Farm Biosecurity Manual
for the Cotton Industry

Reducing the risk of new pests impacting on your farm

Version 1.01

Plant Health AUSTRALIA

NSW Department of Primary Industries

Queensland Government

Australian Government Cotton Research and Development Corporation

CSIRO

COTTON AUSTRALIA
Advancing Australian Cotton

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

COTTON AUSTRALIA
Advancing Australian Cotton

Cotton Australia is the key representative body for the Australian cotton growing industry, representing and promoting the interests of Australia's 1000 cotton producers.

Cotton Australia determines and drives the industry's strategic direction, retaining its strong focus on research and development, promoting the value of the industry, reporting on its environmental credibility, and implementing policy objectives in consultation with its stakeholders.

Cotton Australia works to ensure an environment conducive to efficient and sustainable cotton production. It is the cotton industry member of Plant Health Australia and the National Farmers Federation.
www.cottonaustralia.com.au

Queensland Government

Biosecurity Queensland and Agri-Science Queensland, parts of the Queensland Department of Agriculture, Fisheries and Forestry, are working to promote profitable primary industries for Queensland. This will be 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.

Queensland DAFF 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.daff.qld.gov.au

NSW GOVERNMENT Department of Primary Industries

NSW Department of Primary Industries works with agricultural industries, collaborators and stakeholders to improve the profitability, sustainability and skills of the agricultural sector. Staff deliver research, development, extension, education and industry development programs in the fields of agricultural productivity, food security, climate, water and soil. In addition, the Department plays an important role through managing the risks posed by pests, weeds, diseases and chemicals to the economy, community and the environment.
www.dpi.nsw.gov.au

Australian Government
Cotton Research and Development Corporation

Cotton Research and Development Corporation is a partnership between the Australian cotton industry and the people through the Australian Government. Our vision is a globally competitive and responsible cotton industry.

The Corporation provides leadership and investment in research, innovation, knowledge creation and transfer.
www.crdc.com.au

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An electronic copy of this manual is available from the website listed above.

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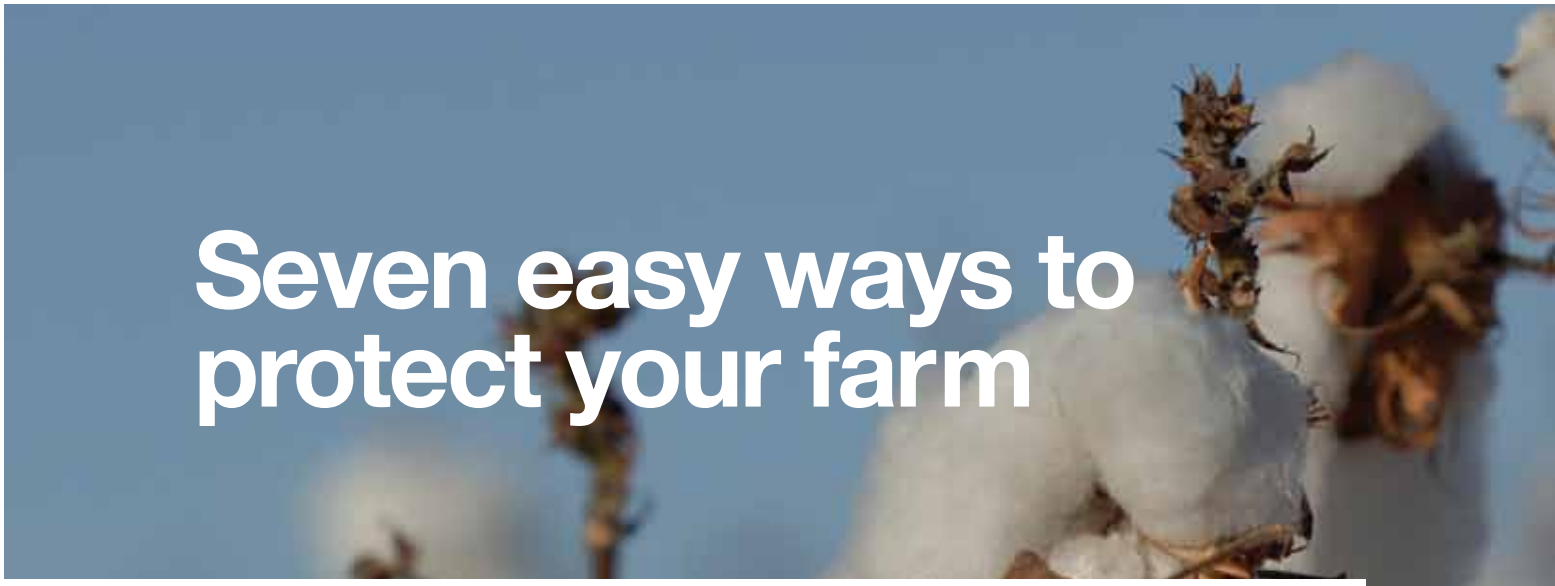

Seven easy ways to protect your farm

Here are seven easy ways you can reduce the threat of new pests (which includes insects, diseases and weeds) entering, establishing and impacting on your farm. These practices apply to all activities being carried out on your property.

1. Be aware of biosecurity threats

Make sure you, your farm workers and contractors are familiar with the most important exotic cotton pests (see page 8).

2. Use 'clean' farm inputs

Ensure all seed (for cotton and other crops) and other farm inputs that are brought onto your farm are pest-free. Keep records of your farm inputs and where they came from.

3. 'Come Clean Go Clean'

Practicing good farm 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 decontaminated before they enter and leave your farm. Have a designated visitor's area and provide wash-down facilities for machinery, vehicles and people. Keep up-to-date with recommended protocols for wash-down.

4. Control volunteers

Keep your farm free of cotton volunteer plants at all times throughout the year.

5. Check your crop

Monitor your crop frequently. Being familiar with the usual appearance of your crop and local pests will help you recognise new or unusual symptoms and pests. Keep written and photographic records of all unusual observations. Vigilance is vital for early detection of any exotic plant pest threat.

6. Abide by the law

Be aware of and support laws and regulations established to protect the cotton industry.

7. 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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myBMP – Best management practices for cotton biosecurity

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myBMP is the "one stop shop" for best practice in the Australian cotton industry. It provides growers information and guidelines to implement best practice in all farm activities. The latest scientific knowledge, resources, personalised support and technical assistance is available to growers to meet best practice standards along the entire cotton value chain. Gain access to myBMP at **www.mybmp.com.au**.

myBMP comprises 11 modules (see below), each selected and written to provide a library of practices and information covering every aspect of the farm.

myBMP

Module	Details
Biosecurity	Covering the avoidance, management and control of pests and diseases
Biotechnology	For GM cotton varieties
Energy and greenhouse gases	More efficient use of energy inputs such as fuel and fertilisers
Fibre quality	For growing the best quality cotton that you can
Human resources	Best Management Practices for staff and contractors
IPM	For weeds, pests and diseases
Natural assets	Managing the vegetative and riparian assets on your farm
Pesticide management	For all aspects of pesticide storage and use
Petrochemical storage and handling	For all aspects of petrochemical storage and use on farm
Soil health	How to best look after one of your most important assets
Water management	Covering water quality, efficiency of storage and distribution as well as both dryland and irrigated farming practices

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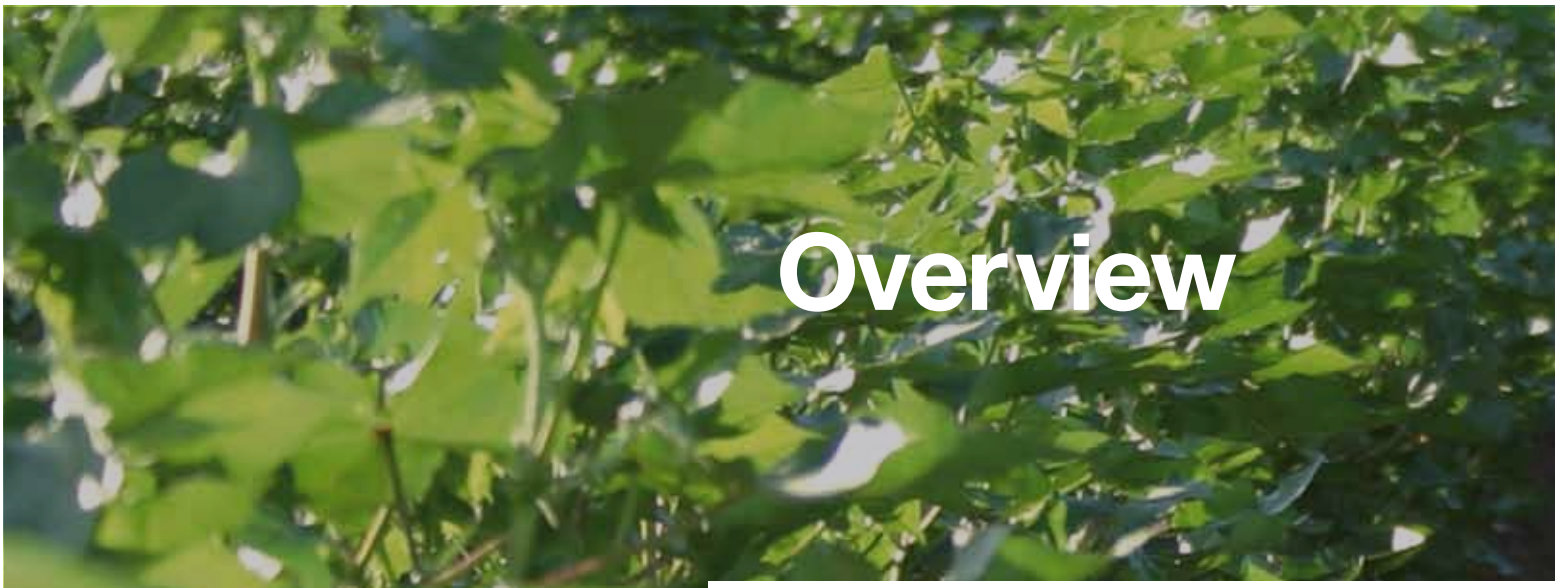

Overview

This manual is designed to assist you in protecting your farm and the entire cotton industry from new and invasive pests. By implementing the recommended measures in your day-to-day operations, you will improve your farm's biosecurity and that of your region. For the best protection of your farm, this manual should be used in conjunction with myBMP (see page 4).

What is biosecurity?

Biosecurity is the protection of your property and the entire industry from the entry, establishment and impact of exotic pests. Biosecurity measures implemented on-farm by growers play a key role in protecting the Australian cotton industry from exotic pests.

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

Effective biosecurity can keep Australia free from many of the pests that affect plant industries overseas, increasing our sustainability and production efficiency. In addition, biosecurity practices can limit the effect of endemic pests through maintaining area freedom or minimising their impacts and spread.

What is farm biosecurity?

Farm biosecurity is a set of management practices and activities that are carried out on-farm to protect your property from the impact of pests.

Implementing farm biosecurity is essential for your business. If a new pest becomes established on your farm it may result in increased farm costs (e.g. additional control/management measures) and reduced productivity (yield and/or quality).

Farm biosecurity is your responsibility and that of every person visiting or working on your property.

Regional biosecurity

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

Potential sources of biosecurity threats may be neighbouring farms (cotton or otherwise, operating or abandoned), native vegetation, gardens, roadside vegetation and volunteer plants.

Promotion of biosecurity at the regional level is enhanced through broad engagement of the community, understanding the region's vulnerability and the source and nature of threats, and having knowledge of the expertise base and resources available to the region.

This is supported by a commitment from stakeholders to implement biosecurity measures, carry out surveillance and report suspect pests. Through these mechanisms a regional framework for biosecurity can be coordinated and is achievable.

Implementation of farm biosecurity underpins regional biosecurity, which in turn underpins national biosecurity.

Pests

High priority exotic pests of the cotton industry

The following are high priority exotic pest threats for the Australian cotton industry. For a complete list of exotic pest threats for the cotton industry, refer to the Cotton Industry Biosecurity Plan (IBP), available by contacting Cotton Australia **www.cottonaustralia.com.au** or Plant Health Australia **www.phau.com.au**.

Additional information on each of these pests is included in the fact sheets at the back of his manual.

Fusarium wilt (exotic races)

OVERALL RISK – EXTREME

- Fungus – *Fusarium oxysporum* f. sp. *vasinfectum*
- Found in every cotton-growing region in the world
- Risk is from new strains establishing to which the local cotton varieties have little or no resistance
- External symptoms: stunted growth, wilted leaves, yellowing, browning, eventual death
- Internal symptoms: brown discolouration of stem tissue
- Spread by spores in soil, water and infected plant material
- Look for Fusarium symptoms on varieties that should be resistant

Jack Kelly Clark, UC Statewide IPM Program

Bacterial blight (exotic/hypervirulent races)

OVERALL RISK – HIGH

- Bacterium – *Xanthomonas citri* subsp. *malvacearum*
- Hypervirulent strains found in North Africa
- Risk is from new strains establishing to which the local cotton varieties have little or no resistance
- Angular water-soaked lesions on leaves, stems and bolls
- Severe infestations lead to defoliation
- Stems show 'black arm' symptom, bolls unable to open
- Look for Bacterial blight symptoms on varieties that should be resistant
- Spread by rain-splash, in seed and plant material

Stephen Allen, CSIRO

Cotton aphid (exotic strains)

OVERALL RISK – HIGH

- Aphid (Hemiptera) – *Aphis gossypii*
- Found in every cotton-growing region in the world
- Risk is from new strains establishing that may carry exotic pathogens or show greater pesticide resistance
- Small (less than 1.5 mm), range in colour from pale green to almost black, and have two short projections ('exhaust pipes') from the rear end
- Infestations often associated with honey-dew on leaves
- Look for aphid infestations that do not respond to current pesticide applications
- Can walk or fly between plants and spread long distances in wind or on plant material

Lewis Wilson, CSIRO

Cotton boll weevil

OVERALL RISK – HIGH

- Weevil (Coleoptera) – *Anthonomus grandis*
- Found in North, Central and South America
- Greyish-brown adults, body 5 mm, conspicuous snout 3 mm
- White legless larvae, 13 mm, grow within developing squares and bolls
- Spread in seed or bolls and harvested seed cotton
- Can fly long distances on wind currents

Alton N. Sparks, Jr., University of Georgia, Bugwood.org

Cotton leaf curl disease

OVERALL RISK – HIGH

- Virus complex – including the *Cotton leaf curl virus* (*Begomovirus*)
- Found in Pakistan, India, Egypt, Nigeria, Tanzania, Sudan
- Swelling, darkening of leaf veins, cupping leaves, leaf-like growths from veins, early stunting
- Many alternative hosts (e.g. tobacco, tomato, chilli, radish, okra)
- Spread by whiteflies

Rob Briddon, National Institute for Biotechnology and Genetic Engineering, Pakistan

Spider mites (exotic species)

OVERALL RISK – HIGH

- Mites – e.g. *Tetranychus turkestani*, *T. pacificus*, *T. cinnabarinus*
- Spider mites high risk to the Australian cotton industry are present in North and South America, Asia and Africa
- Small (less than 0.5 mm), red or green in colour and have eight legs
- Exotic species may not respond to current pesticides or may attack crops not normally affected by spider mites
- Look for intense crop damage, unusual looking mites or the presence of mites on the upper leaf surface (*T. pacificus* only)
- Long distance spread may occur with infested plant material

Jack Kelly Clark, UC Statewide IPM Program

Verticillium wilt (defoliating strains)

OVERALL RISK – HIGH

- Fungus – *Verticillium dahliae*
- Found in China, Iran, Israel, Mexico, Peru, Spain, USA, former USSR
- Risk is from new, defoliating strains establishing to which the local cotton varieties have little or no resistance (non-defoliating strains present in Australia)
- Extremely wide host range, including vegetable, fruit and broadacre crops
- Leaf mottling, vascular peppering, total defoliation, boll shedding
- When the stem is cut lengthways, vascular discolouration exhibits flecking of the inner tissues
- Spread by spores in water, soil and infected plant material, clothing and equipment

Jack Kelly Clark, UC Statewide IPM Program

Cotton blue disease

OVERALL RISK – MEDIUM

- Virus – Luteovirus (suspected)
- Found in parts of Africa, Asia and South America
- Stunted plants with down-rolling leaf edges, intense blue-green leaves, darkening of veins, petioles, stems, zig-zag stems, smaller flowers and bolls
- Cotton aphid is the only known vector
- Host plant resistance is available but may be overcome by some variants of the disease

Stephen Allen, CSIRO

Indian green jassid

OVERALL RISK – MEDIUM

- Sap-sucking insect (Hemiptera) – *Amrasca devastans*
- Found in Asia and the Indian subcontinent
- Yellowish white eggs (1 mm long) and greenish-yellow nymphs (1-2 mm long) with bluish legs
- Adults yellowish-green in summer, reddish-brown in winter
- Prominent black spots – two on head and one on each forewing
- Plant symptoms include leaf yellowing, crinkling, curling, stunted growth and fewer bolls
- Flying adults spread in wind currents, and eggs and nymphs can be carried on seeds, bolls and harvested seed cotton

James Litsinger, IRRI

Tarnished plant bug

OVERALL RISK – MEDIUM

- Insect (Hemiptera) – *Lygus lineolaris*
- Found throughout North America
- Wide host range
- Greenish yellow to brown bug (6 mm long) with varied markings
- Nymphs are yellow-green with dark markings
- Infest leaves, squares, bolls, flowers, cause seed/shoot damage, lint discolouration and delayed maturity
- Adults spread in wind, especially in storms
- Can develop resistance to pesticides

Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Texas root rot

OVERALL RISK – MEDIUM

- Fungus – *Phymatotrichopsis omnivora*
- Found in USA, Mexico, Brazil, Venezuela and reported in Libya
- Wide host range, including vegetable, fruit and broadacre crops
- Symptoms include wilting, dead leaves on plant, dead roots covered with white-tan fungus
- Generally results in circular patches of dead/dying plants in the field
- Spread via infected root contact, in soil and with infected root material

Chris Anderson, I&I NSW

Look for anything unusual on your farm. If a pest is not normally present on your farm, it may be new not only to your farm, but to the region, state or even Australia.

12 Exotic pest surveillance

To improve biosecurity measures on your farm, include exotic pests, such as those listed in this manual, when undertaking routine pest surveillance activities. Ensure that all surveillance activities, for both endemic and exotic pests, are recorded.

Consultants carrying out the surveillance should be provided with pest fact sheets that show key symptoms for identifying characteristics of the target exotic pests.

In addition, any unusual plant symptoms, pests or abnormal responses to pesticides, should be reported and submitted for identification.

Report suspect pests

Early detection and reporting of new pests will minimise their long-term impact on your farm and the cotton industry as a whole.

If you see anything unusual, call 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 will either arrange to collect a sample or give information on how and where a sample should be sent.

Do not send samples without first speaking to an entomologist, pathologist, weed scientist or biosecurity officer from the state department, who can discuss the correct protocol for sampling, packaging, handling and transport to a laboratory assigned for diagnosis.

Incorrect handling could spread the pest further or render the samples unfit for diagnosis.

In some states, 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 checked out and treated confidentially.

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

- Do not touch, move or transport affected plant material.
- Wash hands, clothes and footwear that have been in contact with affected plant material or soil.
- Mark the location of the pest detection and limit access to the area.
- 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

The Emergency Plant Pest Response Deed and the cotton industry

The Emergency Plant Pest Response Deed (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, Cotton Australia 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, Cotton Australia has a responsibility to report suspect pests and promote the importance of reporting to cotton growers. 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.

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 consequence, under the EPPRD, grower reimbursement payments (Owner Reimbursement Costs; ORCs) are 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 and additional chemical treatments.

For more information about the EPPRD refer to the PHA website at **www.phau.com.au/epprd**

Product management

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Cotton seed purchased in the Australian cotton industry is certified to be disease-free. However, cotton pests may be brought onto the property with seed for other crops. Ensure seed for alternate crops is also from a reputable source, preferably with certification.

Many cotton pests, both endemic and exotic, can attack alternate crops, allowing for an increase in pest population levels before moving into cotton crops. To minimise the potential impacts, ensure the good biosecurity practices applied to the cotton crop are also applied to other crops grown on your property.

Weed management

Weed species are a significant biosecurity threat in their own right as well as acting as alternate hosts for many cotton pests. Good weed control practices can significantly contribute to limiting the impact of pests on crops.

Encourage staff to stay alert to new infestations of weeds, as the early detection of a new weed species and limiting its distribution on your property make it easier to control. Monitor risk areas, such as roadways, and river and channel banks for new weeds.

Monitor results from spray applications, as new weed seeds introduced onto your farm may be herbicide resistant.

Key points for on-farm weed management include:

- Develop a weed management plan or incorporate weed seed spread prevention into existing management systems.
- Use integrated weed management for more effective control. For more information see relevant sections of WEEDpak.
- Manage the buffer area or windbreak around your boundary.
- Clean machinery, vehicles and tools that have been in weed-infested areas.
- Request that visitors (including service providers) have cleaned their vehicles, machinery and equipment before entering your property.
- Request written assurance that vehicles and machinery are clean.
- Request a Weed Hygiene Declaration when buying anything that has the potential to be contaminated with weed seed.
- Familiarise yourself with existing weed species on your farm so you can tell if you spot something different.

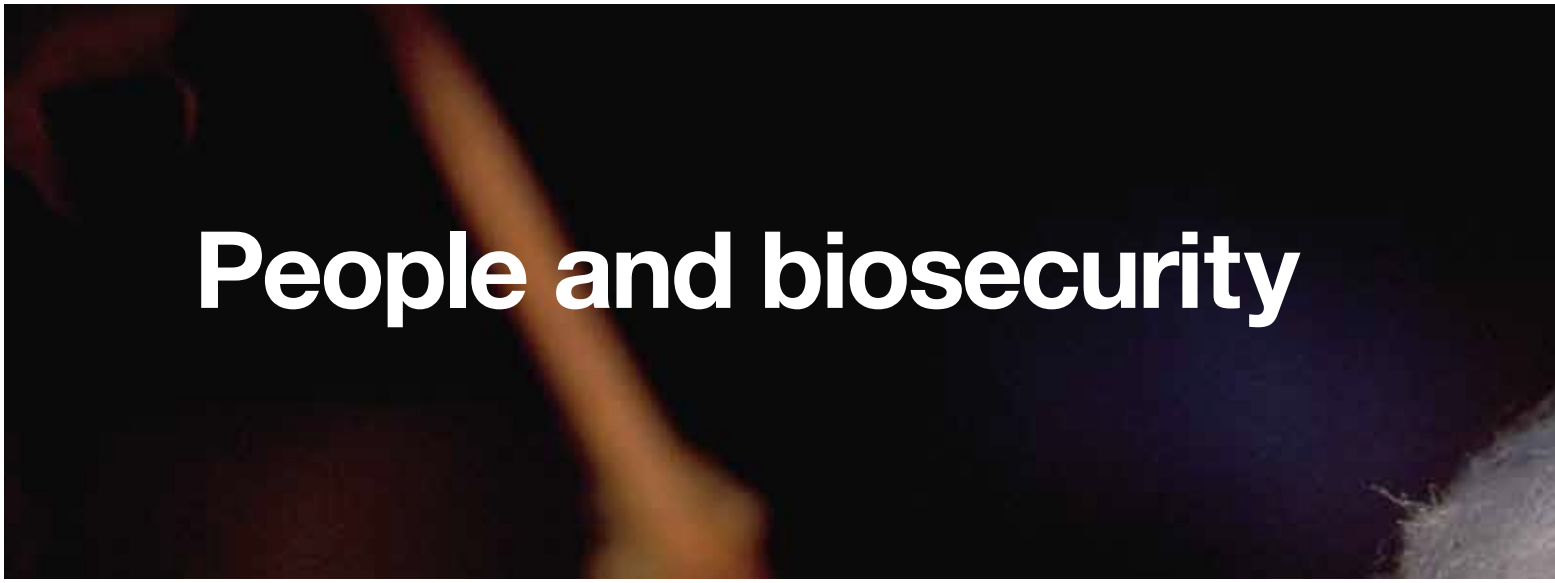
Ratoon and volunteer cotton

Volunteer and ratoon cotton can harbour pests, carrying them from season to season and providing an inoculum source for early re-infection of the following year's crop.

Ensure crop destruction and follow-up controls remove all volunteer/ratoon cotton in fields. In addition, control volunteer cotton external to the field (e.g. roadways, head ditches, etc.).

Ten reasons why ratoon and volunteer cotton must go:

1. Mealybugs survive from one season to the next on these food sources, infesting crops earlier in the following season.
2. Cotton aphids with resistance to neonicotinoids survive between seasons on these plants, reducing insecticide effectiveness.
3. Bunchy top disease can be transmitted by Cotton aphids from infected ratoons to new cotton crops.
4. Silverleaf whitefly survive between seasons on these plants, resulting in earlier infestation in the following season.
5. They provide a winter host for Pale cotton stainers and solenopsis mealybugs.
6. Inoculum of soil-borne diseases such as Black root rot, Fusarium and Verticillium builds up in ratoons.
7. Ratoon plants place extra selection pressure on *Bt* cotton in two ways:
   a. Ratoon cotton can be used as a host by the earliest and latest *Helicoverpa* generations.
   b. Ratoon plants may only express sub-lethal doses of the *Bt* proteins, therefore increasing resistance selection pressure.
8. Fields with ratoons from *Bt* cotton are unsuitable for planting refuge crops, as the refuges cannot be effective if contaminated with *Bt* cotton plants.
9. Removing ratoons may be a costly exercise, but it is cheaper than the costs of dealing with the problems resulting from not removing them.
10. They are a biosecurity risk. Ratoons harbour pests and are a potential point of establishment for exotic pests.



People and biosecurity

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Biosecurity signs

Well designed signage informs visitors that biosecurity on your property is important and that they share responsibility for maintaining it.

Signs also demonstrate your commitment to farm 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 sheds should direct visitors to contact the owner or farm manager to formally register their presence before entering your property or any production areas. The sign should include important contact details, such as the home telephone number, mobile number and/or UHF channel.

A template that can be used for the printing of biosecurity signs can be obtained from the PHA website **www.phau.com.au/biosecurity**.

Managing people movement

People moving between farms and regions can spread pests on vehicles, equipment, footwear and clothing. The most obvious risks are pests carried in soil and plant material, but pests may also be present on clothing, especially aphids, mites, mealybugs and pathogens.

Maintaining a visitor register (example on page 22) to track the movement of people on your farm, may allow the source of any pest introductions to be identified.

Implementing the following measures will reduce the threat of introducing new pests onto your farm:

- Brief all workers, contractors and visitors about your farm hygiene measures.
- Ensure employee and visitor footwear and clothing are free of soil and plant material before entering or leaving the farm.
- Provide scrubbing brushes, footbaths, boot covers, rubber boots and protective clothing such as disposable overalls, for people entering or leaving your farm, or moving from contaminated to clean areas of the property.

Footbaths

Footbaths should be used when moving from infested fields to clean fields, at the start and end of a field day, and on departure from a Fusarium trial site. Remove excess mud and debris from boots before using the footbath.

The footbath should be located on a clean, hard and dry surface and contain a 10% Farmcleanse® (recommended) or 1% bleach (active chlorine) solution.

As an alternative, boots and lower legs can be covered with large polythene bags fastened with a rubber band before entering the field. Bags are then discarded appropriately on leaving the field.

Overseas travellers

People returning from overseas are a threat to our biosecurity, especially if they have visited crops, farms or markets where plant material was grown or for sale.

Check that family members, employees and visitors recently returned from overseas have washed themselves, their clothes and cleaned their footwear before entering your farm. Also check that they have not brought in any plant material.

Clothes, hair and even watchbands can carry fungal spores or bacteria and weed seeds can easily lodge in pockets, sleeves and trouser cuffs. Great care should be taken to prevent the accidental introduction of overseas plant pests into Australia. Be aware that plant pests are only a few hours away by air travel.

Consultants, casual workers, contractors

Throughout the cotton season a number of farm consultants, earthmoving companies, utility providers, research personnel, contractors and casual workers may come onto your property.

While their contribution is highly valued, they can be a particular biosecurity threat because they move from property to property and region to region. They can potentially spread pests from and to susceptible hosts on their clothing, footwear, gloves, vehicles and equipment.

Be mindful of the increased biosecurity threat they pose, and ensure that these groups are aware of your farm biosecurity program during their induction. Like all visitors and staff on your property, they should follow your farm biosecurity practices.

Equipment and vehicles

18 Movement of vehicles and machinery

Vehicles and farm equipment can carry pests in attached soil and plant material, allowing them to be introduced to a previously clean property or crop.

To reduce the risk of pest entry, ensure all visitors ‘Come Clean Go Clean’:

- Do not allow dirty vehicles on or off your farm.
- Provide access to a wash-down pad with access to high pressure water and Farmcleanse®.
- Ensure all vehicles and machinery have been washed down, inside and out, before entering or leaving your farm.
- Ensure all contractor or borrowed equipment is free of soil or plant material before entering or leaving your farm.
- Provide a visitor parking area, and where possible, use your own vehicle to carry visitors around your farm.
- Minimise driving in muddy conditions and limit farm traffic to regular roadways.
- Minimise spillage and loss when transporting modules, hulls, cotton seed, husks or gin trash.
- Wherever practical, known pest-affected areas should be the last to be worked or picked, to minimise the risk of pest spread via machinery to other parts of the farm.

Designated parking areas

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

Designated parking areas help limit the entry of new pests to an area away from production sites. They also allow for the inspection of tyres, equipment, floor mats and boots for soil and plant material. This area should be frequently monitored for the presence of new pests.

A biosecurity sign should be placed in the parking area to remind visitors that biosecurity is taken seriously on your farm.

Do not allow the movement of farm machinery or farm vehicles through the parking area.

Wash-down facilities

A wash-down facility allows farm employees, contractors and visitors to clean their vehicle and equipment in an easily managed area where waste water is contained.

Wash-down facilities should:

- Be readily accessible and located between the driveway and farm roads.
- Have a sealed (concrete or bitumen) or packed gravel surface.
- Have access to high-pressure water and power.
- Be isolated from production areas and not drain into waterways or cropping areas.
- Have a sump or collection area for easy inspection and waste management.

For additional protection, an added detergent-based degreaser or disinfectant (e.g. Farmcleanse®) may be appropriate. For best results, apply the disinfectant to mud and plant debris and allow it to soak before using high pressure water to blast mud and plant debris from your vehicle.

When cleaning equipment with high pressure water, make sure mud, soil and plant material are kept away from crops, storage areas and waterways. The waste water should be collected in a sump or waste water collection area. This area should be checked and treated frequently for the presence of pests and weeds.

For the best results, dismantle the machinery as far as possible to give access to internal spaces. Also, leave covers off after cleaning to allow for inspection.

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 must be taken into account.

Further information on wash-down facilities can be found at **www.daff.qld.gov.au/4790_7071.htm**

Farm biosecurity checklist

Property name: _____

Date of biosecurity check: _____

RECOMMENDED PRACTICES	YES	NO	COMMENTS
Pests			
Commercial crops and neighbouring vegetation are frequently inspected for pests			
Active pest surveillance is regularly conducted, with activities and results recorded even when nothing is found			
You, your family and your staff are familiar with endemic cotton pests, so you know when you spot something unusual			
You, your family and your staff are familiar with the high priority pest threats for the cotton industry (page 8)			
You, your family and your staff know how and where to report suspect pests			
Pest management plans (endemic and exotic) are developed for the farm			
Work with neighbours, government agencies, Landcare and/or pest control groups to reduce the spread of unwanted pests			
Product management			
Planting material for all crops grown are free from pests			
Records of planting material and its source are maintained			
Staff can identify symptoms of cotton pests spread in propagation material			
No soil, plant material or insects are left on or in bulk bins			
Cotton loaded and unloaded on compacted surfaces away from production areas			
People movement			
Biosecurity signs advising visitors to check-in are located at main entrance gates (include phone numbers and/or UHF channel)			
Visitor vehicle access is restricted to designated visitor parking areas			
Visitors sign a visitor register on arrival to monitor on-farm movements and for trace-back purposes in case of biosecurity emergency			
Only on-site vehicles are used to transport visitors and equipment around the farm			

People movement *cont*.			
Contractor entry to the farm is conditional on adhering to farm biosecurity plans and hygiene protocols; site biosecurity inductions are delivered where appropriate			
Contractors/visitors made aware if property has a declared or notifiable pest			
Visitors' clothing, footwear and tools are free of soil or plant material before entering or leaving the farm			
All people recently returned from overseas have clean footwear and clothes before entering the farm			
Farm biosecurity plan is available for farm staff, consultants, contractors and visitors			
Farm staff are trained in biosecurity and farm hygiene practices (e.g. pest management, personal, equipment and vehicle hygiene practices)			
Staff hygiene supplies are available where appropriate (e.g. hand sanitiser, gloves, masks, disinfectant footbaths, disposable over-boots and overalls)			
Equipment and vehicles			
Designated parking area with clear signs provided for visiting vehicles and contractor equipment and area is checked frequently for pests			
Cleaning and wash-down facilities are provided for people, machinery and equipment and clearly signposted with instructions			
High-pressure water and air are available for use to remove plant material and soil from equipment and machinery			
Machinery is inspected and disinfected before entering your production areas			
Borrowed and second-hand machinery and equipment are cleaned of all plant material and soil before use			
Sump installed in wash-down facility to catch unwanted pests and waste, and to stop run-off into waterways			
Wash-down facility and surrounds are inspected frequently; records are kept and updated			
Farm vehicles are kept clean by regularly clearing the vehicle floor of soil, weed seeds and insects			
Vehicle movement is kept to a minimum in production areas			
Vehicle movement is limited to regular pathways through the farm			
Machinery is cleaned before being moved off property			

Visitor register

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

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

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

EXOTIC PLANT PEST HOTLINE
1800 084 881

* A copy of this visitor register can be downloaded from **www.phau.com.au/biosecurity**

Further information

24 More information on biosecurity, farm hygiene, pests and the cotton industry can be found through the following sources.

		Contact details
ORGANISATION	**Cotton Australia**	**Phone**: 02 9669 5222 (NSW) or 07 4639 4908 (QLD) **Website**: www.cottonaustralia.com.au
	Cotton Research and Development Corporation (CRDC)	**Phone**: 02 6792 4088 **Website**: www.crdc.com.au
	Plant Health Australia	**Phone**: 02 6215 7700 **Website**: www.planthealthaustralia.com.au
	Farm Biosecurity	**Phone**: 02 6215 7700 **Website**: www.farmbiosecurity.com.au
GOVERNMENT	**Australian – Department of Agriculture, Fisheries and Forestry**	**Phone**: 02 6272 3933 **Website**: www.daff.gov.au
	Queensland – Department of Agriculture, Fisheries and Forestry	**Phone**: 13 25 23 or 07 3404 6999 **Website**: www.daff.qld.gov.au
	New South Wales – Department of Primary Industries	**Phone**: 1800 808 095 or 02 6391 3100 **Website**: www.dpi.nsw.gov.au

Fact sheet

Plant Health AUSTRALIA

Fusarium wilt (exotic races)

Compiled by Linda Smith (DAFF Queensland)

What is Fusarium wilt?

Fusarium wilt, caused by the soil-borne fungal pathogen *Fusarium oxysporum* f. sp. *vasinfectum* (*Fov*), is almost impossible to eradicate following introduction and can result in fields becoming unsuitable for cotton production.

A number of strains are present in Australia, however, if new exotic strains (races) were introduced, new management strategies and resistant varieties would be required. In addition, some exotic races are more damaging, particularly in association with nematode pests.

What does it look like?

External plant symptoms include stunted growth, wilted leaves followed by yellowing or browning and eventual death from the top of the plant. Internal symptoms of a continuous brown discolouration of stem tissues can be seen when stems are cut lengthways. This is most apparent in the lower stem and upper taproot.

Certain exotic strains only cause symptoms when plants are also infected with a Root knot nematode (also absent from Australia). In these cases, galls are usually present on lateral roots.

It is not possible to determine what strain of pathogen is affecting a plant (endemic or exotic) based on plant symptoms alone. Therefore, it is important to have all new outbreaks of Fusarium wilt checked out by a pathologist.

What can it be confused with?

Symptoms of Fusarium wilt and Verticillium wilt are similar. When the stem is cut lengthways, vascular discolouration exhibits flecking of the inner tissues in Verticillium wilt, rather than continuous browning associated with Fusarium wilt infected plants.

Chris Anderson, I&I NSW

Cotton roots infected with Race 1 *Fov* and Root knot nematode; galls produced by nematodes feeding can be seen on roots

Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Cotton stem vascular discolouration as a result of Fusarium wilt infection

Chris Anderson, I&I NSW

Cross-section of a cotton stem infected with Race 1 *Fov* and Root knot nematodes, showing vascular discolouration and galls

When the stem is cut diagonally, Verticillium wilt infected plants show dark brown to black streaks through the centre.

What should I look for?

Watch out for leaf wilt and death of plant tops, and confirm the presence of Fusarium wilt by cutting the stem and looking for continuous vascular browning. Seek professional advice if you are unsure.

How does it spread?

There is no commercially viable way to eradicate this pathogen from infested soil. Spores are effectively spread over long distances in infected soil attached to boots, vehicles and farm equipment, and in water (irrigation and overland flows). It can also be transferred in infected plant material, including seed.

Where is it now?

This pathogen has been recorded in every cotton-growing region in the world. However, the distribution of eight known races (genotypes) of *Fov* varies.

How can I protect my farm from Fusarium wilt?

Check your farm frequently for the presence of unusual symptoms. Make sure you are familiar with common cotton pests so you can tell if you see something different. Have all new outbreaks of Fusarium wilt analysed by a pathologist to determine what strain of pathogen is present.

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

EXOTIC PLANT PEST HOTLINE
1800 084 881

Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Vascular discolouration in the roots of infected cotton plants

Jack Kelly Clark, UC Statewide IPM Program

Damage to a cotton field due to the presence of the Fusarium wilt/Root knot nematode complex

Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Infection with Fusarium wilt is characterised by the presence of vascular discolouration

Fact sheet

Plant Health AUSTRALIA

Bacterial blight (exotic/hypervirulent races)

Compiled by Chris Anderson (NSW DPI)

What is Bacterial blight?

Bacterial blight (caused by the bacterium *Xanthomonas citri* subsp. *malvacearum*) cost Australian cotton farmers millions of dollars in the 1980's. Most cotton varieties now grown in Australia have excellent resistance to local races of the blight pathogen and only the older US varieties and some cultivars of Pima are susceptible.

Two races that originated in parts of Africa are described as hypervirulent. These races are not present in Australia and it is expected that they would be pathogenic on all Australian varieties.

What does it look like?

The bacterium affects the plant above ground with disease symptoms on the leaves, stems and bolls.

Leaves often display angular water-soaked lesions, sometimes extending along the veins. Symptoms are usually more common on lower leaves than on upper leaves. Lesions dry and darken with age and leaves may be shed prematurely resulting in extensive defoliation.

Stems display a 'black arm' symptom with black lesions spreading along the stems eventually girdling them. Bolls are often infected at the base (under the calyx) but may also be infected at the tip. As the boll matures the lesions dry out and prevent normal boll opening.

What can it be confused with?

Alternaria leaf spot or spray drift. Exotic races of Bacterial blight produce the same symptoms as races already present but will infect resistant cotton varieties.

Stephen Allen, CSIRO

Lesions and localised discolouration on cotyledons caused by Bacterial blight infection

Stephen Allen, CSIRO

Bacterial blight symptoms on upper and lower leaf surface, along veins and on bolls

Stephen Allen, CSIRO

'Black arm' symptom in cotton

What should I look for?

Classic symptoms of Bacterial blight including angular water-soaked lesions on the leaves, bracts and bolls and “black arm” on the petioles. Report any Bacterial blight symptoms on previously resistant cotton varieties.

How does it spread?

Bacterial blight can be spread within the crop by rain splash from crop residues or infected leaves. Once established at the growing points of the plant, all leaves produced from this point become infected.

The bacterium is also seed-borne, allowing spread over long distances. Under some circumstances the pathogen can survive in plants without showing symptoms.

Where is it now?

This disease has been reported from almost all cotton growing countries. The hypervirulent races, which would threaten current Australian cotton varieties, are currently found in North Africa.

How can I protect my farm from Bacterial blight?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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

Stephen Allen, CSIRO

Bacterial blight symptoms on bolls and bracts

Stephen Allen, CSIRO

Early water-soaked symptoms on the base of bolls

Stephen Koenning, North Carolina State University

Angular lesions on leaf and petiole (black arm)

Fact sheet

Plant Health AUSTRALIA

Cotton aphid (exotic species)

Compiled by Lewis Wilson (CSIRO)

What is Cotton aphid?

Cotton aphids *(Aphis gossypii)* are worldwide pests of cotton and for a range of other commercial plant species, including melons and citrus. Cotton aphids impact cotton production as they:

- Produce honeydew which contaminates the cotton lint.
- Reduce yield through feeding activities.
- Introduce and spread pathogens, such as the exotic Cotton blue disease.

Cotton aphid can also develop resistance to insecticides, making control difficult. There is a risk to Australian cotton production if insecticide-resistant clones or aphids carrying exotic disease enter the country and become established in cotton regions.

What does it look like?

Cotton aphids are small insects (less than 1.5 mm in length), varying in colour from pale green or yellow through to dark brown or almost black. They typically have two short projections from the rear end (siphunculi) that look like exhaust pipes. Infestations are often associated with deposits of shiny honey-dew on the leaves.

What can it be confused with?

Exotic species can be easily confused with endemic species already present in Australia. Any aphid that does not respond to treatment or attacks crops not normally affected by aphids should be reported immediately.

Lewis Wilson, CSIRO

A population of Cotton aphids present on the underside of a leaf

Jack Kelly Clark, UC Statewide IPM Program

Cotton aphid population, showing multiple stages of development and an example of the projections ('exhaust pipes') on the rear of the wingless adults

Ronald Smith, Auburn University, Bugwood.org

Cotton leaf curling symptom of Cotton aphid attack

What should I look for?

An Indicator of exotic aphid clones could be poor control with registered insecticides. Symptoms could also be seen as patches of plants infested with aphids that show unusual symptoms indicating the possible presence of an exotic aphid-borne disease such as Cotton Blue disease. Leaves that are covered with honeydew may also be detected following aphid infestations.

How does it spread?

Aphids can be spread as hitch-hikers on nursery plants. In addition, aphids can walk (non-winged form) or fly (winged form) between plants. Long distance movement can occur when assisted by wind currents.

Where is it now?

A range of exotic aphid clones that are a threat to the Australian cotton industry are found in the USA, South America, SE Asia and Africa.

How can I protect my farm from Cotton aphid?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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

Lewis Wilson, CSIRO

Cotton aphids vary in colour from pale yellow to almost black

William Lambert, University of Georgia, Bugwood.org

Honeydew produced by aphids gives the cotton leaves a 'glossy' appearance

Phillip Roberts, University of Georgia, Bugwood.org

Sooty mould on open cotton boll resulting from aphid infestation

Fact sheet

Plant Health AUSTRALIA

Cotton boll weevil

Compiled by Dave Murray (DAFF Queensland)

What is Cotton boll weevil?

The Cotton boll weevil, *Anthonomus grandis*, is a major pest of cotton, attacking the developing squares and bolls. Feeding damage causes young squares to shed and affects the lint in older bolls. Infestations in the USA have cost hundreds of millions of dollars to control.

The Cotton boll weevil has been successfully eradicated from several regions of USA using area wide management programs.

What does it look like?

Adult weevils are a greyish-brown with a body about 5 mm in length and conspicuous snout (which is an additional 3 mm long). The larvae, which grow inside developing squares and bolls, are white, legless grubs that grow up to 13 mm in length. The head and chewing mouthparts are brown, and the body is curved and wrinkled.

What can it be confused with?

The Cotton boll weevil resembles some native weevil species. However, no weevils in Australia attack cotton, so any weevils found feeding on cotton plants or within cotton bolls should be reported immediately.

What should I look for?

Look for small puncture marks on the side of flower buds. Egg-laying punctures are covered with a sticky secretion that hardens to form a wart-like protuberance that can be easily seen and felt.

Alton N. Sparks, Jr., University of Georgia, Bugwood.org

Adult weevil on a developing cotton boll

Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Larvae develop within the cotton bolls

Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Typical egg-laying puncture (upper right edge on the left boll) and feeding puncture (on right hand square)

How does it spread?

Adult weevils are strong fliers and can disperse long distances on wind currents (up to 72 km has been recorded). In trade, boll weevils may be carried with cotton seeds or bolls, with raw cotton and various cotton products.

Where is it now?

The Cotton boll weevil is thought to be native to Central America and has spread to both North and South America.

How can I protect my farm from Cotton boll weevil?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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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Alton N. Sparks, Jr., University of Georgia, Bugwood.org

Adult feeding on cotton square

Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Pupae found within a damaged cotton boll

Ronald Smith, Auburn University, Bugwood.org

Adult weevils feed externally on the bolls

Fact sheet

Plant Health AUSTRALIA

Cotton leaf curl disease

Compiled by Cherie Gambley (DAFF Queensland)

What is Cotton leaf curl disease?

Cotton leaf curl disease (CLCuD) is caused by a complex of a Begomovirus (a number of different virus species cause the disease) and a DNA beta satellite (DNA-ß) molecule.

CLCuD is a major constraint to cotton production where it occurs. For example, it devastated the Pakistan cotton industry in the 1990's where it caused an estimated loss of US$5 billion.

What does it look like?

Initial symptoms of CLCuD are a swelling and darkening of leaf veins, followed by a deep downward cupping of the youngest leaves and curling of the leaf margins. Growths extending from the leaf veins can also occur, typically found on the lower side of the leaf. In some cotton varieties these can appear as cup-shaped leaf-like structures.

Plants infected with the virus only are symptomless or exhibit very mild symptoms unless also infected with the DNA-ß. Plants can be stunted as a result of early infection.

What can it be confused with?

Feeding damage caused by high populations of insects called jassids can cause similar symptoms. Two diseases not found in Australia, Cotton leaf crumple disease and Cotton yellow mosaic disease, have symptoms which can look similar and are distinguished from CLCuD by the presence of a foliar mosaic and an absence of the vein outgrowths.

What should I look for?

Plants that are stunted and/or have deformed leaves, particularly with cupping, should be selected for closer evaluation.

Rob Briddon, National Institute for Biotechnology and Genetic Engineering, Pakistan

Vein thickening in cotton leaves caused by CLCuD infection

Rob Briddon, National Institute for Biotechnology and Genetic Engineering, Pakistan

Infection can result in the development of leaf-like growths on the underside of leaves

Rob Briddon, National Institute for Biotechnology and Genetic Engineering, Pakistan

'Cupping' of the young leaves caused by CLCuD infection

Holding suspect leaves up to the light can help in identifying disease symptoms of thickening and darkening of the leaf veins and the presence of abnormal growths emerging from leaf veins.

How does it spread?

CLCuD is spread between plants by *Bemisia tabaci* (whitefly), and movement of the insect can rapidly spread the disease through a crop and over large distances.

Alternative hosts, such as okra, cowpea, radish, tobacco, tomato, french bean, chilli, *Hibiscus* species and papaya may act as reservoirs for the pathogens during and between cotton crops. These plant species are also hosts of the whitefly vector.

CLCuD is not known to be mechanically or seed-transmitted.

Where is it now?

CLCuD has been reported from Pakistan, India, Egypt, Nigeria, Tanzania and Sudan but the viruses and DNA-ß satellite vary by region. Neither the viruses nor the DNA-ß satellites are known to occur in Australia.

How can I protect my farm from Cotton leaf curl disease?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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

Rob Bridon, National Institute for Biotechnology and Genetic Engineering, Pakistan

Abnormal growth, vein thickening and secondary leaf-like structures

Rob Bridon, National Institute for Biotechnology and Genetic Engineering, Pakistan

Infected cotton leaf with a number of abnormal growths developing from the veins

Rob Bridon, National Institute for Biotechnology and Genetic Engineering, Pakistan

Abnormal growth produced from the leaf veins

Fact sheet

Plant Health AUSTRALIA

Spider mites (exotic species)

Compiled by Lewis Wilson (CSIRO)

What are Spider mites?

Spider mites are pests of a range of economic field, orchard and glasshouse plants, including cotton.

Three spider mite species are found on cotton in Australia (the major pest *Tetranychus urticae*, and the minor pests *T. ludeni* and *T. lambi*). However, other spider mite species are present overseas and are a threat to the Australian cotton industry because they are more damaging (e.g. *T. turkestani, T. pacificus* and *T. cinnabarinus*).

The exotic spider mites have different host ranges or may carry new acaricide resistance genes, making them more difficult to control. For instance in California, *T. pacificus* and *T. urticae* have developed resistance to dicofol, propargite or abamectin and in some cases all three.

What do they look like?

Spider mites are small (less than 0.5 mm in length), have eight legs and are green or red. Exotic species look very similar to species already present in Australia and will be difficult to spot.

What can they be confused with?

Exotic spider mites look very similar to species already present in Australia. Any spider mite that does not respond to treatment or attacks crops not normally affected by spider mites should be reported immediately.

Jack Kelly Clark, UC Statewide IPM Program

Mite feeding damage on the underside of a cotton leaf

Merle Shepard, Gerald R.Carner, and P.A.C Ooi, Bugwood.org

Adult *T. cinnabarinus* spider mite next to eggs deposited on the underside of a leaf

Merle Shepard, Gerald R.Carner, and P.A.C Ooi, Bugwood.org

Feeding can cause whitish-yellow spots on leaves

What should I look for?

Indicators of the presence of exotic species could be very intense damage, poor control with registered acaricides or mites with unusual spot patterns or colour (see pictures).

Mites on the upper surface of leaves could indicate the presence of Pacific mites (*T. pacificus*).

How does it spread?

Mites can be spread over long distances on infected nursery plants. In the field they spread from plant-to-plant by walking and can also be dispersed on wind currents over longer distances. Mites can also be spread on clothing.

Where are they now?

A range of exotic mite species that are a threat to the Australian cotton industry are found in the USA, South America, SE Asia and Africa.

How can I protect my farm from Spider mites?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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

Jack Kelly Clark, UC Statewide IPM Program

Adult Pacific spider mite (*T. pacificus*)

Natalie Hummel, Louisiana State University AgCenter, Bugwood.org

Infestation of *T. turkestani* on the underside of a strawberry leaf

Jack Kelly Clark, UC Statewide IPM Program

Cotton leaf turns upward and later turns red where *T. turkestani* infestation occurs on the underside

Fact sheet

Plant Health AUSTRALIA

Verticillium wilt (defoliating strains)

Compiled by Linda Smith (DAFF Queensland)

What is Verticillium wilt?

Verticillium dahliae is a widespread soil-borne fungal plant pathogen that causes wilt disease on many important crops and trees, including cotton.

Verticillium wilt is one of the most damaging diseases of cotton worldwide.

On cotton, strains of *V. dahliae* have been classified into two pathotypes: defoliating strains, which are highly virulent and can completely defoliate the plant, and non-defoliating strains, which are mildly virulent and cause wilt and partial or no defoliation.

No defoliating strains have been detected in Australia, but non-defoliating strains of the pathogen are present.

What does it look like?

Defoliating strains lead to a rapid downcurling of the terminal leaf resulting in severe epinasty (downward bending leaves). Irregular chlorotic areas develop on infected leaves between the main veins and along the margins, which gradually become larger and paler, resulting in a mottled appearance. Light to dark brown vascular discolouration is prominent in the main stem, branches and petioles of diseased plants. As the disease progresses there is a sudden and almost total defoliation and shedding of bolls.

What can it be confused with?

Symptoms of Verticillium wilt and Fusarium wilt are similar. Verticillium wilt has dark brown to black streaks through the centre of the stem when cut diagonally. When cut lengthways, stems show brown flecking of the inner tissues, rather than continuous browning which is associated with Fusarium wilt infected plants.

Jack Kelly Clark, UC Statewide IPM Program

Symptoms of Verticillium wilt in cotton begin as patchy yellowing between the veins

Jack Kelly Clark, UC Statewide IPM Program

Brown streaks appear in the xylem of cotton plants with Verticillium wilt (right), in contrast to the unaffected stems (left)

Jack Kelly Clark, UC Statewide IPM Program

Leaf yellowing and necrosis caused by Verticillium wilt

What should I look for?

Watch out for downward bending leaves, and confirm the presence of Verticillium wilt by cutting the stem lengthways and looking for brown flecking of the inner tissues. Seek professional advice if you are unsure.

How does it spread?

Planting into infected soil is the primary mechanism for new infections. Spores are effectively spread over long distances in infected soil attached to boots, vehicles and farm equipment, and in water (irrigation and overland flows).

Where is it now?

Defoliating isolates have been reported from China, Iran, Israel, Mexico, Peru, Spain, USA and the former USSR.

How can I protect my farm from Verticillium wilt?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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

Roland J. Stipes, Virginia Polytechnic Institute and State University, Bugwood.org

Verticillium wilt can also infect trees, where it produces similar foliar and vascular symptoms as in cotton

Howard F. Schwartz, Colorado State University, Bugwood.org

Sunflower plants wilting due to infection with Verticillium wilt

Howard F. Schwartz, Colorado State University, Bugwood.org

External stem symptoms of infection in sunflower

Fact sheet

Plant Health AUSTRALIA

Cotton blue disease

Compiled by Cherie Gambley (DAFF Queensland), Lewis Wilson (CSIRO) and Stephen Allen (CSIRO)

What is Cotton blue disease?

Cotton blue disease (CBD) is suspected to be caused by aphid-transmitted viruses. The disease has been reported from Africa, Asia and the Americas.

In Brazil, Cotton leafroll dwarf virus (CLRDV) has been identified as the causal agent, however, it is not known if this is the causal agent in other regions. CBD has similarities with other diseases of cotton, such as Cotton bunchy top, anthocyanosis and Cotton leaf roll and all are spread by the Cotton aphid, *Aphis gossypii*.

What does it look like?

CBD-affected leaves tend to be small, thick, more brittle and leathery than healthy leaves and have an intense green to bluish colour with yellow veins. Reddening of stem petioles and leaf veins can occur. Leaf edges tend to roll downwards, plants become stunted due to a shortening of the branch internodes and produce many branches, giving a bunchy zig-zag stem habit. Symptoms are more obvious in plants infected at an early age. Infected plants also produce smaller bolls and boll shed may occur.

CBD is often seen as small patches of plants, often in a single row, and infected plants can be overgrown by nearby healthy plants. The susceptibility of different cotton species and commercial varieties to CBD varies.

There are no known hosts of CBD outside cotton.

What can it be confused with?

CBD has similar symptoms to Cotton bunchy top disease. Both diseases display shortened internodes and can result in stunted plants. The typical green-blue colour and yellow veins observed in CBD-affected leaves is absent from those affected by Cotton bunchy top. CBD causes an angular pattern of pale green margins and darker green centres.

Stephen Allen, CSIRO

Rolled leaf contrasts with unaffected surrounding leaves

Stephen Allen, CSIRO

Severe stunting of growth occurs following CBD infection

Stephen Allen, CSIRO

Deformed growth habit and blue discolouration of CBD-infected cotton

What should I look for?

Plants that are stunted, have downward rolling leaf edges and/or an odd growth habit should be selected for closer evaluation. Other symptoms may include:

- Intense green or bluish colour of leaves.
- Veins, petioles and stems becoming dark red-purple.
- Yellowing of minor veins.
- Zig-zag stem habit, shortened internodes and many branches.
- Leaves with a brittle and leathery texture.
- Flowers and bolls fewer and smaller than normal.

How does it spread?

CBD is moved between plants by the Cotton aphid (*Aphis gossypii*) and therefore, disease spread is favoured by conditions which are suitable for aphid reproduction, feeding and spread.

Where is it now?

CBD and other similar leaf roll diseases are known to occur in Benin, Chad, Cameroon, Ivory Coast and Zaire as well as in Brazil, Argentina and Paraguay. Similar symptoms have also been described from Azerbaijan, Turkmenistan and Armenia as well as from the Philippines and Thailand.

How can I protect my farm from Cotton blue disease?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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

Stephen Allen, CSIRO

Leaf discolouration and downward rolling in infected plants

Stephen Allen, CSIRO

Petioles develop a dark red colour and leaves curl downwards

Stephen Allen, CSIRO

Symptomatic leaf showing red vein colouring, darkening of whole leaf and curling

Fact sheet

Plant Health AUSTRALIA

Indian green jassid

Compiled by Robert Mensah (NSW DPI)

What is Indian green jassid?

Amrasca devastans is commonly known as the Green or Indian cotton jassid, and also by the scientific name *A. biguttula biguttula*. Indian green jassids are sapsuckers that can cause severe yield loss if present in high numbers. They have not been recorded in Australia.

The pest would be expected to establish very well in the cotton growing regions of Australia as well as areas where soybean, sunflower, mungbean, pigeon pea, tomato, peanut and maize are grown.

What does it look like?

Indian green jassid lays yellowish-white eggs less than 1 mm long and 0.5 mm wide within the leaf. Eggs hatch into nymphs which are 1-2 mm long and are greenish-yellow with bluish legs.

Adults have prominent black spots on both sides of the top of the head, and another on each forewing. Forewings vary from yellowish-green to yellow during the summer. In India, during winter the adults develop a reddish-brown colour with dark-violet eyes, brownish forewings and green legs. Indian green jassid is not known to transmit any virus or mycoplasma diseases.

If disturbed, jassids move very rapidly sideways and often hop. Feeding usually occurs on the underside of leaves.

What can it be confused with?

Indian green jassid can be confused with other small green leafhoppers such as *Amrasca splendens, Jacobsiana distinguenda* or *J. formosana*. However, all of these leafhoppers are exotic and should be reported.

Graham Jackson

Leaves damaged through feeding, with jassids visible as specks on the underside of the leaf

James Litsinger, IRRI

Yellowing of leaves as a result of jassid infestation

James Litsinger, IRRI

Adult (right) and nymph (left) developmental stages of Indian green jassid

What should I look for?

Large numbers of jassids can cause leaf damage especially lower in the cotton canopy. Initial symptoms of leafhopper damage are yellowing of leaves, followed by crinkling around the margins and upward curling of leaves. The leaf tips and margins start to die and at later stages, bronzing of entire leaves can be seen. This may or may not be associated with leaf fall. Severely affected plants have stunted growth and fewer bolls.

How does it spread?

Wind currents may disperse flying adults over long distances. Indian green jassids may be carried with cotton seeds or bolls as eggs or nymphs with raw cotton and various cotton products.

Where is it now?

Indian green jassid is widespread in the Indian subcontinent, covering Bangladesh, India, Nepal and Pakistan. It is also recorded in Afghanistan, Vietnam, Japan, China, Taiwan and in the Pacific island of Guam.

How can I protect my farm from Indian green jassid?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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

James Litsinger, IRRI

Symptoms of jassid attack, including crinkling around the margins and upward curling of leaves

PaDIL

Fixed specimen showing prominent spots at the ends of the forewings

James Litsinger, IRRI

In peanut, later stages of infestation result in the bronzing of entire leaves

Fact sheet

Plant Health AUSTRALIA

Tarnished plant bug

Compiled by Robert Mensah (NSW DPI)

What is Tarnished plant bug?

The Tarnished plant bug, *Lygus lineolaris*, was first described from North America, and has a host range of at least 130 species of economic importance, including cotton. It is not present in Australia.

The Tarnished plant bug has the potential to develop pesticide resistance.

Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Brown and yellow coloured adults grow up to 0.6 cm in length

What does it look like?

Adults are approximately 0.6 cm in length, and although they are true bugs, they have a flat, 'beetle-like' appearance. They fly readily when disturbed. Colour patterns vary considerably, ranging from greenish-yellow to brown, with the body marked with white, yellowish-brown, reddish-brown and black markings. The eggs hatch into nymphs that gradually become more like adults in appearance with each moult. Nymphs are yellow to green in colour and have extensive and variable dark-red, red-brown or brown markings. Larger nymphs can be recognised by a distinctive pattern of five dots on the back.

Barry Freeman, Auburn University, Bugwood.org

External black markings on cotton bolls as a result of feeding damage

What can it be confused with?

Tarnished plant bug looks similar to several other *Lygus* species. However, all such species are exotic to Australia so the presence of any bug fitting the description above should be reported.

Ronald Smith, Auburn University, Bugwood.org

'Crazy cotton' growth pattern as a result of Tarnished plant bug feeding

What should I look for?

Tarnished plant bug infests the leaves, squares, bolls and blooms of cotton, where they can cause considerable yield loss. Economic damage to cotton occurs during the period from first square through to early bloom. The damage is caused primarily by feeding resulting in squares aborting ('blasted squares') leaving a scar.

High Tarnished plant bug populations can further reduce yields by delaying maturity and altering fruiting patterns. Feeding on the bolls themselves may cause seed damage, discolouration of lint and decreased lint weight. Heavy infestations can sometimes kill terminal shoots, resulting in numerous secondary terminals ('crazy cotton').

How does it spread?

Abandoned crop fields and roadsides are favourite breeding habitats, although it can also breed in crops. The Tarnished plant bug adult's flight is aided by wind, and severe infestation can occur after storms. Damage to cotton is intensified when adults migrate to cotton from weed hosts that are no longer in flower. Although the Tarnished plant bug can reproduce on cotton, reproduction is slower on this crop compared to certain weed hosts.

Where is it now?

Tarnished plant bug is found throughout the USA, Canada, and Mexico.

How can I protect my farm from Tarnished plant bug?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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

Barry Freeman, Auburn University, Bugwood.org

Feeding damage on a boll. Noting the dark sunken spots and the brown immature seeds

Ronald Smith, Auburn University, Bugwood.org

Stem damage as a result of Tarnished plant bug egg laying activities

University of Georgia Archive, Bugwood.org

Tarnished plant bug developmental stages, from the first instar nymph (on left) through to the adult

Fact sheet

Plant Health AUSTRALIA

Texas root rot

Compiled by Chris Anderson (NSW DPI)

What is Texas root rot?

Texas root rot, caused by the fungus *Phymatotrichopsis omnivora*, is one of the most destructive fungal plant diseases. It is a soil-borne fungus that attacks the roots of susceptible plants. It causes sudden wilt and death of affected plants, usually during the warmer months.

Texas root rot affects over 2000 species of plants. It is an important disease of cotton as well as alfalfa, grapes, fruit trees, and many ornamentals.

What does it look like?

Plants initially wilt during hot weather as the rotted roots are unable to take up enough water and the stem may become girdled at soil level. Soon after this the plant will die. The dead leaves usually remain attached to the plant. At this stage, the roots are dead and their surface is covered with a network of white to tan fungal strands. Affected areas expand to form circular patches of dead plants.

What can it be confused with?

Sudden wilt, Fusarium wilt and lightning strike.

What should I look for?

In the field, look for patches of dead and dying plants (often with the dead leaves still attached). Patches may expand in a circular pattern during warm weather as the fungus spreads through the soil from plant to plant.

Dead plants should be pulled up and examined for the presence of white to tan fungal strands on the roots and girdling of the stem at ground level.

Chris Anderson, I&I NSW

Cotton plants infected with Texas root rot fungus, which have developed yellow, wilting leaves

Chris Anderson, I&I NSW

Tractor driver's view of severely damaged cotton field

S.D. Lyda, Bugwood.org

Fungal strands on cotton root

How does it spread?

Locally, the disease spreads from infected to healthy roots via fungal strands which grow through the soil. Long-distance spread most often occurs through the movement of soil or roots of infected host plants. The fungus does not spread readily from one location to another.

Where is it now?

Texas root rot is found in the southwest USA, Mexico, Brazil and Venezuela and has recently been reported in Libya, North Africa.

How can I protect my farm from Texas root rot?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common cotton 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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1800 084 881

Chris Anderson, I&I NSW

Cotton crop severely damaged by Texas root rot

S.D. Lyda, Bugwood.org

Spore mat produced from Texas root rot infected lucerne roots

C.M. Kenerley

Yellowing and wilting leaves on infected cotton plants

EXOTIC PLANT PEST HOTLINE
1800 084 881

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