and plant material

Maintaining good orchard and nursery hygiene can minimise cross-contamination and breeding environments for pests. This should be achieved in combination with an effective monitoring/pest management program. A 'spray diary' record should accompany each consignment of mango fruit.

Collect all plant waste and dispose of it away from nursery and orchard areas and water sources. Appropriate disposal mechanisms for plant waste include deep burial (away from production areas), burning or hot composting.

Ensure that no soil, plant material or insects are left adhering to vehicles, bins, and other equipment (including hand tools) used for the harvesting of fruit.



RJH Dibaba

Biosecurity and Quality Assurance

If your orchard or the nursery providing your trees is accredited (i.e. maintains a Quality Assured scheme such as ISO 9000, SQF 2000, NIASA, Freshcare or Woolworths Quality Assurance Scheme), it is likely that some fundamental techniques of biosecurity best practice are already being applied.

Ensure that your scheme and records allow full traceability. That is, the ability to trace-back plant material on your orchard to its source (including the budwood sources, health testing and authenticity records), to trace-forward plant material or produce that has left your property, and records of surveillance and pest management practices undertaken on your property.

Auditable Quality Assurance schemes are beneficial in terms of biosecurity, market access, meeting specifications and customer expectations, and food safety.

People and biosecurity

14 Biosecurity signs

Well-designed signage informs visitors that biosecurity on your property is important and that they share responsibility for maintaining it. The signs also serve to alert people to the potential impact of their visit.

Signs demonstrate your commitment to orchard hygiene, safety and auditable systems. Biosecurity signage should be placed at the main gate, external entrances, visitor parking areas and wash-down facilities.

Biosecurity signs at entrances or near storage facilities should direct visitors to contact the owner or orchard manager and formally register their presence, before entering any production areas. The sign should include important contact details, such as the home telephone number, mobile number and/or UHF channel.



A template for the above sign is available for download from www.phau.com.au/biosecurity

Managing people movement

People moving between orchards, nurseries and other horticultural regions can spread pests on vehicles, equipment, boots and clothing. Even hair and watchbands can carry fungal spores or bacteria. The most obvious risks are pests carried in soil and plant material.

Implementing the following measures will reduce the threat of human activity introducing new pests into your orchard:

- Maintain a visitor register (example on page 22), which will record visitor movements and help manage safety issues.
- Brief all workers, contractors, and visitors of your orchard biosecurity measures.
- Employee and visitor footwear and clothing must be free of soil and plant material before entering or leaving the orchard.
- Provide scrubbing brushes, footbaths, boot covers, rubber boots and protective clothing for people entering or leaving your orchard, or moving from contaminated to clean areas of the property.
- Ensure grafting crews are particularly diligent about cleaning their knives and footwear between cuts. At a minimum, knives should be cleaned between each bundle.
- Display biosecurity awareness material in staff rooms, trimming and packing sheds. Keep the messages simple and effective.



Casual workers and tourists

Casual workers (e.g. contract harvest crews, backpackers, retirees, etc.) are often employed to assist with orchard topworking, pruning, harvesting/picking and packing. While their contribution is highly valued, they are a particular biosecurity threat because they move from orchard-to-orchard and region-to-region. They can potentially carry and spread pests from and to susceptible hosts on their clothing, footwear, gloves, and equipment.

Before entering production areas or packing sheds, make sure casual workers are well briefed on biosecurity measures at your property, have changed or washed their clothes and boots, and have disinfected and cleaned all tools and equipment.

Overseas travellers

People returning from overseas are a threat to our biosecurity, especially if they have visited orchards, nurseries, or markets where plant material and produce was sold.

Several specimens carrying mango fruit pests have been intercepted at the Australian border and overseas travellers have unknowingly brought in pests in the past. Air travel means exotic plant pests are only a few hours away.

To protect your orchard from overseas pests, ensure that all people who have recently returned from overseas have cleaned their boots and clothes before entering the orchard. Great care should be taken to prevent the introduction of new plant pests into Australia.

Contractors and utility providers

The term 'contractors' includes utility providers, orchard contractors, earthmoving companies and research personnel who enter an orchard in their day-to-day operations. As with casual workers, contractors pose a significant risk because of their movement between properties.

Placing biosecurity signs on external property gates can play an important part in raising biosecurity awareness with contractors, especially providers of power, water, gas and communications. Limit the risk of contractors introducing new pests onto your property, by requesting all contractors' vehicles and equipment be cleaned before starting work on your property. Provide a suitable wash-down bay to complete this task.

To ensure your property does not become the source of pest infections for others, you have a responsibility to inform contractors of any declared or notifiable pests already present in your orchard.

Equipment and vehicles

16 Movement of vehicles and machinery

Vehicles and orchard equipment, such as sprayers, tractors and hand tools, can carry pests in adhering soil, sap and plant material. Pests may then be introduced to a previously clean property or crop.

It is impractical to stop all vehicle and equipment movement on and off the property, but using dedicated orchard vehicles, washing down machinery on concrete pads and denying access of dirty machinery can reduce the spread of pests.

Contractors, re-sellers, service providers and drivers of delivery trucks (e.g. nursery stock, fertiliser, etc.) and earth moving equipment should be requested to clean their vehicles and equipment before entering your orchard. Orchards open to the public and those open to growers (e.g. for field days, equipment demonstrations, etc.) have a heightened risk and therefore designated parking areas away from production sites are important.



Weedstop

Inspecting and cleaning machinery is more time and cost effective than managing a new pest introduced to your property

Measures to reduce the risk of pest entry on equipment and vehicles include:

- Cleaning vehicle floors and tyres of soil, plant material and pests, especially after visiting other properties.
- Where possible, use your own vehicle to carry visitors around your orchard.
- In production areas, keep vehicle movement to a minimum, especially on wet soil. Stick to regular pathways through the orchard.
- Hose off and disinfect machinery in a designated wash-down area (see page 17) before moving between properties.
- Ensure contractor equipment is washed down thoroughly to remove any plant material or soil before entering your orchard.
- Always make sure that borrowed and second-hand equipment and machinery is cleaned of all plant material and soil before moving them into your orchard.
- Regularly clean all tools and equipment, including pallets, pallets, cherry pickers, boxes, bags, trimmers, ladders and any other equipment used in the orchard, preferably with a disinfectant or bleach solution.



Designated parking areas

A well sign-posted designated parking area should be provided for all visitors. Ideally, dedicated orchard vehicles should be used for transport around your property with other vehicle movement limited to direct entry to a designated visitor parking area only.

Parking areas serve to contain the entry of new pests away from production sites. They also allow for the inspection of tyres, equipment, floor mats and boots for soil and plant material which may carry new pests. This area should be regularly monitored for the presence of new pests.

A biosecurity sign in the parking area will remind visitors of the threat of spreading pests between properties.

Do not allow the movement of orchard machinery through the parking area.

Wash-down facilities

A wash-down facility allows orchard employees, contractors and visitors to clean their vehicle and equipment (including hand tools) in an easily managed area where wash water is contained. This will ensure that plant material, pests and soil are not moved into or out of your orchard.

A wash-down area should:

- Be readily accessible and located between the driveway and orchard roads.

- Be isolated from production areas.
- Have access to power and high-pressure water.
- Have a sealed (concrete or bitumen) or packed gravel surface.
- Not drain into a waterway or production area.
- Have a sump or collection area for easy inspection and waste management.

Clean machinery from the top down to avoid contaminating areas already cleaned, and consider the following points:

- Dismantle as far as practically possible to give access to internal spaces.
- Leave covers off after cleaning to allow inspection.
- Get a second opinion – a fresh look will see contamination you may have missed.

For additional protection, an added detergent-based degreaser or disinfectant (for example, Septone Truckwash®, Castrol Farmcleanse® or Virkon®) may be appropriate. For best results, seek advice from re-sellers on the best product, and remove as much soil and plant material as possible from the equipment before using the disinfectant.

The wash-down area may be the same as that used for chemical wash-down of vehicles and equipment. If so, all occupational health and safety issues associated with chemical wash-down areas must be taken into account.

Biosecurity best practice checklist

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To ensure your property has the best protection against the introduction and spread of new pests, identify the strengths and weaknesses of your orchard's biosecurity activities through the following self-assessment questions.

Once identified, a few simple, non-costly and practical procedures can be implemented to strengthen areas of greatest risk to your orchard. While changing everyday practices can take more effort in the short term, these will become second nature with time and are easier and cheaper than dealing with the introduction of a new pest.



Natalie Moore

Date of biosecurity check: _____

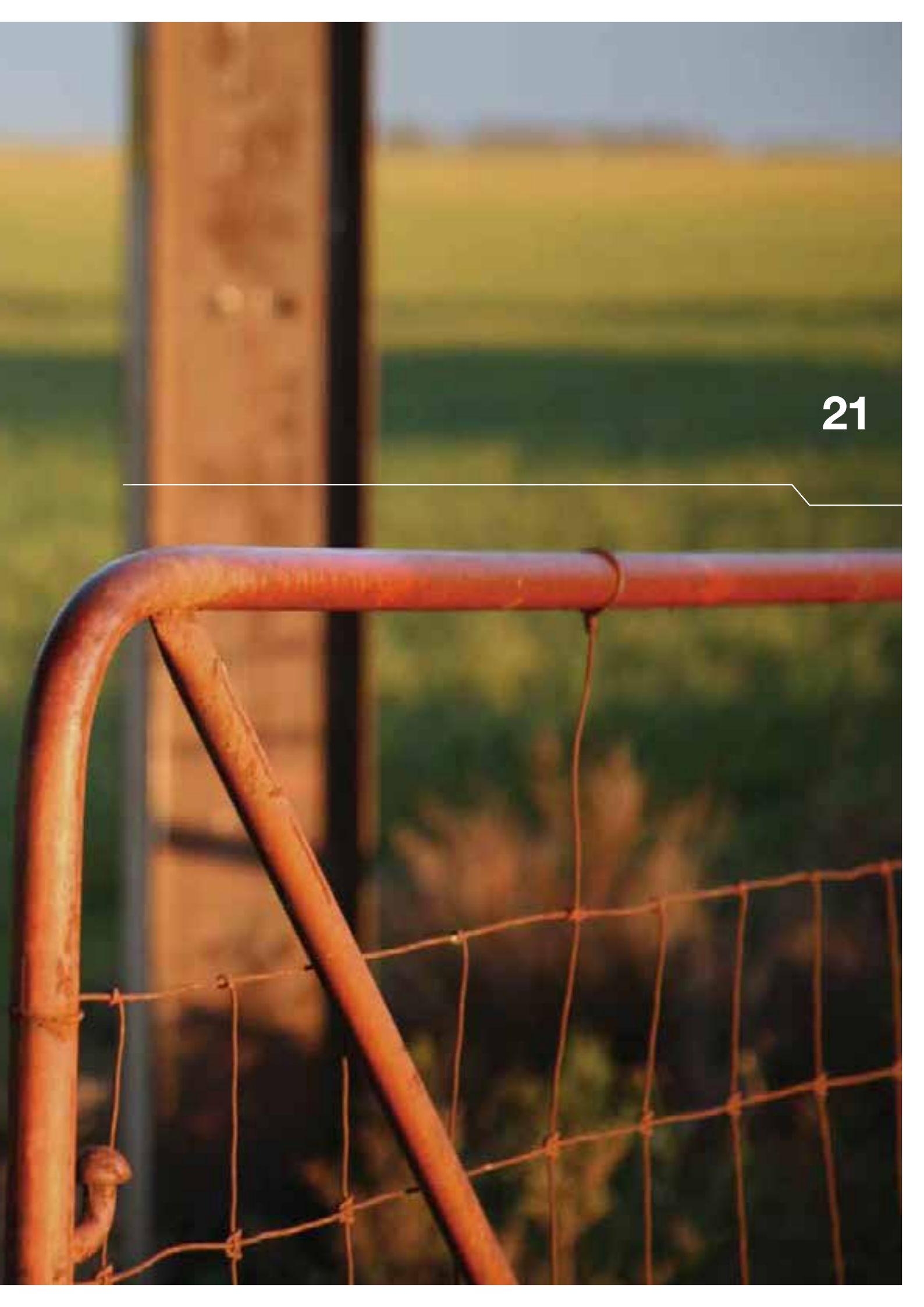
RECOMMENDED PRACTICES	YES	NO	COMMENTS
Pests			
Orchard staff know how and where to report pests			
Pest surveillance regularly conducted, with activities and results recorded even when nothing is found			
Orchard staff are familiar with common established pests and the high priority exotic pests of mangoes			
Commercial trees and neighbouring vegetation regularly inspected for pests			
Pest threat posters displayed			
Product management			
Planting or propagation material is 'certified' or has a defined and documented health status			
Propagation material thoroughly checked upon receipt			
Records of planting material and its source are maintained			
Staff are aware of symptoms of mango pests spread with propagation material			
No soil, plant material or insects left on equipment or bins			
Fruit loaded and unloaded on paved or sealed pad away from production areas			
Fallen or waste fruit, packing shed waste and plant trimmings disposed of away from production areas and irrigation sources			
People movement			
Biosecurity signs with contact details located at main entrance			
Staff trained in biosecurity measures and threats			
All visitors sign a visitor register on arrival			
All visitor and staff clothing, footwear and tools are free of loose soil or plant matter before entering and leaving the orchard			
All people recently returned from overseas are checked to ensure they have clean footwear and clothing before entering orchard			
Footbaths and scrubbing brushes are provided			
Staff understand neighbouring enterprises and their activities			
Equipment and vehicles			
Designated parking area for visitors and contractor's equipment available and clearly signed			
Cleaning and wash-down facilities, preferably on a concrete pad, provided for people, machinery and equipment and clearly signposted with instructions			
High pressure water or air available for use to remove plant material and soil from equipment and machinery			
Sump installed in wash-down facility to catch pests and weeds and stop run-off			
Machinery entering the property inspected for pests, soil and plant material prior to entering production areas			
Borrowed and second-hand machinery and equipment is cleaned and disinfected before use			
Vehicle movement kept to a minimum in production areas			

Further information

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More information on biosecurity, orchard hygiene, pests and the mango industry can be found through the following sources.

Useful contacts		Contact details
ORGANISATION	Australian Mango Industry Association	Phone: 07 4086 6007 Website: industry.mangoes.net.au
	Plant Health Australia	Phone: 02 6215 7700 Email: biosecurity@phau.com.au Website: www.planthealthaustralia.com.au
	Farm Biosecurity	Phone: 02 6215 7700 Email: info@farmbiosecurity.com.au Website: www.farmbiosecurity.com.au
GOVERNMENT	Australian Government – Department of Agriculture, Fisheries and Forestry	Phone: 02 6272 3933 Website: www.daff.gov.au
	New South Wales – Industry and Investment NSW	Phone: 1800 808 095 or 02 6391 3100 Website: www.industry.nsw.gov.au
	Northern Territory – Department of Resources	Phone: 08 8999 5511 Website: www.nt.gov.au/d
	Queensland – Department of Employment, Economic Development and Innovation	Phone: 13 25 23 or 07 3404 6999 Website: www.deedi.qld.gov.au
	Western Australia – Department of Agriculture and Food	Phone: 08 9368 3333 Website: www.agric.wa.gov.au



Visitor register

Please enter your details to assist us with our orchard biosecurity records

Date	Time on property		Name	Reason for visit	Vehicle registration and mobile phone	Blocks visited	Location/date of last contact with commercial mango plants
	Arrival	Departure					

EXOTIC PLANT PEST HOTLINE
1800 084 881

If you see anything unusual, call the Exotic Plant Pest Hotline

* An electronic version of this Visitor Register can be downloaded from the Farm Biosecurity website www.farmbiosecurity.com.au

Pest surveillance data sheet

Orchard:

Scout:

Date:

Block	No. sites	Established pests				Exotic pests			Other pests found	Comments
		Pest 1	Pest 2	Pest 3	Pest 4	Pest 1	Pest 2	Pest 2		

EXOTIC PLANT PEST HOTLINE
1800 084 881

If you see anything unusual, call the Exotic Plant Pest Hotline

* Estimated infestation level (e.g. zero/low/med/high or % trees affected) of established pests and presence/absence of exotic pests should be scored. Pests targeted by surveillance must be named before surveillance initiated (for both established and exotic pests)

* An electronic version of this Pest Surveillance Datasheet can be downloaded from the Farm Biosecurity website www.farmbiosecurity.com.au

Production record

Completing the following production value summary each year, and keeping supporting documentation records, will increase the accuracy of Owner Reimbursement Cost calculations if required during an eradication campaign for an Emergency Plant Pest under an approved Response Plan (see page 10 for details).

24

Year/Season: _____

Crop value			
Area cropped	Total:		
	Breakdown by variety		
	Variety	Location	Area cropped
Yield	Variety	Yield	Comments
Market price	Market location	Variety	Price
Capital items			
Items installed on site (e.g. irrigation lines, harvest bins, protective covers, trellising, etc.)	Item details	Amount	Cost (depreciated)
Tree value			
Stock take of trees	Variety (and commercial life)	Tree age	Number of trees
Tree costs	Trees planted this season		
	Variety	Number	Cost

Stored products			
Products stored	Product/variety	Amount	Time period of storage
Pruning and harvesting costs			
Time	Total staff hours for harvest (including start and finish dates):		
	Total staff hours for pruning (including start and finish dates. If more than one round, list all dates):		
Machinery costs	Cost to run/hire machinery for harvest:		
	Cost to run/hire machinery for pruning:		
Contractor costs	Cost of employing a harvest contractor (if used):		
	Cost of employing a pruning contractor (if used):		
Net profit from season			
Total sales	Value:	Evidence (e.g. receipt):	
Total costs	Value:	Evidence (e.g. receipt):	
Total net profit	Value:	Evidence (e.g. receipt):	

Oriental fruit fly complex

What is Oriental fruit fly complex?

Papaya fruit fly (*Bactrocera papayae*), Oriental fruit fly (*B. dorsalis*) and Carambola fruit fly (*B. carambolae*) are all part of the Oriental fruit fly complex. All three species look extremely similar, but are all exotic, and can only be distinguished by a fruit fly expert.

Fruit flies are major pests and have been recorded on over 200 types of fruit and vegetables and can cause losses of up to 100% of unprotected fruit.

What do they look like?

Fruit flies are about the same length as a common housefly, but more slender. They grow to 6-8 mm in length and have clear wings, generally black chests and paler abdomens with a distinctive black T-shaped marking on the back. The Queensland fruit fly, by comparison, is much the same size but is an overall reddish-brown colour. An expert eye is needed to identify Oriental fruit flies under a microscope.

Pupae are white to yellow-brown in colour and barrel shaped, whilst larvae are about 10 mm long and creamy white. Eggs are white, elongate and elliptical measuring about 0.9 x 0.2 mm.

What can they be confused with?

Symptoms are similar to those caused by endemic fruit flies, such as the Queensland fruit fly. Papaya, Oriental and Carambola fruit flies look very similar to each other. Any fruit flies that look different from those regularly encountered should be reported and further examined by an entomologist.

What should I look for?

Adult female flies have exceptionally long ovipositors, allowing them to lay their eggs just under the skin of fruit, depositing fruit decaying bacteria at the same time. Within one to two days, the eggs hatch into maggots (larvae) which feed on the decaying fruit, causing premature fruit drop. Considerable damage



Scott Bauer

The female has a serrated-tip ovipositor for penetrating the skin of fruit



Division of Plant Industry Archive, Florida Department of Agriculture and Consumer Services, Bugwood.org

A T-shaped mark is often visible on the abdomen



PaDIL

Adult flies have a narrow brown band along the edge of their wings



can occur inside the flesh before obvious signs of infestation can be seen on the fruit. The most obvious signs of infestation are small discoloured patches on the skin, which develop from punctures or stings made by the female as she lays her eggs.

Infested young fruit becomes distorted, callused and usually drop, while mature fruit develop a water soaked appearance. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot.

How does it spread?

Adult flies can disperse over long distances through flight, while the transport of larvae in infested fruit can result in global movement.

Where is it now?

Papaya fruit fly is native to and widespread in south-east Asia (Thailand, Malaysia, Borneo, Singapore, and Indonesia). It is present in most provinces of mainland Papua New Guinea. It was detected in Cairns, Australia in October 1995 and was eradicated. Oriental fruit fly is widely spread throughout Asia and in the north of South America and parts of the South Pacific. Carambola fruit fly is found in South America.

How can I protect my orchard from Oriental fruit fly?

Source plant material only from clean, accredited suppliers, and preferably material that is certified. Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common mango pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline

**EXOTIC PLANT PEST HOTLINE
1800 084 881**



Adults grow up to 6-8mm in length



The thorax has yellow stripes on top and yellow marks on each side

Merle Shepard, Gerald R. Carner and P.A.C. Ooi, Insects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia, Bugwood.org

Division of Plant Industry Archive, Florida Department of Agriculture and Consumer Services, Bugwood.org

Mango pulp weevil

What is Mango pulp weevil?

Mango pulp weevil (*Sternochetus frigidus*) is a serious exotic pest that has the potential to cause high economic losses to the mango industry. Its close relative the Mango seed weevil (*S. mangiferae*) is already present in Eastern Australia.

What does it look like?

Mango pulp weevil larvae are white, legless grubs with brown to black head. Immature larvae can be up to 1.5 mm in length with mature larvae up to 17 mm long. Pupae are white to pale red and can be 10 mm long. Pupae stay in a chamber hollowed out in the flesh adjacent to the seed as they develop into adults. Eggs are white or pale yellow, elliptical and around 0.6 mm.

Adult weevils are small (6-9 mm) and stout and are dark brown in colour with paler patches. The head is small and the body covered with papillate scales. Adults stay in the chamber until mature and then emerge from the fruit by boring a hole through the skin.

What can it be confused with?

Mango pulp weevil larvae, pupae and adults look very similar to those forms of the Mango seed weevil. Whilst adults can be distinguished as separate species by entomologists, the most obvious difference in the orchard is that Mango pulp weevils destroy the pulp whereas the Mango seed weevil primarily infests the seed.



Adult weevils are dark brown with paler patches

PaDIL



Larvae tunnel into the fruit and feed on the pulp

Dr Mohd. Shamsudin Osman, MARDI, Malaysia



Green mangos are also susceptible to infestation

Dr Mohd. Shamsudin Osman, MARDI, Malaysia



What should I look for?

Eggs are laid in young fruit of at least 6 cm diameter and adult puncture wounds (small brown sites) may be seen on the fruit. Larvae tunnel into the fruit, feeding on the pulp, leaving brown, granular faeces behind, but showing no outward sign of infestation. Only when adults emerge are obvious symptoms visible, with circular emergence holes appearing in the skin of the fruit. Fruit drop may also occur. To check for infestation, the fruit must be sliced open.

How does it spread?

Adults are capable of flight but do not disperse long distances by this method. Long range dispersal of the weevil occurs primarily through the transport of infested fruit containing adults (which generally survive in fruit).

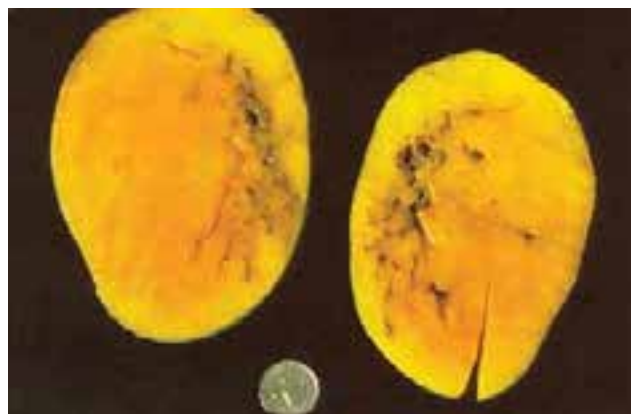
Where is it now?

Mango pulp weevil is widely distributed throughout Asia and is also present in Papua New Guinea.

How can I protect my orchard from Mango pulp weevil?

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common mango pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline



Prior to emergence of adults, damage can only be seen by opening the fruit

Dr Mohd. Shamsudin Osman, MARDI, Malaysia



Unlike seed weevils, Mango pulp weevils only feed on the flesh of the fruit

Dr Mohd. Shamsudin Osman, MARDI, Malaysia

Mango malformation disease

What is Mango malformation?

Mango malformation disease (MMD) was first observed in India in 1891 and has since spread across the globe to become the most important floral disease of mangoes. MMD is caused by one or more fungal species of the genus *Fusarium*.

What should I look for?

Young trees in nurseries are most vulnerable to vegetative malformation, including abnormal development of vegetative shoots and inflorescences. Shoots from apical or axillary buds are misshapen and have dramatically shortened internodes with narrow brittle leaves. Galls may be produced in the leaf axils. Primary and secondary axes on inflorescences are shortened, thickened and highly branched. Shoots tend to remain compact causing a bunchy-top-like appearance.

Panicles are thickened and produce enlarged flowers, and inflorescences typically contain three times the normal number of flowers. In particular, MMD increases the number of male flowers and hermaphrodite flowers that are produced. These are either sterile, or if fertilised, eventually abort. Malformed inflorescences do not produce mature fruit.

What can it be confused with?

The symptoms on vegetative tissue look similar to the malformation caused by bud mites. However, bud mites do not cause malformation of floral tissue, and tend to impact on older trees (unlike MMD which affects younger trees).



Barry Conde, DoR, NT

Primary and secondary axes on inflorescences are shortened



Barry Conde, DoR, NT

Thickened panicle caused by MMD



Barry Conde, DoR, NT

Malformed inflorescences do not tend to produce fruit



How does it spread?

Mango malformation disease is spread long distance on vegetative propagating material or infected pruning equipment. Circumstantial evidence indicates that its spread from plant to plant within orchards is aided by injuries from the Mango bud mite (*Aceria mangiferae*).

Where is it now?

It is now present in India, Brazil, Central America, Egypt, Florida, Israel, Mexico, Pakistan, South Africa, Sudan, Swaziland and Uganda, and possibly Malaysia.

How can I protect my orchard from Mango malformation disease?

Source plant material only from clean, accredited suppliers and preferably use material that is certified. Grafting or marcot material should never be taken from an infected orchard. Thorough cleaning of pruning equipment between trees reduces the spread of pests. Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common mango diseases so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline

**EXOTIC PLANT PEST HOTLINE
1800 084 881**



Axes on the inflorescence become highly branched

DEEDI



Inflorescences are malformed

DEEDI



Inflorescences typically contain three times the normal number of flowers

DEEDI

Mango gall midges

What are Mango gall midges?

Mango gall midges (*Procontarinia* spp.) are a range of damaging fly species. The different species can attack leaves [such as Mango leaf-gall midge (*P. matteiana*)], which reduces photosynthesising capacity), flowers (affecting fruit set), shoots or fruit (blemishing the fruit).

What do they look like?

In some species the eggs are laid into tender leaves, causing small reddish spots (oviposition marks). The tissue under these spots becomes soft. Gall formation begins within a week and attain their maximum diameter of 3-4 mm before the larva is even 0.5 mm. Adults usually emerge from the lower side of the leaves, leaving the pupal skin protruding from the emergence hole. Heavy oviposition in leaves causes them to dry and curl up.

What can they be confused with?

Galls are distinctive raised spots or bumps. Other spots or lesions (not raised) may be caused by Mango scab (a fungus), Stigmata leaf spot, Fruit spotting bugs or mechanical damage.

What should I look for?

Eggs are laid onto leaves causing small, red spots. The most prominent symptom is the presence of wart-like galls up to 4 mm in diameter on the leaves and occasionally on stems or fruit. Heavily galled leaves may curl up and drop prematurely, causing dieback of whole branches in susceptible mango cultivars.

How does it spread?

Mango gall midge is spread by wind currents and long distance dispersal is through movement of infested plant material.



Eggs are laid onto leaves causing small red spots



Galls can appear wart-like



Leaf photosynthetic capacity can be greatly reduced



Where is it now?

Mango leaf-gall midge (*P. matteiana*), is indigenous to India and has spread via imported mango plants to Mauritius, Kenya, Reunion, South Africa and Malaysia. Significant damage to mango plants by the pest has been reported in Mauritius.

Another species, *P. pustulata*, is present in Papua New Guinea, the Torres Strait Islands and northern tip of Cape York Peninsula but has not reached commercial mango production areas of Australia. The Mango fruit-gall midge (*P. frugivora*) is found in the Philippines, whilst the Mango blossom-gall midge (*P. mangiferae*) is found throughout Asia.

How can I protect my orchard from Mango gall midge?

Source plant material only from clean, accredited suppliers and preferably source material that is certified. Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common mango pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline

**EXOTIC PLANT PEST HOTLINE
1800 084 881**



Whole branches may be affected



Galls are 3-4 mm in diameter



Heavily galled leaves curl up and may drop prematurely

Red banded mango caterpillar

What is Red banded mango caterpillar?

Red banded mango caterpillar (RBMK; *Deanolis sublimbalis*) is a pest of mango in tropical parts of Asia where it causes commercial losses in the order of 10-15%. It is considered a serious threat to Australia's commercial mango industry.

What does it look like?

The larvae are plump and glossy with distinctive bright white and dark red bands and they have a black collar near the head. More than one larva can be present in each fruit.

Eggs are laid by the fawn coloured adult moth on the peduncle (fruit stalk) and after 7-8 days hatch into larvae, which tunnel into the flesh and then into the seed. Larvae feed for 15-20 days and pupate in the soil for around 20 days, before emerging as the adult moth to continue egg-laying. The biology and life history of RBMK is not completely understood.

What can it be confused with?

Dark streaks on the mango skin may be similar to those caused by Mango pulp weevil and Mango seed weevil.

What should I look for?

An obvious external sign of infestation is the presence of a liquid exudate from the mouth of a tunnel chewed by the caterpillar through the skin. It trickles down to the tip of the fruit and accumulates. Although almost clear when fresh, the liquid darkens and shows up as a dark streak on the skin leading to a dark spot at the fruit tip.

Early signs of infestation may not be as easily seen and could include small darkened boreholes on the fruit caused by entering larvae.



Adult moths are fawn coloured

PaDIL (Lindsay Chandler)



Larvae have distinctive dark red bands

PaDIL (Glynn Maynard)



Larvae are usually seen tunnelling in the seed

PaDIL (Lindsay Chandler)



Damaged fruit may be attacked secondarily by fruit flies or various decay organisms and may fall from the tree prematurely.

To inspect fruit for RBMC, cut it open to expose the inside of the seed. The larvae will most likely be seen tunnelling in the seed, but can also be present in the flesh.

How does it spread?

RBMC is spread through movement of infested plant material.

Where is it now?

RBMC exists in India, Burma, the Philippines, Indonesia and Papua New Guinea. It may be more widely distributed in South-East Asia than records indicate. Since 1990 it has been detected on several Torres Strait Islands and is now known to occur at several locations near the northern tip of Cape York Peninsula, but it has not reached any commercial mango plantations.

How can I protect my orchard from Red banded mango caterpillar?

Keep watch for this pest during the fruiting period and advise Biosecurity Queensland of any suspected infestation. Due to the isolation of RBMC detections on Cape York Peninsula and the Torres Strait, it poses no immediate threat to the mango industry. The detections should also not affect national or international trade from commercial mango production areas. Biosecurity Queensland regularly surveys Cape York Peninsula for RBMC and other mango pests.

If you see anything unusual, call the Exotic Plant Pest Hotline

**EXOTIC PLANT PEST HOTLINE
1800 084 881**



PaDIL (Lindsay Chandler)

To inspect fruit for RBMC, cut it open to expose the inside of the seed



DEEDI

Darkened borehole on the fruit caused by entering larvae



PaDIL (Lindsay Chandler)

Liquid exudate shows up as a dark streak on the skin leading to a dark spot at the fruit tip

For more information visit www.planthealthaustralia.com.au

Blue-striped nettle grub

What is Blue-striped nettle grub?

The Blue-striped nettle grub (*Parasa lepida*) is a damaging pest with a wide host range, including banana, cocoa, castor, citrus, coconut, palms, peas, pineapple, mango, rice, and rose.

What does it look like?

The grubs have thick, fleshy green bodies with three pale blue longitudinal stripes. When mature, they are about 3-4 cm long. The cocoons look like large seeds. They are spherical, about 5-15 mm in diameter, and consist of a hard papery shell covered with a thin layer of silk. Cocoons are found buried in the soil (within the top 2 cm) or among dead leaves.

The overall colour pattern of the adults (moths) is similar in both sexes. The head and thorax are yellowish-green. The abdomen is reddish-brown, and the legs are dark red-brown with well-developed tufts of bristles. A brownish fringe surrounds the outer edge of the wing.

What can it be confused with?

Leaf damage and defoliation of trees can be caused by other insect pests. Positive identification requires detecting the moths or grubs themselves.

What should I look for?

The grubs are conspicuous, recognised by three blue longitudinal stripes on the body. Symptoms of their presence in trees include holes chewed in leaves and later, defoliation of the whole tree. The first outbreaks of the Blue-striped nettle grub are usually localised, with only a few trees defoliated.



Masaki Ikeda

An early instar larva



Dr V. Shubhalaxmi

The head and thorax of adult moths are yellowish-green



DEEDI

Grubs are 3-4 cm long when mature



How does it spread?

Blue-striped nettle grub may be dispersed through plant material contaminated with eggs or larvae.

Where is it now?

The Blue-striped nettle grub is found in Papua New Guinea, Indonesia (Sumatra, Java, Bali), the Philippines, Malaysia, Thailand, Vietnam, Laos, China, Japan, Pakistan, Bangladesh, India, Nepal, Sri Lanka and Africa.

How can I protect my orchard from Blue-striped nettle grub?

Source plant material only from clean, accredited suppliers, and preferably material that is certified. Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common mango pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline

**EXOTIC PLANT PEST HOTLINE
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Adult moth

Show Ryu, Wikimedia Commons

Mango fruit borer

What is Mango fruit borer?

Mango fruit borer (*Citripestis eutraphera*) is a pest of mangoes in India, Indonesia and parts of the Northern Territory.

What does it look like?

Adult moths live for about a week and lay 125-450 eggs on rough areas of the fruit and pedicels. Larvae enter the fruit and feed on the pulp and seed. The infested fruit drop prematurely. A fully grown caterpillar can measure 20 mm in length. It pupates in a loosely woven silken cocoon in the soil adjacent to the fallen fruit. Development takes 30 days.

The larvae are reddish violet and turn darker as they develop into pupae.

The adult is a medium-sized moth with a wingspan of 20 mm. The fore-wings are grey without any specific markings, whereas the hind wings are transparent.

What can it be confused with?

Mango seed borer, Red Banded Mango Caterpillar and mango weevils all cause staining on the surface of the fruit.

What should I look for?

Boreholes, from which frass is ejected, can be seen in infested fruit. Premature fruit drop is an indication of infestation. Hundreds of young fruit can be found under heavily infested trees.

How does it spread?

Adults are capable of flight and their distribution can be assisted by the wind or can be spread through movement of infested fruit.



Lanni Zhang, DoR, NT

Adult moths have a wing span of around 20 mm



Lanni Zhang, DoR, NT

Young larvae are reddish-violet in colour



Glenn Bellis, NAQS

Larvae turn darker as they develop into pupae



Where is it now?

India, Indonesia and parts of the Northern Territory.

How can I protect my orchard from Mango fruit borer?

Source plant material only from clean, accredited suppliers, and preferably material that is certified. Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common mango pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline

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Lanni Zhang, DoR, NT

Eggs are laid on rough areas of the fruit



Lanni Zhang, DoR, NT

Larvae enter and feed on pulp and seed



Lanni Zhang, DoR, NT

Frass can be seen in infested fruit

Mango sudden decline syndrome

What is Mango sudden decline syndrome?

Mango sudden decline syndrome (MSDS) describes one or a series of diseases and disease symptoms, including blight, canker, gummosis, twig blight, tip dieback and vascular staining, caused by several species of the fungus *Ceratocystis*. The disease is widespread and can be very destructive, particularly when introduced into a new area.

What does it look like?

MSDS causes parts or all of the tree to wilt and die. Amber coloured gum exudes from the bark of branches and trunks and vascular tissue is discoloured, firstly blue-grey but then chocolate brown as the disease progresses. Pin-sized holes, caused by the Mango bark beetle, which can spread the disease, are also often present.

What can it be confused with?

MSDS can be confused with other fungal pathogens or termite damage that can cause decline of major branches. The Brown root rot fungus (*Phellinus noxius*) has also been recorded causing a sudden wilt and death of mango trees.

What should I look for?

Wilting or death of a major branch of the tree followed by complete tree death. Pare back the bark and look for a blue-grey staining of the vascular tissue or in more advanced cases a light brown to chocolate brown rot of the sap wood.



Staining of vascular tissues due to MSDS



Vascular tissue becomes brown as disease progresses



Boreholes from the Mango bark beetle may be present

Ali Obaid Al-Adawi, Ministry of Agriculture, Sultanate of Oman

Ali Obaid Al-Adawi, Ministry of Agriculture, Sultanate of Oman

Ali Obaid Al-Adawi, Ministry of Agriculture, Sultanate of Oman



How does it spread?

The lifecycle of the disease is not fully understood, however there is clear evidence for the role of the Mango bark beetle in spreading the disease.

Where is it now?

MSDS has been reported from Brazil, Pakistan and Oman.

How can I protect my orchard from Mango sudden decline syndrome?

Source plant material only from clean, accredited suppliers and preferably material that is certified. Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common mango diseases so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline

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1800 084 881



Amber coloured gum exudes from the bark of the trunk

Ali Obaid Al-Adawi, Ministry of Agriculture, Sultanate of Oman



Early signs include wilting of branches

Ali Obaid Al-Adawi, Ministry of Agriculture, Sultanate of Oman



Wilted branches later die, leading to death of whole trees

Ali Obaid Al-Adawi, Ministry of Agriculture, Sultanate of Oman

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AUSTRALIA**