Biosecurity Plan for the Cotton Industry

Version 3.0 August 2015

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The *Biosecurity Plan for the Cotton Industry* was coordinated by Plant Health Australia and developed through a partnership approach using government and industry resources and expertise. The following organisations and agencies were involved in the development and finalisation of the plan:

Endorsement

The *Biosecurity Plan for the Cotton Industry* (Version 3.0) was formally endorsed by the cotton industry (through Cotton Australia) in July 2015, and the Australian Government and all state and territory governments (through the Plant Health Committee) in August 2015. The Australian Government endorses the document without prejudice for the purposes of industries planning needs and meeting the Department's obligations under Clause 13 of the EPPRD. In providing this endorsement the Department notes page 38 of the Plan which states: "This Document considers all potential pathways by which a pest might enter Australia, including natural and assisted spread (including smuggling). This is a broader view of potential risk than the IRA conducted by the Department of Agriculture which focus only on specific regulated import pathways."

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List of acronyms

ACPPO	Australian Chief Plant Protection Office
APVMA	Australian Pesticides and Veterinary Medicines Authority
AS/NZS	Australian Standard/New Zealand Standard
BOLT	Biosecurity On-Line Training
CA	Cotton Australia
CCA	Crop Consultants Australia
CCEPP	Consultative Committee on Emergency Plant Pests
CPHM	Chief Plant Health Manager
CRDC	Cotton Research and Development Corporation
CSD	Cotton Seed Distributors
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAF Qld	Department of Agriculture and Fisheries, Queensland
DAFWA	Department of Agriculture and Food, Western Australia
DEDJTR	Department of Economic Development, Jobs, Transport and Resources, Victoria
DPIF NT	Department of Primary Industry and Fisheries, Northern Territory
DPIPWE	Department of Primary Industries, Parks, Water and Environment, Tasmania
EPP	Emergency Plant Pest
EPPO	European and Mediterranean Plant Protection Organization
EPPRD	Emergency Plant Pest Response Deed
FAO	Food and Agriculture Organization of the United Nations
HPP	High Priority Pest
IBG	Industry Biosecurity Group
IBP	Industry Biosecurity Plan
ICA	Interstate Certification Assurance
ICON	Import Conditions Database
IGAB	Intergovernmental Agreement on Biosecurity
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IRA	Import Risk Analysis
ISPM	International Standards for Phytosanitary Measures
MICoR	Manual of Importing Country Requirements
NAQS	Northern Australian Quarantine Strategy
NDP	National Diagnostic Protocol

NGIA	Nursery and Garden Industry Australia
NIASA	Nursery Industry Accreditation Scheme Australia
NMG	National Management Group
NPBDN	National Plant Biosecurity Diagnostic Network
NPBS	National Plant Biosecurity Strategy
NPSRT	National Plant Surveillance Reporting Tool
NSW DPI	Department of Primary Industries, New South Wales
NT	Northern Territory
ORIA	Ord River Irrigation Area
PaDIL	Pest and Disease Image Library
PHA	Plant Health Australia
PIDD	Pest Information Document Database
PIRSA	Primary Industries and Regions South Australia
RD&E	Research Development and Extension
SA	South Australia
SARDI	South Australian Research and Development Institute
SDQMA	Subcommittee for Domestic Quarantine and Market Access
SLW	Silver leaf whitefly
SOP	Standard Operating Procedure
SPHD	Subcommittee on Plant Health Diagnostics
SPS	Sanitary and Phytosanitary
TST	Threat Summary Table
Vic	Victoria
WA	Western Australia
UQ	University of Queensland
VCG	vegetative compatibility group
WTO	World Trade Organization

Reporting suspect pests

Any unusual plant pest should be reported immediately to the relevant state/territory agriculture agency through the Exotic Plant Pest Hotline (1800 084 881). Early reporting increases the chance of effective control and eradication.

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

EXECUTIVE SUMMARY

Executive Summary

To ensure its future viability and sustainability, it is vital that the Australian cotton industry minimises the risks posed by exotic pests and responds effectively to plant pest threats. The *Biosecurity Plan for the Cotton Industry* is a framework to coordinate biosecurity activities and investment for Australia's cotton industry. It provides a mechanism for industry, governments and stakeholders to better prepare for and respond to, incursions of pests that could have significant impacts on the cotton industry. It aims to assist cotton producers to evaluate the biosecurity risks within their everyday farming and business activities, formally identify and prioritise exotic plant pests (not currently present in Australia), and focus on future biosecurity challenges.

The *Biosecurity Plan for the Cotton Industry* was developed in consultation with the Industry Biosecurity Group (IBG), a select group of plant health and biosecurity experts. The IBG was coordinated by Plant Health Australia (PHA) and included representatives from Cotton Australia, Cotton Research and Development Corporation (CRDC), Cotton Seed Distributors (CSD), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Department of Agriculture and Fisheries, Queensland (DAF Qld), New South Wales Department of Primary Industries (NSW DPI) and PHA.

The development of threat summary tables, constituting a list of more than 100 exotic plant pests and the potential biosecurity threat that they represent to the Australian cotton industry was key to the industry biosecurity planning process. Each pest on that list was given an overall risk rating based on four criteria; entry, establishment, spread potential and economic impact. In this biosecurity plan, established pests and weeds of 'biosecurity significance' for the cotton industry were also listed. The identification of potential biosecurity threats focuses on pests known to have impact on cotton internationally and is limited by the available information at the time of compiling the IBP. Implementation of the plan also needs to consider the potential for new and emerging biosecurity threats not identified to ensure that the ultimate goal of protecting the industry from biosecurity threats is achieved. It is well understood that good biosecurity practice is beneficial for the ongoing management of established pests and weeds, as well as for surveillance and early detection of exotic pests

Importantly, the high priority pests identified in the Industry Biosecurity Plan (IBP) include;

- Bacterial blight (*Xanthomonas citri* subsp. *malvacearum* (exotic/hypervirulent races))
- Boll weevil (*Anthonomus grandis*)
- Brown marmorated stinkbug (*Halyomorpha halys*)
- Cotton aphid (*Aphis gossypii* (exotic strains))
- Cotton blue disease (*Cotton leafroll dwarf virus* (*Polerovirus*))
- Cotton bollworm (*Helicoverpa armigera* (carrying Bt resistance alleles))

- Cotton leaf curl virus (*Cotton leaf curl virus complex* (*Begomovirus*))
- Cotton stainer; red bugs (American species) (*Dysdercus* spp. including: *D. honestus*, *D. maurus*, *D. suturellus*)
- False codling moth (*Thaumatotibia leucotreta*)
- Fusarium wilt (*Fusarium oxysporum* f. sp. *vasinfectum* (exotic races))
- Silverleaf whitefly (*Bemisia tabaci* (Biotypes other than B and AN))
- Tarnished plant bug (*Lygus lineolaris*)
- Texas root rot (*Phymatotrichopsis omnivora*)
- Verticillium wilt (*Verticillium dahliae* (defoliating strain))[1]
- Western plant bug (*Lygus hesperus*)

The *Biosecurity Plan for the Cotton Industry* also details current surveillance activities being undertaken by Australia's states and territories, and identifies contingency plans, fact sheets and diagnostic protocols that have been developed for pests relevant to the cotton industry. This enables identification of gaps and prioritises actions as listed in the biosecurity implementation table (Page 13). The development of this table aims to increase industry's biosecurity preparedness and response capability by outlining specific areas of action which could be undertaken through a government and industry partnership.

This plan is principally designed for decision makers. It provides the cotton industry and government with a mechanism to identify exotic plant pests as well as the strengths and weaknesses in relation to the industry's current biosecurity position. It is envisaged that a formal review of this biosecurity plan will be undertaken in five years.

[1] Non-defoliating strains of Verticillium dahliae occur in Australia. The defoliating strain VCG 1A is known to occur in Australia and is currently under review.

Implementing biosecurity for the Australian cotton industry 2015-2020

Following the prioritisation and gap analysis through the Industry Biosecurity Group biosecurity planning process, both industry and government identified gaps and opportunities to assist in implementation of the Cotton Industry Biosecurity Plan. Further review identified the importance of ensuring that the IBP should be revisited by industry and government decision makers regularly throughout the life of the plan. To achieve this, a Cotton Industry Biosecurity Group will be formed to develop and annually review the Cotton Industry Biosecurity Plan. Membership of the committee will be determined by Cotton Australia in consultation with the CRDC.

The Cotton Industry Biosecurity Implementation Plan (Table 1) aims to develop the focus and strategic direction for plant biosecurity activities relating to the cotton industry over the next five years (i.e. for the life of IBP version 3.0). Recognising that biosecurity is a shared responsibility between industry and governments, the Implementation Plan will develop strategies that build upon the themes outlined in the Intergovernmental Agreement on Biosecurity (IGAB) and the National Plant Biosecurity Strategy (NPBS), providing a clear line of sight between the development of this IBP and broader plant health policy and legislation. While the Cotton Industry Biosecurity Group will provide recommendations on strategic direction, it is important to note that the actual implementation will be a shared responsibility between industry and government.

Table 1. *The proposed Biosecurity Implementation Table for the Australian Cotton Industry (2015-2020)*

Biosecurity theme	Action	Responsible party	Due date
Coordinated Surveillance Strategy (aligns with Strategy 2 of NPBS, Schedule 4 IGAB)	Develop a surveillance strategy that links industry and government efforts and ensures cotton industry HPPs are adequately considered.	CA, CRDC, PHA & State & Federal Government agencies	31/12/2015
Building capacity and capability (aligns with Strategy 4 of NPBS, Schedule 6 of IGAB)	Establish a Cotton Industry Biosecurity Group to provide technical support and recommendations to both CRDC and Cotton Australia (CA) on biosecurity issues.	CA/CRDC	31/12/2015
	Develop a Charter for the Biosecurity Group.	CA/CRDC	31/12/2015
Contingency plans (aligns with Strategy 3of NPBS, Schedule 7 of IGAB)	A Brown marmorated stink bug contingency plan will be developed in 2015	Department of Agriculture, PHA (in consultation with potentially impacted industries)	31/12/2015
Cotton Industry Biosecurity Group to annually to review the Cotton Industry Biosecurity Plan (Version 3.0) including:			
Industry Biosecurity Plan review	Review IBP, including emerging pests and categorisation.	Cotton Industry Biosecurity Group	31/07/2016 31/07/2017 31/07/2018 31/07/2019 31/07/2020
Biosecurity Implementation Table review	Review compliance and revise the Biosecurity Implementation Table		
Cotton Industry Biosecurity Group charter review	Review of the Biosecurity Group Charter including membership.		
Biosecurity Awareness/Training (aligns with Strategy 7 of NPBS, Schedule 6 of IGAB)	Identify industry training and extension needs, recommend priorities.		
Contingency plans and diagnostic protocols (aligns with Strategy 3&5 of NPBS, Schedule 4&7 of IGAB)	Develop and review contingency plans (including APVMA permits) and diagnostic protocols for HPPs and prioritise any identified gaps.		
Biosecurity RD&E (aligns with Strategy 8 of NPBS, Schedule 8 of IGAB)	Identify and prioritise Biosecurity RD&E gaps to inform investment. Identify and recommend opportunities for cross industry/government collaboration in biosecurity RD&E.		

Biosecurity theme	Action	Responsible party	Due date
Cotton Industry Biosecurity Statement	Annual Cotton Industry Biosecurity Statement prepared by CA in consultation with the Cotton Industry Biosecurity Group.		

Australian cotton industry - biosecurity preparedness

This document represents the third industry biosecurity planning process undertaken for the Australian cotton industry.

The following table (Table 2) has been populated with the high priority pests of the cotton industry. The aim of this table is to document the current preparedness documents and activities which are available and are currently being undertaken. This will allow industry, governments and RD&E agencies to better prepare for these high priority pests and align future activities as listed in the Biosecurity Implementation Table (Table 1).

Table 2. Documents and activities currently available for cotton high priority pests[2] [3]

Scientific name	Common name	National diagnostic protocol[4]	Surveillance programs[5]	Fact sheets[6]	Contingency Plan[7]	EPPRD Category
INVERTEBRATES						
Anthonomus grandis	Boll weevil	Not yet developed	Not covered by a pest specific surveillance program	Yes	No	3
Aphis gossypii (exotic strains)	Cotton aphid (exotic strains)	Not yet developed	Yes	Yes	No	

[2] Copies of these documents are available from: **www.planthealthaustralia.com.au/pidd**
[3] Information presented has been taken from the National Plant Health Status Report 2014 and confirmed or updated through either Plant Health Committee, the Subcommittee on Plant Health Diagnostic Standards, the Subcommittee on National Plant Health Surveillance or other stakeholders
[4] See Page 88 for further information.
[5] For specific information about surveillance programs in place see Table 11.
[6] See Table 15 for more information.
[7] See Table 15 for more information.

Scientific name	Common name	National diagnostic protocol[4]	Surveillance programs[5]	Fact sheets[6]	Contingency Plan[7]	EPPRD Category
Bemisia tabaci (Biotypes other than B and AN)[8]	Silverleaf whitefly (exotic biotypes)	Not yet developed	Yes	No	No	
***Dysdercus* spp.** (including: *D. honestus, D. maurus, D. suturellus* (American species))	Cotton stainer; red bugs	Not yet developed	Not covered by a pest specific surveillance program	No	No	
Halyomorpha halys	Brown marmorated stink bug	Not yet developed	Yes	No	No[9]	
Helicoverpa armigera (carrying Bt resistance alleles)	Cotton bollworm; African boll worm	Not yet developed	Not covered by a pest specific surveillance program	No	No	
Lygus hesperus	Western plant bug	Not yet developed	Not covered by a pest specific surveillance program	Yes	No	4
Lygus lineolaris	Tarnished plant bug	Not yet developed	Not covered by a pest specific surveillance program	Yes	Yes	
Thaumatotibia leucotreta (syn. *Cryptophlebia leucotreta*)	False codling moth	Not yet developed	Not covered by a pest specific surveillance program	Yes	No	2

[8] Biotypes B and AN, occur in Australia (see: DAFF Qld 2012). Exotic biotypes may have different insecticide resistance profiles or cause differing levels of damage on cotton than biotypes already in Australia.
[9] PHA (in consultation with potentially impacted industries) will be developing a new contingency plan in 2015 for Brown marmorated stink bug as part of a Department of Agriculture funded project.

Scientific name	Common name	National diagnostic protocol[4]	Surveillance programs[5]	Fact sheets[6]	Contingency Plan[7]	EPPRD Category
PATHOGENS & NEMATODES						
***Cotton leafroll dwarf virus* (*Polerovirus*)**	Cotton blue disease	Draft under development	Yes	Yes	Draft under development	
***Cotton leaf curl virus complex* (*Begomovirus*)**	Cotton leaf curl virus; Cotton leaf crumple virus; Cotton leaf curl gezira virus; Cotton leaf curl Alabad virus; Cotton leaf curl Burewala virus; Cotton leaf curl Kokhran virus; Cotton leaf curl Multan virus; Cotton leaf curl Rajasthan virus; Cotton leaf curl Shahdadpur virus	Draft under development	Yes	Yes	Draft submitted for assessment	3
Fusarium oxysporum* f. sp. *vasinfectum (exotic races)[10]	Fusarium wilt (exotic races)	Not yet developed	Yes	Yes		
Phymatotrichopsis omnivora (Syn. *Phymatotrichum omnivorum*)	Texas root rot; Phymatotrichum root rot; cotton root rot	Not yet developed	Yes	Yes		2
Verticillium dahliae (defoliating strain)[11]	Verticillium wilt (defoliating strain)	Draft completed	Yes	Yes		3

[10] To date 8 races have been classified (Skovgaard et al., 2001). The Australian race appears to be similar to race 6 (Davis et al., 1996). The Australian isolates belong to Vegetative Compatible Groups (VCG) 01111 and 01112 (Wang et al., 2006) as well as the Mungindi strain.
[11] Non-defoliating strains of *Verticillium dahliae* occur in Australia. The defoliating strain VCG 1A is known to occur in Australia and is currently under review.

Scientific name	Common name	National diagnostic protocol[4]	Surveillance programs[5]	Fact sheets[6]	Contingency Plan[7]	EPPRD Category
Xanthomonas citri* subsp. *malvacearum (Syn. *X. axonopodis* pv. *malvacearum; X.campestris* pv. *malvacearum*) (exotic/hypervirulent races)[12]	Bacterial blight; Angular leaf spot (exotic/hypervirulent races)	Draft under development	Yes	Yes		3

[12] There are at least 32 races of this pathogen (Madani et al., 2010). Races, 1, 2, 3, 4, 5, 7, 9, 10 and 18 (the most common race affecting Australian cotton) occur in Australia (Allen and West 1991). Exotic races refers to all races of the pathogen other than the 9 known to occur in Australia.

Cotton industry biosecurity statement 2014-2015

Cotton Australia recognises the need for the cotton industry to work with the federal, state and territory governments to help reduce the potential for incursions of emergency plant pests that could adversely impact on production, domestic and international trade and the regional economy and environment.

The cotton industry is committed to ensuring effective responses to pest incursions are possible to minimise costs to growers, the industry, other plant industries, government parties and the wider community.

The cotton industry through Cotton Australia is working with Plant Health Australia (PHA) to develop a comprehensive national approach to managing biosecurity risks in the cotton industry. Valuable assistance is received from researchers and staff from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), NSW Department of Primary Industries (NSW DPI), Queensland Department of Agriculture, Fisheries and Forestry (QDAF), Biosecurity Queensland, Cotton Research and Development Corporation (CRDC), Cotton Seed Distributors (CSD) and the Australian Government Department of Agriculture and a number of Universities.

Cotton Industry Biosecurity Plan

The National Cotton Industry Biosecurity Plan, consistent with PHA's National Industry Biosecurity Planning Guidelines, was launched in November, 2006. A major review of the National Cotton Industry Biosecurity Plan (Version 2) was released in February 2010. The Cotton Research & Development Corporation provided funding to Plant Health Australia Ltd to conduct a major review of the plan during 2015, which will be released as the Cotton Industry Biosecurity Plan version 3.0.

The biosecurity plan identifies and prioritises the cotton industries biosecurity risks and provides a framework for risk mitigation and preparedness activities. The awareness section identifies a range of existing industry processes, fact sheets and other sources of information for the identified 15 high priority pests (HPPs) that can be used to promote biosecurity awareness throughout the industry.

An outcome of the Industry Biosecurity Plan review is the recommendation for the Industry Biosecurity Group to develop an implementation program that recognises the joint responsibilities of government and industry and includes annual meetings that encompass:

- Identify industry Biosecurity Awareness/Training needs and recommend priorities.
- Review draft/developed contingency plans and provide recommendation on priority of gaps.

- Identify and prioritise Biosecurity R&D gaps to inform investment decisions.
- Help develop a surveillance strategy that ensures adequate consideration of cotton industry HPPs and is linked to both industry and Government to focus on early detection and avoid duplication.

On-farm biosecurity

The cotton Best Management Practices program (*my*BMP) is the core platform for delivery of best practice across the Australian Cotton Industry. The *my*BMP program includes a farm biosecurity module.

CRDC funding enabled Cotton Australia and PHA to review the Cotton Farm Biosecurity Manual to support the cotton *my*BMP biosecurity module. A total of 4,000 copies of the manual have been distributed to cotton growers, farm managers, agribusiness and consulting agronomists since the first edition in 2010.

The Cotton Research & Development Corporation has also funded Cotton Australia to implement biosecurity awareness training. The intended outcome of this training is a grass-roots network of growers, crop consultants, Cotton Australia Regional Managers, and the industry's CottonInfo extension team that are aware of and understand the role they may be asked to play in an incursion event. Cotton Australia directors and staff as well as CottonInfo's team of regional development officers participated in this training that was conducted with Department of Agriculture in Sydney in 2014. Additional training for growers, consultants and other industry representatives will be implemented throughout the life of this IBP.

Several key industry publications that are widely used by industry now include specific sections to raise awareness of biosecurity risks. These include the Cotton Pest Management Guide, which is updated annually and delivered to every cotton grower and pest control adviser.

The Australian Cotton Industry's CottonInfo team play a key role in the development and delivery of research extension resources. CottonInfo have identified on farm biosecurity as a key campaign and are working with Cotton Australia to promote on farm biosecurity, including good farm hygiene and wash down of equipment, promoted as 'Come Clean. Go Clean.'

Pest Categorisation

Cotton Australia will, as far as it is within its power to do so, ensure that appropriate industry technical experts will be available to participate in future meetings of the Categorisation Group to consider either pest categorisation or funding weight calculations for Emergency Plant Pests with multi-industry impacts. Cotton Australia has participated in all relevant categorisation group meetings. Currently, seven cotton industry identified Emergency Plant Pests have been categorised and are listed in Schedule 13 of the Emergency Plant Pest Response Deed.

National Decision Making Processes

Cotton Australia will endeavour to ensure that senior and qualified industry delegates are available at short notice to participate in meetings of the Consultative Committee on Emergency Plant Pests or the National Management Group and to take up roles in Local Pest Control Centres or the State Pest Control Headquarters in the event of an incursion. Cotton Australia will also endeavour to ensure that all delegates participate in relevant competency and non-competency based training, which is being delivered through Plant Health Australia's Emergency Plant Pest Preparedness Training Program.

Owner Reimbursement Costs

In association with Plant Health Australia, Cotton Australia will progress the finalisation of the draft Owner Reimbursement Cost template for cotton during 2015.

Enhanced cotton biosecurity capacity and awareness

Cotton Australia is the [PIRD Act 1989] representative organisation for the cotton industry to the Cotton Research and Development Corporation (CRDC) and as such, has a strong role in advising industry priorities for the Corporation's R&D budget. Cotton Australia is committed to supporting proposed projects that enhance our industry's biosecurity expertise and response preparedness.

Biosecurity research and diagnostic capacity for cotton has been leveraged through a number of scientific exchanges.

Improved diagnostic capacity was key to new strains of Verticillium Wilt (*Verticillium dahliae*) being identified in Australian cotton. In cotton, strains of *Verticillium dahliae* have been classified into two pathotypes: defoliating (D) strains, which are highly virulent and can completely defoliate the plant; and nondefoliating (ND) strains, which are mildly virulent and can only cause wilt and partial or no defoliation. NSW DPI and Qld DAF pathologists, with funding from CRDC were integral in identifying that there were multiple strains of *Verticillium dahlia* affecting Australian cotton, including the defoliating strain, which was thought to be exotic.

New CRDC-funded research is underway, aimed at developing new diagnostic tools to enable the quick and reliable detection of viruses in infected plants and also in the Silver leaf whitefly (SLW) insect vectors. The project is being undertaken by Sharon van Brunschot, a Postdoctoral Research Fellow at The University of Queensland (UQ). The research is being done in association with Dr James Hereward (UQ), Dr Cherie Gambley (DAF Qld) and Dr Paul De Barro (CSIRO), under the supervision of Professor Gimme Walter (UQ). She will also be examining the capacity of the SLW populations in Australian cotton to transmit viruses that cause Cotton leaf curl disease (CLCuD). Another component of this work is focused on examining the relationship that SLW shares with symbiotic bacteria (endosymbionts) that are

harboured within the insect's body and cells. Clarifying the influence that these endosymbionts have on the biology of SLW may reveal opportunities for new pest management approaches.

Pest Surveillance

Numerous pest surveys and crop monitoring activities are undertaken each season by cotton industry and State government researchers. Formal alignment of monitoring protocols for high priority exotic pathology pests enables the collection of widespread surveillance data throughout NSW and Queensland annually during routine benchmarking of endemic diseases (NSW DPI and DAF Qld early and late season disease surveys). Viral surveys of major commercial areas are conducted annually. Through the CRDC funded project, 'Surveillance for exotic cotton viruses: Multiple targets in and nearby Australia' the industry is forging stronger connectivity between the cotton industry and surveillance activities in northern Australia by the Department of Agriculture (Northern Australian Quarantine Strategy (NAQS)). This means that the industry can access relevant information earlier, and be better prepared to respond to changing threats. This project is also responsible for delivering a contingency plan for cotton leaf curl virus, which is seen as a significant threat to Australian cotton. A structured surveillance system for exotic cotton viruses both pre and post border is also being developed.

Cotton leafroll dwarf virus (CLRDV), as the cause of Cotton blue disease was detected in an asymptomatic Pima cotton plant (*Gossypium barbadense*) from Laivai, Timor Leste in February 2014. This sample was collected in May 2013 by the Department of Agriculture and sent to Cherie Gambley and Murray Sharman, DAF Qld for screening.

Cotton blue disease (*Cotton leafroll dwarf virus*) is generally regarded as the second most damaging virus disease to commercial cotton *Gossypium hirsutum*, (second to Cotton leaf curl virus) and is a significant threat to the Australian cotton industry. The vector (cotton aphid – *Aphis gossypii*) is widespread in all Australian cotton growing regions. This virus is a Plant Health Australia high priority pest and a draft National diagnostic protocol developed by Murray Sharman DAF Qld is under review, as part of CRDC funded project 'Surveillance and studies for endemic and exotic virus diseases of cotton'.

Cotton leafroll dwarf virus is in the same genus (*Polerovirus*) as the endemic *Cotton bunchy top virus*. CRDC funded DAF Qld research into this virus and hosts has highlighted the risk of a host pathway for incursion from SE-Asia into Northern Australia and to commercial cotton growing regions. This research has also provided important input into the industry's Cotton blue disease contingency plan being prepared by Murray Sharman.

In addition, most cotton growers employ consulting agronomists who generally conduct twice weekly crop inspections for pests. The reporting and confirmation of the Reniform nematode in Central Queensland highlights the successful linkage between consultant monitoring and linkage to researchers and industry. Extensive monitoring by DAF Qld, with funding from CRDC has confirmed an overall trend of increasing Reniform populations commonly

associated with back to back cotton. Growers have reported up to 40% yield loss from Reniform nematodes in these back to back situations. Research into agronomic and crop rotation management options is ongoing.

In an effort to better support growers and consultants the industry has, through the '*Networking remote diagnostics for the Australian cotton industry*' project, trialled a digital platform to facilitate in-field pest identification, and to record all pest information in a searchable database. The Pestpoint platform, created by the Plant Biosecurity CRC allows users to create their own diagnostic networks, and capture and share pest observations with their networks or with selected diagnostic experts. During the 2014-15 season, 29 people participated in the test group, including 16 Cotton Grower Services field agronomy staff from across the cotton growing valleys, and 13 specialists: pathologists, entomologists and weed scientists from CSIRO, NSW DPI, DAF Qld and QUT. Training workshops were conducted, with participants issued a portable wireless microscope paired with a mobile device and Pestpoint software.

INTRODUCTION

Introduction

What is biosecurity and why is it important?

Plant biosecurity is a set of measures which protect the economy, environment and community from the negative impacts of plant pests. A fully functional and effective biosecurity system is a vital part of the future profitability, productivity and sustainability of Australia's plant production industries and is necessary to preserve the Australian environment and way of life.

Plant pests are organisms that have the potential to adversely affect food, fibre, ornamental crops and stored products, as well as environmental flora and fauna. For agricultural systems, if exotic pests enter Australia they can reduce crop yields, affect trade and market access, significantly increase costs and in the worst case scenario, bring about the complete failure of a production system. Historical examples present us with an important reminder of the serious impact that exotic plant pests can have on agricultural production.

Australia's geographic isolation and lack of shared land borders have, in the past, provided a degree of natural protection from exotic plant pest threats. Australia's national quarantine system also helps to prevent the introduction of harmful exotic threats to plant industries. However, there will always be some risk of an exotic pest entering Australia, whether through natural dispersal (such as wind) or assisted dispersal as a result of increases in overseas tourism, imports and exports, mail and changes to transport procedures (e.g. refrigeration and containerisation of produce).

The Plant Biosecurity System in Australia

Australia has a unique and internationally recognised biosecurity system to protect our plant production industries and the natural environment against new pests. The system is underpinned by a cooperative partnership between plant industries and all levels of government.

The framework for managing the cooperative partnership for delivering an effective plant biosecurity system is built on a range of strategies, policies and legislation, such as the Intergovernmental Agreement on Biosecurity[13] and the National Plant Biosecurity Strategy[14]. These not only provide details about the current structure, but provide a vision of how the future plant biosecurity system should operate.

Australia's biosecurity system has been subject to several reviews in recent times, with the recommendations recognising that a future-focused approach is vital for maintaining a strong and resilient biosecurity system that will protect Australia from new challenges. As a result, there is a need for continuous improvement from industry and governments with respect to Australia's plant biosecurity system, with the key themes including:

- Targeting what matters most, including risk-based decision making and managing biosecurity risks across the biosecurity continuum (pre-border, border and post-border).
- Good regulation, including reducing regulatory burden and having effective legislation in place.
- Better processes, including service, delivery and modernisation with electronic, streamlined systems.
- Sharing the responsibility, including maintaining productive relationships with all levels of government, primary industries and the wider Australian public.
- Maintaining a capable workforce.

Through these themes, a focus on the biosecurity continuum better supports consistent service delivery offshore, at the border and onshore, and provides an effective biosecurity risk management underpinned by sound evidence and technical justification.

The benefits of the modern biosecurity system are realised by industry, government and the community, with positive flow on effects to the economy more generally. This is through streamlined business processes, productivity improvements and reduced regulatory burden in a seamless and lower cost business environment, by emphasising risk based decision making and robust partnerships.

[13] For more information visit **http://www.agriculture.gov.au/animal-plant-health/pihc/intergovernmental-agreement-on-biosecurity**
[14] For more information visit **http://www.planthealthaustralia.com.au/national-programs/national-plant-biosecurity-strategy/**

Plant Health Australia

Plant Health Australia (PHA) is the national coordinator of the government-industry partnership for plant biosecurity in Australia.

PHA is a not-for-profit, subscription-funded public company based in Canberra. PHA's main activities are funded from annual subscriptions paid by members. The Australian Government, state and territory governments and 34 plant industry organisations are all members of PHA and each meet one third of the total annual membership subscription. This tripartisan funding model ensures the independence of the company.

The company was formed to address high priority plant health issues and to work with all its members to develop an internationally outstanding plant health management system that enhances Australia's plant health status and the sustainability and profitability of plant industries. Through PHA, current and future needs of the plant biosecurity system can be mutually agreed, issues identified and solutions to problems found. PHA's independence and impartiality allow the company to put the interests of the plant biosecurity system first and support a longer-term perspective.

For more information about PHA visit **www.planthealthaustralia.com.au**

The Industry Biosecurity Plan

The Cotton Industry Biosecurity Plan was developed in consultation with the Industry Biosecurity Group (IBG), a select group of industry, plant health and biosecurity experts. The IBG was coordinated by PHA and included representatives from Cotton Australia, Cotton Research and Development Corporation (CRDC), Cotton Seed Distributors (CSD), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Department of Agriculture, Fisheries, Queensland (DAF Qld), New South Wales Department of Primary Industries (NSW DPI) and PHA.

The Cotton Industry Biosecurity Plan not only details exotic pest threats of the Australian cotton industry but also contains information on the current mitigation and surveillance activities being undertaken and identifies contingency plans, fact-sheets and diagnostic protocols that have been developed for pests relevant to the industry.

The plan is a framework to coordinate biosecurity activities and investment for Australia's cotton industry and to address the strengths and weaknesses in relation to industry's current biosecurity position. It provides a mechanism for industry, governments and stakeholders to better prepare for and respond to, incursions of pests that could have significant impacts on the cotton industry.

Biosecurity planning

Biosecurity planning provides a mechanism for the cotton industry, government and other relevant stakeholders to actively determine pests of highest priority, analyse the risks they pose and put in place practices and procedures that would rapidly detect an incursion, minimise the impact if a pest incursion occurs and/or reduce the chance of pests becoming established. Effective industry biosecurity planning relies on all stakeholders, including government agencies, industry and the public (Figure 1).

Ensuring the cotton industry has the capacity to minimise the risks posed by pests and to respond effectively to any pest threats is a vital step for the future sustainability and viability of the industry. Through this pre-emptive planning process, the industry will be better placed to maintain domestic and international trade, and reduce the social and economic costs of pest incursions on both growers and the wider community. The information gathered during these processes provides additional assurance that the Australian cotton industry is free from specific pests and has systems in place to control and manage biosecurity risks, which assists the negotiation of access to new overseas markets.

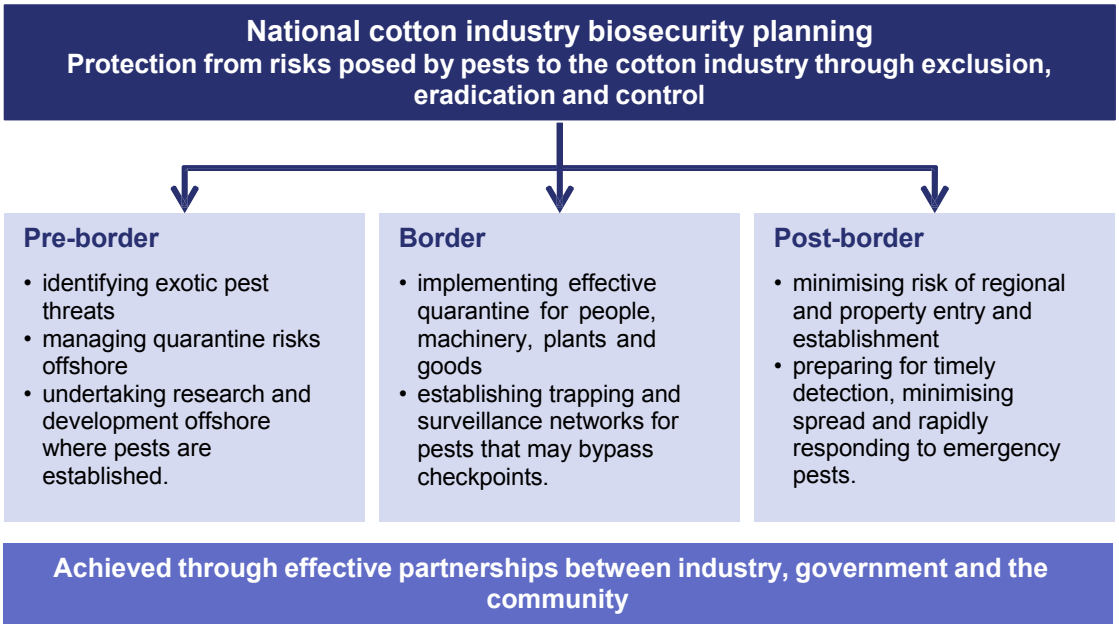

Figure 1. *Industry biosecurity: a shared responsibility*

Industry Biosecurity Plan development

With the assistance of Cotton Australia, an Industry Biosecurity Group (IBG), coordinated by PHA, was formed to review the Cotton Industry Biosecurity Plan (IBP). The IBG included representatives from Cotton Australia, CRDC and relevant state/territory agriculture agencies, as well as private consultants and researchers (Table 3).

Key steps in the development of the cotton IBP included:

- identifying and documenting key threats to the cotton industry
- confirming an agreed high priority pest (HPP) list
- documenting pest-specific fact sheets, contingency plans, diagnostic protocols and surveillance programs for HPPs
- documenting the roles and responsibilities of stakeholder groups.

Table 3. *Members of the cotton IBG*

Name	Organisation	Area of expertise
Stephen Allen	CSD / CSIRO	Plant pathology
Rohan Burgess	Plant Health Australia	
Nicola Cottee	Cotton Australia	
Damien Erbacher	Cotton Australia	
Cherie Gambley	DAF Qld	Virology
Paul Grundy	DAF Qld	Entomology
Christine Horlock	DAF Qld	Biosecurity
Karen Kirkby	NSW DPI	Plant pathology
Susan Maas	Cotton Research and Development Corporation	
Robert Mensah	NSW DPI	Entomology
Rebekah Niall	NSW DPI	
Alison Saunders	Plant Health Australia	
Murray Sharman	DAF Qld	Virology
Linda Smith	DAF Qld	Plant pathology
Sarah Sullivan	NSW DPI	
Sharon Van Brunschot	University of Queensland	Virology
Warwick Waters	Cotton Research and Development Corporation	
Lewis Wilson	CSIRO	Entomology

Review processes

With the support of Cotton Australia and PHA, this plan should be reviewed on a 4-5 year basis. The review process will ensure:

- threat summary tables (TST) are updated to reflect current knowledge
- pest risk assessments are current
- changes to biosecurity processes and legislation are documented
- contact details and the reference to available resources is accurate.

In addition to the formal review process above, the document should be reviewed/revisited annually by industry and government to ensure currency and relevance and to consider progress with implementation. As an example, the industry biosecurity priorities identified within the plan could feed directly into industry R&D priority setting activities on an annual basis.

Opportunities to make out of session changes to the IBP, including the addition/subtraction of high priority pests or changes to legislation are currently being investigated. Such changes would need to include consultation and agreement of industry and government. This flexibility will facilitate the plan's currency and relevance.

Document overview

The biosecurity package developed for the Australian cotton industry focuses on a number of key areas.

Threat identification and pest risk assessments

Guidelines are provided for the identification and ranking of biosecurity threats through a process of qualitative risk assessment. The primary goal is to coordinate identification of exotic pest threats that could impact on productivity, sustainability, and marketability and to assess their potential impacts. This plan strengthens risk assessment work already being done both interstate and overseas. Key cotton biosecurity threats are detailed in the TST (Appendix 1) and HPP list (the top ranked threats to the cotton industry, Table 5).

The EPPRD outlines a mechanism whereby Industry and Government Parties will contribute to the total cost of a response to an EPP Incident based on agreed Categories. The process used for categorisation of EPPs is included in this section of the IBP, along with a list of cotton EPPs that have been categorised to date.

Risk mitigation and preparedness

This section provides a summary of activities to mitigate the impact of pest threats on the Australian cotton industry, along with a set of guidelines for managing risk at all operational levels. Many pre-emptive practices can be adopted by plant industries and government agencies to reduce risks. The major themes covered include:

- barrier quarantine
- surveillance
- training
- awareness
- farm biosecurity
- reporting suspect pests.

Response management

PHA has coordinated the development of PLANTPLAN, a generic emergency response plan for the Australian plant industries. This plan details the procedures required and the organisations responsible in the event of an incursion of an EPP. Pest-specific contingency plans may be developed as a result of the pest threats identified in this plan.

Reference

Plant Health Australia (2014) PLANTPLAN: Australian Emergency Plant Pest Response Plan. Version 2.0. Plant Health Australia, Canberra ACT.

THREAT IDENTIFICATION AND PEST RISK ASSESSMENTS

Introduction

This section identifies high risk exotic pest threats to the cotton industry, and presents a framework for assessing the potential economic, social and environmental impacts associated with each threat. This part of the biosecurity plan uses a nationally consistent and coordinated approach to threat identification and risk assessment to provide a strong base for future risk management in the cotton industry.

By identifying key threats a pre-emptive approach may be taken to risk management. Under this approach, mechanisms can be put into place to increase our response effectiveness if pest incursions occur. One such mechanism is the Emergency Plant pest and Response Deed (EPPRD) that has been negotiated between PHA government and industry members. The EPPRD ensures reliable and agreed funding arrangements are in place in advance of EPP incursions, and assists in the response to EPP incursions, particularly those identified as key threats.

Identification of high risk pests will also assist in the implementation of effective grower and community awareness campaigns, targeted biosecurity education and training programs for growers and diagnosticians, and development of pest-specific incursion response plans.

Established pests and weeds of biosecurity significance have also been listed in this plan (Page 48). It is well understood that good biosecurity practice is beneficial for the ongoing management of established pests and weeds, as well as for surveillance and early detection of exotic pests. Established pests cause ongoing hardships for growers and these pests have been listed with the support of industry and government in recognition that they need a strategic, consistent, scientific and risk-based approach to better manage these pests for the cotton industry.

Exotic Pests of the Cotton Industry

Threat identification

Information on biosecurity threats to the cotton industry described in this document came from a combination of:

- past records
- existing industry protection plans
- industry practice and experience
- relevant published literature
- local industry and overseas research
- specialist and expert judgment.

At this time, only invertebrate pests (insects, mites, molluscs and nematodes) and pathogens (disease causing organisms) have been identified, although the issue of weeds may be revisited through future reviews of this plan.

Pest risk assessments

The assessment process used in this IBP was developed in accordance with the International Standards for Phytosanitary Measures (ISPM) No. 2 and 11 [Food and Agriculture Organization of the United Nations (FAO), 2004; 2007]. A summary of the pest risk analysis protocol followed in this IBP is shown in Table 4, and the complete protocol used for pest risk analysis in this IBP can be found on the PHA website[15].

While there are similarities in the ranking system used in this document and the Import Risk Analysis (IRA) process followed by the Department of Agriculture, there are differences in the underlying methodology and scope of consideration that may result in different outcomes between the two assessment systems. This includes different guidance to assignment of qualitative probabilities when compared with the Department of Agriculture's IRA process.

Modifications of the Department of Agriculture, Fisheries and Forestry (2011) protocol have been made to suit the analysis required in the IBP development process, including, but not limited to:

[15] Available from **www.planthealthaustralia.com.au/biosecurity/risk-mitigation**

- **Entry potential:** The determination of entry potential in this IBP takes into account multiple possible pathways for the legal importation of plant material as well as illegal pathways, contamination and the possibility of introduction through natural means such as wind. Therefore the scope is wider than that used by the Department of Agriculture in their IRA process, which only considers legal importation of plants or plant commodities.
- **Potential economic impact** of pest establishment in this document only takes into account the impacts on the cotton industry. The Department of Agriculture IRA process has a wider scope, including the effects to all of Australia's plant industries, trade, the environment and public health.
- **Risk potentials and impacts:** The number of categories used in this IBP for describing the entry, establishment, spread, and potential economic impact (see 'Description of terms used in pest risk tables', Page 39) differs in comparison to that used in the Department of Agriculture IRA process.

Table 4. *Summary of pest risk assessment process used in IBPs*

Step 1	Clearly identify the pest	• Generally pest defined to species level • Alternatively a group (e.g. family, genus level) can be used • Sub-species level (e.g. race, pathovar, etc.) may be required
Step 2	Assess entry, establishment and spread likelihoods	• Assessment based on current system and factors • Negligible, low, medium, high or unknown ratings
Step 3	Assess likely consequences	• Primarily based on likely economic impact to industry based on current factors • Negligible, low, medium, high, extreme or unknown ratings
Step 4	Derive overall risk	• Entry, establishment and spread likelihoods are combined to generate a likelihood score • Likelihood score combined with the likely economic impact to generate an overall risk score
Step 5	Review the risk	• Risk ratings should be reviewed with the IBP

The objective of risk assessment is to clearly identify and classify biosecurity risks and to provide data to assist in the evaluation and treatment of these risks. Risk assessment involves consideration of the sources of risk, their consequences, and the likelihood that those consequences may occur. Factors that affect the consequences and likelihood may be identified and addressed via risk mitigation strategies.

Risk assessment may be undertaken to various degrees of refinement, depending on the risk information and data available. Assessment may be qualitative, semi-quantitative, quantitative, or a combination of these. The complexity and cost of assessment increase with the production of more quantitative data. It is often more practical to first obtain a general indication of the level of risk through qualitative risk assessment, and if necessary, undertake more specific quantitative assessment later [Australian Standard/New Zealand Standard (AS/NZS) ISO 31000, 2009].

Ranking pest threats

Key questions required for ranking the importance of pests include the following:

- What are the probabilities of entry into Australia, establishment and spread, for each pest?
- What are the likely impacts of the pest on cost of production, overall productivity and market access?
- How difficult is each pest to identify and control and/or eradicate?

The TSTs (Appendix 1) present a list of potential plant pest threats to the cotton industry and provide summarised information on entry, establishment and spread potential, the economic consequences of establishment and eradication potential (where available). The most serious threats from the TSTs were identified through a process of qualitative risk assessment[16] and are listed in the HPP list (Table 5).

This document considers all potential pathways by which a pest might enter Australia, including natural and assisted spread (including smuggling). This is a broader view of potential risk than the IRA conducted by the Department of Agriculture which focus only on specific regulated import pathways.

When a pest that threatens multiple industries is assessed, the entry, establishment and spread potentials take into account all known factors across all host industries. This accurately reflects the ability of a pest to enter, establish and spread across Australia and ultimately results in different industries, and their IBPs, sharing similar pest ratings. However the

[16] An explanation of the risk assessment method used can be found on the PHA website (**www.planthealthaustralia.com.au/biosecurity/risk-mitigation**)

economic impact of a pest is considered at an industry specific level (i.e. for the cotton industry only in this IBP), and therefore this rating may differ between IBPs.

Description of terms used in pest risk tables

The descriptions below relate to terms in Table 5.

Entry potential

Negligible	The probability of entry is extremely low given the combination of all known factors including the geographic distribution of the pest, quarantine practices applied, probability of pest survival in transit and pathways for pest entry and distribution to a suitable host.
Low	The probability of entry is low, but clearly possible given the expected combination of factors described above.
Medium	Pest entry is likely given the combination of factors described above.
High	Pest entry is very likely and potentially frequent given the combination of factors described above.
Unknown	The pest entry potential is unknown or very little of value is known.

Establishment potential

Negligible	The pest has limited potential to survive and become established within Australia given the combination of all known factors.
Low	The pest has the potential to survive and become established in approximately one-third or less of the range of hosts. The pest could have a low probability of contact with susceptible hosts.
Medium	The pest has the potential to survive and become established in between approximately one-third and two-thirds of the range of hosts.
High	The pest has potential to survive and become established throughout most or all of the range of hosts. Distribution is not limited by environmental conditions that prevail in Australia. Based upon its current world distribution, and known conditions of survival, it is likely to survive in Australia wherever major hosts are grown.
Unknown	The establishment potential of the pest is unknown or very little of value is known.

Spread potential

Negligible	The pest has very limited potential for spread in Australia given the combination of dispersal mechanisms, availability of hosts, vector presence, industry practices and geographic and climatic barriers.
Low	The pest has the potential for natural or assisted spread to susceptible hosts within Australia yet is hindered by a number of the above factors.
Medium	The pest has an increased likelihood of spread due to the above factors.
High	The natural spread of the pest to most production areas is largely unhindered and assisted spread within Australia is also difficult to manage.
Unknown	The spread potential is unknown or very little of value is known.

Economic impact

Negligible	There are very minor, often undetectable, impacts on production with insignificant changes to host longevity, crop quality, production costs or storage ability. There are no restrictions to market access.
Very low	There are minor, yet measurable impacts on production including either host longevity, crop quality, production costs or storage ability. There are no restrictions to market access.
Low	There are measurable impacts to production including either host mortality, reduction in yield, production costs, crop quality, storage losses, and/or minimal impacts on market access.
Medium	There are significant impacts on production with either host mortality, reduction in yield, production costs, crop quality, storage losses, and/or moderate impacts on market access.
High	There are severe impacts on production including host mortality and significant impacts on either crop quality or storage losses, and/or severe impacts on market access.
Extreme	There is extreme impact on standing crop at all stages of maturity, with high host mortality or unmanageable impacts to crop production and quality, and /or extreme, long term, impacts on market access.
Unknown	The economic potential of the pest is unknown or very little of value is known.

Cotton industry high priority plant pest threat list

Table 5 provides an overview of the top ranked threats to the cotton industry. Further details on each pest along with the basis for the likelihood ratings are provided in the TSTs (Appendix 1). Assessments may change given more detailed research, and the priority list will be reviewed with the Biosecurity Plan on a 4-5 year basis. An explanation of the method used for calculating the overall risk can be found on the PHA website[17].

Table 5. *Cotton industry high priority plant pest threat list*

Scientific name	Common name	Host(s)	Plant part affected	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
INVERTEBRATES								
Anthonomus grandis	Boll weevil	Cotton (*Gossypium barbadense*, *G. hirsutum*) and related *Gossypium* species. Rose of Sharon (*Hibiscus syriacus*) has also been reported as an alternative host[18]	Bolls	MEDIUM[19]	HIGH[20]	HIGH	HIGH[21]	**HIGH**

[17] Available from **www.planthealthaustralia.com.au/biosecurity/risk-mitigation**
[18] See: CABI and EPPO (date of publication unknown A) for further details.
[19] Could enter on crop debris (e.g. on machinery). Pest present in North and South America.
[20] Based on this species distribution in the United States, Australian cotton growing areas would be suitable for its establishment.
[21] Would have large impact on the industry through yield losses and additional chemical control costs.

Scientific name	Common name	Host(s)	Plant part affected	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Aphis gossypii (exotic strains)	Cotton aphid (exotic strains)	Wide host range including: cotton, cucumber, pumpkin, melon, faba bean and eggplant.	Above ground plant parts	MEDIUM	HIGH	HIGH	HIGH[22]	**HIGH**
Bemisia tabaci (Biotypes other than B and AN)[23]	Silverleaf whitefly (exotic biotypes)	Broad host range including cotton, vegetables & ornamentals	Leaves, honeydew on lint	MEDIUM	HIGH	HIGH	MEDIUM - HIGH[24]	**MEDIUM - HIGH**
***Dysdercus* spp.** (including: *D. honestus, D. maurus, D. suturellus* (American species))	Cotton stainer; red bugs	Cotton, green sorghum, okra, Malvaceae, boab	Bolls, seeds	MEDIUM[25]	HIGH[26]	HIGH	HIGH[27]	**HIGH**
Halyomorpha halys	Brown marmorated stink bugs	Wide host range with over 100 species reported as hosts including cotton, sweetcorn, soybeans, vegetables and fruit trees	Bolls	MEDIUM-HIGH[28]	HIGH[29]	HIGH	HIGH[30]	**HIGH**
Helicoverpa armigera (carrying Bt resistance alleles)	Cotton bollworm; African boll worm	Wide host range including: cotton, maize, chickpea, lucerne, soybean, peanuts	Above ground plant parts	MEDIUM	HIGH	HIGH	HIGH	HIGH

[22] Exotic strains may have different insecticide resistance profiles or cause differing levels of damage on cotton than strains already in Australia. Cotton aphids cause honey dew on lint and act as potential vectors of cotton various viruses (e.g. the exotic *Cotton anthocyanosis virus* (*Luteovirus*)).
[23] Biotypes B and AN, occur in Australia (see: DAFF Qld 2012). Exotic biotypes may have different insecticide resistance profiles or cause differing levels of damage on cotton than biotypes already in Australia.
[24] Can have a significant impact on lint yield when plants are heavily infested (Naranjo et al., 1996).
[25] These species occur in North and South America.
[26] There are species in this genus that occur in Australia.
[27] *D. suturellus* is the most damaging of the American species. These bugs feed on bolls and stain the cotton lint a yellow-brown colour. If young bolls are fed on they may not mature (Mead 2005), can also affect mature bolls.
[28] Was recently (late 1990s) introduced from China into North America, where it is spreading rapidly (Kamminga et al., 2014). Spread on cargo from infected areas.
[29] Given the spread of this species in the United States.
[30] This species is spreading into the United States cotton belt and is reported to attack large bolls in preference to small bolls (Kamminga et al., 2014).

Scientific name	Common name	Host(s)	Plant part affected	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Lygus hesperus	Western plant bug	Feeds primarily on cotton and strawberry. Also affects a range of other species	Squares, bolls	MEDIUM[31]	HIGH	HIGH	HIGH[32]	**HIGH**
Lygus lineolaris	Tarnished plant bug	Wide host range including: cotton, strawberry, lucerne, peach, common bean, *Rubus* spp., vetch, canola, sunflower, soybeans and maize.	Squares, bolls	MEDIUM	HIGH	HIGH	HIGH[166]	**HIGH**
Thaumatotibia leucotreta (syn. *Cryptophlebia leucotreta*)	False codling moth	Feeds on more than 50 species of plants in over 30 plant families including: cotton, lima bean, common bean, sorghum, maize, cowpea	Bolls, seed	MEDIUM[33]	HIGH	HIGH[211]	HIGH[34]	**HIGH**

[31] Eggs laid in plant material.
[32] Significant pest of cotton overseas. feeding causes damage to squares, feeding on bolls can cause seed and lint damage.
[33] Could spread inside fruit, etc.
[34] In Uganda this pest has been reported to cause 20-90% losses in cotton due to boll damage. Late sown crops were most effected (Byaruhanga 1977).

Scientific name	Common name	Host(s)	Plant part affected	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
PATHOGENS & NEMATODES								
***Cotton leafroll dwarf virus* (*Polerovirus*)**	Cotton blue disease	Cotton, Pima cotton (*Gossypium barbadense*) and chickpea[35], *Hibiscus sabdariffa*, *Sida acuta*.	Causes stunting, leaf damage, reduced flowering, boll sheading, whole plant affected	MEDIUM[36]	HIGH	HIGH[37]	HIGH[38]	**HIGH**
***Cotton leaf curl virus complex* (*Begomovirus*)**	Cotton leaf curl virus; Cotton leaf crumple virus; Cotton leaf curl gezira virus; Cotton leaf curl Alabad virus; Cotton leaf curl Burewala virus; Cotton leaf curl Kokhran virus; Cotton leaf curl Multan virus; Cotton leaf curl Rajasthan virus; Cotton leaf curl Shahdadpur virus	Cotton. Additional hosts include Hibiscus, okra, tobacco, radish, tomato, French bean, chilli, papaya and many weeds	Leaves symptomatic, whole plant affected	MEDIUM[39]	HIGH	HIGH[40]	EXTREME[41]	**EXTREME**
Fusarium oxysporum* f. sp. *vasinfectum (exotic races)[42]	Fusarium wilt (exotic races)	Cotton	Roots, stem, leaves, whole plant	MEDIUM[43]	HIGH	HIGH[44]	EXTREME	**EXTREME**

[35] See: CottonInfo (2014)
[36] Occurs in parts of South America, Africa and Asia (Distefano et al., 2010). Reported from several African countries (Cauquil 1977; Dyck 1979), India (Mukherjee et al 2012), South East Asia (Kaowsiri 1982; Quyen et al 2008; Sharman et al., 2015), East Timor (Ray et al 2014), Brazil (Correa et al 2005) and Argentina (Distefano et al., 2010). Synonymous virus, Chickpea stunt disease associated virus (CpSDaV) appears to be the same virus; naturally infects chickpea and other experimental legume hosts in India (Naidu et al 1997; Reddy and Kumar 2004). It is not seed borne.
[37] Vector (*Aphis gossypii*) and hosts present in all cotton growing regions of Australia.
[38] Most important cotton virus affecting crops in South America (Brazil and Argentina) and SE Asia (Distefano et al., 2010; Kaowsiri 1982; Quyen et al 2008). Atypical strain affects resistant varieties. Considered the second most damaging cotton disease after Cotton leaf curl disease (CottonInfo 2014).
[39] The virus is graft transmitted but is not mechanically or seed-transmitted (USDA 2013). Could enter on live ornamental or horticultural hosts.
[40] Spread by White fly (*Bemisia tabaci*) (USDA 2013; Kirkpatrick and Rothrock 2001).
[41] Early season infections can result in total crop loss (USDA 2013). Thought to be the most damaging cotton disease.
[42] To date 8 races have been classified (Skovgaard et al., 2001). The Australian race appears to be similar to race 6 (Davis et al., 1996). The Australian isolates belong to Vegetative Compatible Groups (VCG) 01111 and 01112 (Wang et al., 2006) as well as the Mungindi strain.
[43] Present in North America, China, Africa.
[44] Soil-borne, and on plant debris (Kirkpatrick and Rothrock 2001).

Scientific name	Common name	Host(s)	Plant part affected	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Phymatotrichopsis omnivora (Syn. *Phymatotrichum omnivorum*)	Texas root rot; Phymatotrichum root rot; cotton root rot	Cotton, peanuts, soybeans, common beans, lucerne and approx. 2000 other plants	Root, whole plant	MEDIUM[45]	MEDIUM	MEDIUM[46]	EXTREME[47]	**HIGH**
Verticillium dahliae (defoliating strain)[48]	Verticillium wilt (defoliating strain)	Cotton, olives, artichoke[49]. Cotton and olives are the most severely affected hosts	Whole plant	MEDIUM[50]	HIGH[51]	HIGH[52]	HIGH[53]	**HIGH**
Xanthomonas citri* subsp. *malvacearum (Syn. *X. axonopodis* pv. *malvacearum; X.campestris* pv. *malvacearum*) (exotic/hypervirulent races)[54]	Bacterial blight; Angular leaf spot (exotic/hypervirulent races)	Cotton	Leaves, stem and bolls	MEDIUM	HIGH	HIGH[55]	HIGH[56]	**HIGH**

[45] Present in North America.
[46] Spread with soil, plant debris, etc.
[47] Symptoms are not usually obvious until flowering. Infections cause wilting and plant death (Kirkpatrick and Rothrock 2001). Due to long lived spores infected areas would likely be unable to grow cotton again.
[48] Non-defoliating strains of *Verticillium dahliae* occur in Australia. The defoliating strain VCG 1A is known to occur in Australia and is currently under review.
[49] See: Jimenez-Diaz et al., (2006) and Mercado-Blanco et al., (2003) for further information.
[50] Present in the United States, Russia, Peru and Uganda (El Zik 1985).
[51] Defoliating strain has a higher temperature requirement than non-defoliating strains.
[52] Soil, plant debris, etc. can spread the pathogen.
[53] Causes defoliation and shedding of bolls (El Zik 1985).
[54] There are at least 32 races of this pathogen (Madani et al., 2010). Races, 1, 2, 3, 4, 5, 7, 9, 10 and 18 (the most common race affecting Australian cotton) occur in Australia (Allen and West 1991). Exotic races refers to all races of the pathogen other than the 9 known to occur in Australia.
[55] Seed, plant debris, rain splash. Symptomless epiphyte.
[56] One of the most damaging pathogens affecting cotton (Madani et al., 2010).

Current resources for detection and identification of HPPs

Diagnostic and surveillance capacity for the HPPs of the cotton industry (Table 6) supports Australia's preparedness and ability to respond to them should they be detected. A summary of this capacity is shown in Table 6, which lists the formal active surveillance programs and the status of national diagnostic protocols developed for each of the cotton HPPs.

Development of national diagnostic protocols is managed through the Subcommittee on Plant Health Diagnostics (SPHD). While diagnostic capacity may exist in Australia in the absence of these documents, an endorsed national diagnostic protocol provides a consistent and agreed diagnostic approach for identifying new pests. Further information on these documents can be found on Page 86.

Table 6. *Diagnostic protocols and surveillance programs for HPPs (as at December 2014)*[57]

Scientific name	Common name	National diagnostic protocol	Surveillance programs
INVERTEBRATES			
Anthonomus grandis	Boll weevil	Not yet developed	Not covered by a pest specific surveillance program
Aphis gossypii (exotic strains)	Cotton aphid (exotic strains)	Not yet developed	NSW aphid surveillance (covers multiple species) NSW urban hazard site surveillance (covers exotic aphids)
Bemisia tabaci (Biotypes other than B and AN)[58]	Silverleaf whitefly (exotic biotypes)	Not yet developed	NT whitefly surveillance Qld Silverleaf whitefly resistance management surveillance Tas Silverleaf whitefly surveillance
***Dysdercus* spp.** (including: D. honestus, D. maurus, D. suturellus (American species))	Cotton stainer; red bugs	Not yet developed	Not covered by a pest specific surveillance program
Halyomorpha halys	Brown marmorated stink bugs	Not yet developed	Tas Brown marmorated stink bug surveillance
Helicoverpa armigera (carrying Bt resistance alleles)	Cotton bollworm; African boll worm	Not yet developed	Not covered by a pest specific surveillance program
Lygus hesperus	Western plant bug	Not yet developed	Not covered by a pest specific surveillance program

[57] Information presented has been taken from the National Plant Health Status Report 2014 and confirmed or updated in 2015 through either Plant Health Committee, the Subcommittee on Plant Health Diagnostic Standards, the Subcommittee on National Plant Health Surveillance or other stakeholders

[58] Bemisia tabaci is recognized as a cryptic species complex, as such biotypes B and AN are recognized as separate species. Exotic biotypes of Bemisia tabaci are therefore now recognized as exotic species of this species complex, see: De Barro et al., (2011). Biotypes B and AN, occur in Australia (see: DAFF Qld 2012). Exotic biotypes may have different insecticide resistance profiles or cause differing levels of damage on cotton than biotypes already in Australia.

Scientific name	Common name	National diagnostic protocol	Surveillance programs
Lygus lineolaris	Tarnished plant bug	Not yet developed	Not covered by a pest specific surveillance program
Thaumatotibia leucotreta (syn. *Cryptophlebia leucotreta*)	False codling moth	Not yet developed	Not covered by a pest specific surveillance program
PATHOGENS & NEMATODES			
***Cotton leafroll dwarf virus* (*Polerovirus*)**	Blue disease	Draft under development	NSW Diseases of cotton surveillance Qld Endemic and exotic diseases of cotton surveys
***Cotton leaf curl virus complex* (*Begomovirus*)**	Cotton leaf curl virus	Draft under development	NSW Diseases of cotton surveillance Qld Endemic and exotic diseases of cotton surveys
Fusarium oxysporum* f. sp. *vasinfectum (exotic races) [59]	Fusarium wilt (exotic races)	Not yet developed	NSW Diseases of cotton surveillance Qld Endemic and exotic diseases of cotton surveys
Phymatotrichopsis omnivora (Syn. *Phymatotrichum omnivorum*)	Texas root rot; Phymatotrichum root rot; cotton root rot	Not yet developed	NSW Diseases of cotton surveillance Qld Endemic and exotic diseases of cotton surveys
Verticillium dahliae (defoliating strain)[60]	Verticillium wilt (defoliating strain)	Draft under development	NSW Diseases of cotton surveillance Qld Endemic and exotic diseases of cotton surveys
Xanthomonas citri* subsp. *malvacearum (Syn. *X. axonopodis* pv. *malvacearum; X.campestris* pv. *malvacearum*) (exotic/hypervirulent races)[61]	Bacterial blight; Angular leaf spot (exotic/hypervirulent races)	Draft under development	NSW Diseases of cotton surveillance Qld Endemic and exotic diseases of cotton surveys

[59] To date 8 races have been classified (Skovgaard et al., 2001). The Australian race appears to be similar to race 6 (Davis et al., 1996). The Australian isolates belong to Vegetative Compatible Groups (VCG) 01111 and 01112 (Wang et al., 2006) as well as the Mungindi strain.
[60] Non-defoliating strains of *Verticillium dahliae* occur in Australia. The defoliating strain VCG 1A is known to occur in Australia and is currently under review.
[61] There are at least 32 races of this pathogen (Madani et al., 2010). Races, 1, 2, 3, 4, 5, 7, 9, 10 and 18 (the most common race affecting Australian cotton) occur in Australia (Allen and West 1991). "Exotic races" refer to all races of the pathogen other than the 9 known to occur in Australia.

Established Pests of Biosecurity Significance

Introduction

This section identifies established pests of biosecurity significance for the cotton industry.

By identifying and prioritising established pests which cotton producers already have to manage, mechanisms can be put in place to better align industry and government resources and provide a strong base for biosecurity risk management for the cotton industry.

Identification of established pests of significance will also assist in the implementation of effective grower and community awareness campaigns, targeted biosecurity education and training programs for growers, surveillance coordinators, diagnosticians and development of pest-specific mitigation activity.

Threat identification

Information on established pests of the cotton industry described in this document came from a combination of:

- past records
- existing industry protection plans
- relevant experience
- industry practice and experience
- relevant published literature
- local industry and overseas research
- specialist and expert judgment

Prioritising pest threats

Although established pests listed in this plan (Table 7) had to meet the criteria listed below for establishment, spread and economic impact, these pests did not undergo a formal pest risk assessment. These pests were considered in an effort to prioritise investment.

Spread: The natural spread of the pest to most production areas is largely unhindered and assisted spread within Australia is also difficult to manage. There may be state or territory specific regulations in place to prevent the pest spreading.

Establishment: The pest has the potential to survive and become established throughout most or all of the range of hosts. Distribution is not limited by environment conditions that prevail in Australia. Based upon its current distribution in Australia, and known conditions of survival, it is likely to survive in Australia in the majority of regions where the host is grown.

Economic Impact: There are severe impacts on production including host mortality and/or significant impacts on either crop quality or storage losses, and/or severe impacts on market access.

Table 7 *Established pests of Biosecurity Significance*

Common name	Scientific Name	Hosts	Distribution in Australia	Plant part affected and effect on crop	Comments
INVERTEBRATES					
ACARI (Mites e.g. spider and gall mites)					
Red spider mite	*Tetranychus evansi*	Mostlry Solanaceae (eg blackberry nightshade (*Solanum nigrum*) and glossy night shade (*S. americanum*). But can also affect cotton, tomato, roses, beans and other plants	Currently confined to Sydney airport and surrounding areas (NSW DPI 2013)	Above ground plant parts	Currently confined to Sydney airport and surrounding areas (NSW DPI 2013)
HEMIPTERA (Stink bugs, aphids, mealybugs, scale, whiteflies and hoppers)					
Solenopsis Mealybug	*Phenacoccus solenopsis*	Wide host range including: cotton, tomato, eggplant, chili, melon, potato, native rosella	Currently only in Queensland does not currently occur in the main New South Wales cotton growing areas. Also present in WA	Whole plant, insects can feed on above or below ground plant parts.	Serious pest of cotton (Cotton Catchment Communities Cooperative Research Centre 2011).

Common name	Scientific Name	Hosts	Distribution in Australia	Plant part affected and effect on crop	Comments
LEPIDOPTERA (Butterflies and moths)					
Pink bollworm	*Pectinophora gossypiella*	Various including: cotton, cottonwood tree (*Hibiscus tiliaceus*) and broadleaf bottle tree (*Brachychiton australis*)	Occurs in WA and NT	Bolls	Occurs in WA and NT where it feeds on cotton bolls and can cause boll rot (Cotton Catchment Communities Cooperative Research Centre 2011). Particular risk when raw cotton is sent from these regions to traditional commercial cotton regions for ginning.
PATHOGENS					
FUNGI					
Target spot	*Corynespora cassiicola*	Wide host range affecting multiple plant families including cotton	NSW, NT, Qld, Vic and WA.	Leaves	The Australian Plant Pest Database holds records for this fungus on a range of hosts in NSW, NT, Qld, Vic and WA.
NEMATODE					
Reniform nematode	*Rotylenchulus reniformis*	Wide host range including cotton, pigeon pea, citrus	Central Queensland	Roots, stunted plants	In cotton regions, currently confined to Central Queensland.
	Rotylenchulus parvus	Wide host range including cotton, papaya, beetroot, cucumber, barley, maize, grape	Confined to small area of Queensland.	Roots	Confined to small area of Queensland. This nematode is reported to affect cotton
VIRUS AND VIROIDS					
Abutilon mosaic virus; Malvaceous chlorosis virus	*Abutilon mosaic virus* (*Begomovirus*)	Malvaceae including *Abutilon* spp. and cotton	Queensland (van Brunschot, et al., 2013)	Leaves	This has been recorded in Australia (van Brunschot, et al., 2013). Not a significant virus of cotton overseas.

Weeds of Biosecurity Significance

Introduction

This section identifies both established and exotic weeds of biosecurity significance for the cotton industry. By identifying and prioritising weeds which cotton producers already have to manage, or may have to deal with in the future, mechanisms can be put in place to better align industry and government resources and provide a strong base for biosecurity risk management for the cotton industry.

Although weeds were not formally included in the EPPRD at the time that this IBP was released, weeds may be included or dealt with in a similar way in the future. Therefore, it is critical that the cotton industry start reviewing the threat of weeds to their production system. It is anticipated that Cotton Australia will provide advice to the National Biosecurity Committee (NBC) for managing exotic weeds incursions not covered by current emergency response agreements through representation on the newly formed Exotic Weeds Incursion Agreement Taskforce.

Identification of weeds of significance will also assist in the implementation of effective grower and community awareness campaigns, targeted biosecurity education and training programs for growers and botanists, and development of specific incursion response plans if an incursion of the weed occurs, or if the weed spreads further in production regions of Australia.

Threat identification

Information on weeds of the cotton industry described in this document came from a combination of:

- existing industry protection plans
- relevant experience
- industry practice and experience
- relevant published literature
- local industry and overseas research
- specialist and expert judgment.

Prioritising pest threats

In an effort to prioritise investment for weeds, each of the pests listed in Table 8 had to meet the required definitions for spread, establishment and economic impact listed below.

Spread: The natural spread of the weed to most production areas is largely unhindered and assisted spread within Australia is also difficult to manage. For established weeds there may be state or territory specific regulations in place to prevent the weed spreading further.

Establishment: The weed, and its reproduction mechanism (i.e. seed, fruit, plant part) has the potential to survive and become established throughout most of the growing regions of the crop. Distribution is not limited by environment conditions that prevail in Australia. Based upon its current distribution in Australia, and known conditions of survival, it is likely to survive in the majority of regions where the host is grown.

Economic Impact: There are severe impacts on production including host mortality, and/or significant impacts on either crop quality or storage losses, and/or severe impacts on market access.

Table 8. Weeds of 'biosecurity significance'

Common name	Scientific Name	Distribution in Australia	Effect on crop	Comments
Palmer amaranth	***Amaranthus palmeri***	Not present in Australia.	Competes with crops.	Significant issue in the United States due to glyphosate resistance.
Anoda weed	***Anoda cristata***	Present in Australia in Queensland and NSW	Competes with crops. This species is known to host endemic cotton pathogens such as Cotton bunchy top and Alternaria leaf spot (see Cotton CRC (2013) WEEDpak).	Originally from Central America it is now a weed of cotton in Queensland and is spreading in NSW. Seeds can be spread on machinery and with cotton lint. This species is known to host endemic cotton pathogens such as Cotton bunchy top and Alternaria leaf spot (see Cotton CRC (2013) WEEDpak).
Feathertop Rhodes grass	***Chloris virgata***	Present in Australia in Queensland and Northern NSW	Competes with crops.	Becoming a major issue in Queensland and northern NSW. Also present in South Australia and parts of the Western Australia grains belt. This species is tolerant of glyphosate so management is difficult.
Wimmera ryegrass	***Lolium rigidum***	Present in Australia in all states. .	Competes with crops.	Wimmera ryegrass has developed resistance to a number of herbicides in Australia (see Cotton CRC (2013) WEEDpak)
Herbicide resistant weeds	**Various species**	Several species present in Australia each with varying distributions.	Competes with crops.	Herbicide, especially Glyphosphate, resistant weeds occur in Australia and overseas. These weeds represent a significant issue for cotton growers as alternative herbicides or cultivation would be required to manage them. See: Cotton CRC (2013) WEEDpak (Section B2) for further information on key species and where they occur.

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RISK MITIGATION AND PREPAREDNESS

Introduction

There are a number of strategies that can be adopted to help protect and minimise the risks of exotic and emergency pests under International Plant Protection Convention (IPPC) standards (**www.ippc.int/standards**) and Commonwealth and state/territory legislation.

Many pre-emptive practices can be adopted to reduce the risk of exotic pest movement for the cotton industry (Figure 2). Such risk mitigation practices are the responsibility of governments, industry and the community.

A number of key risk mitigation areas are outlined in this guide, along with summaries of the roles and responsibilities of the Australian Government, state/territory governments, and cotton industry members. This section is to be used as a guide outlining possible activities that may be adopted by industry and growers to mitigate risk. Each grower will need to evaluate the efficacy of each activity for their situation.

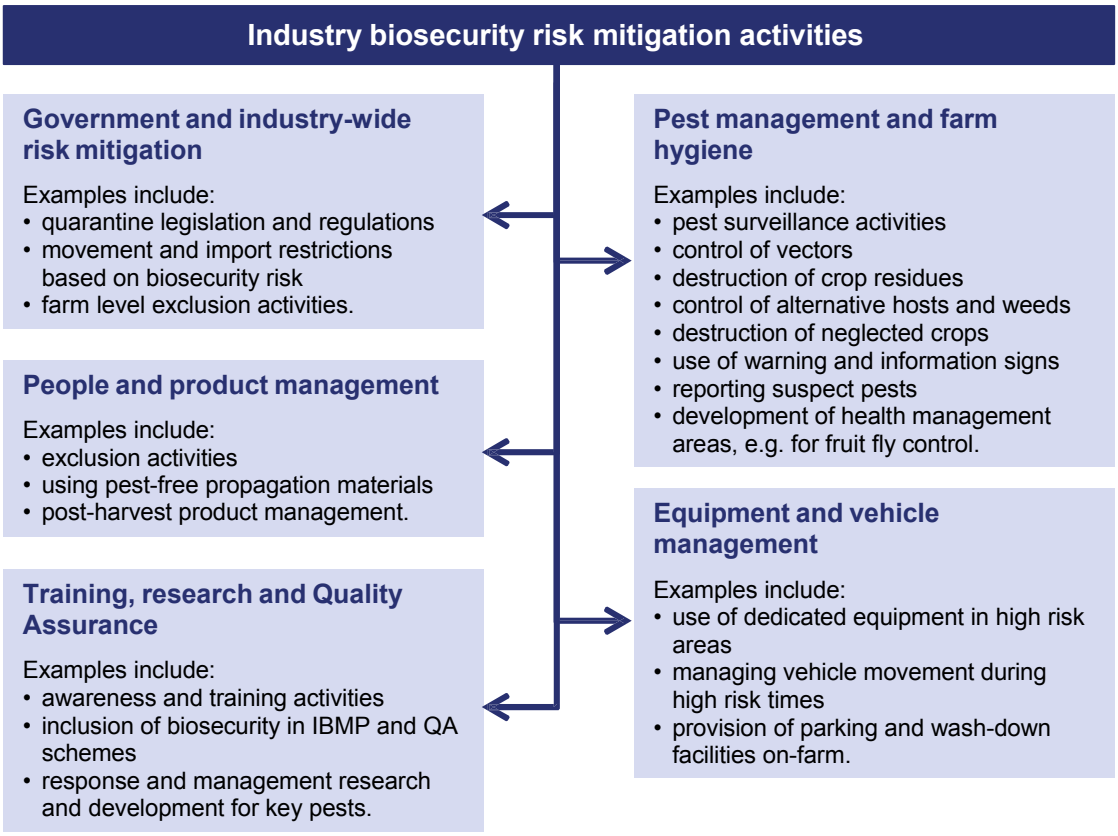


Figure 2. *Examples of biosecurity risk mitigation activities*

Barrier quarantine

Barrier quarantine should be implemented at all levels of the cotton industry including national, state, regional, and farm levels.

National level – importation restrictions

The Department of Agriculture is the Australian Government department responsible for maintaining and improving international trade and market access opportunities for agriculture, fisheries, forestry, and food industries. The Department of Agriculture achieves this through:

- establishment of scientifically-based quarantine policies
- provision of effective technical advice and export certification services
- negotiations with key trading partners
- participation in multilateral forums and international sanitary and phytosanitary (SPS) standard-setting organisations
- collaboration with portfolio industries and exporters.

The Department of Agriculture is responsible for developing biosecurity (SPS) risk management policy and reviewing existing quarantine measures for the importation of live animals and plants, and animal and plant products. In particular, the Department of Agriculture undertakes import risk analyses to determine which products may enter Australia, and under what quarantine conditions. The Department of Agriculture also consults with industry and the community, conducting research and developing policy and procedures to protect Australia's animal and plant health status and natural environment. In addition, the Department of Agriculture assists Australia's export market program by negotiating other countries' import requirements for Australian animals and plants. Further information can be found at **www.agriculture.gov.au**.

The administrative authority for national quarantine is vested in the Department of Agriculture under the *Biosecurity Act 2015*. Quarantine policies are developed on the basis of an IRA process. This process is outlined in the IRA Handbook 2011 (Department of Agriculture, Fisheries and Forestry, 2011). The Department of Agriculture maintains barrier quarantine services at all international ports and in the Torres Strait region. The management of quarantine policy, as it relates to the introduction into Australia of fruit, seed, or other plant material, is the responsibility of the Department of Agriculture.

The Schedule 5 "Permitted Seeds" list from the *Quarantine Proclamation 1998* is maintained on the Import Conditions (ICON) database at **http://apps.daff.gov.au/icon32/asp/ex_querycontent.asp**.

ICON contains the current Australian import conditions for more than 20,000 foreign plants, animal, mineral and human products and is the first point of access to information about Australian import requirements for a range of commodities. It can be used to determine if a commodity intended for import to Australia requires a quarantine import permit and/or treatment or if there are any other quarantine prerequisites. There are currently a number of cases for cotton listed on ICON (see Table 9). For export conditions see the Manual of Importing Country Requirements (MICoR) database at **www.agriculture.gov.au/micor/plants**.

Seed is the only cotton propagative material permitted entry into Australia. These are visually inspected by quarantine officers and subsequently destroyed if there are obvious signs of pests and/or diseases. Cotton seed undergo disease screening and testing and are only released from quarantine if the plant material is found to be negative for quarantine pests and diseases.

The Australian Government is responsible for the inspection of machinery and equipment being imported into Australia. Any machinery or equipment being imported into Australia must meet quarantine requirements. If there is any uncertainty, contact the Department of Agriculture on (02) 6272 3933 or 1800 020 504, or visit the website at **www.agriculture.gov.au/biosecurity/import**.

The World Trade Organization (WTO) SPS Agreement facilitates international trade while providing a framework to protect the human, animal and plant health of WTO members. SPS measures put in place must minimise negative effects on trade while meeting an importing country's appropriate level of protection. For plant products these measures are delivered through the IPPC standard setting organisations and collaboration with portfolio industries and exporters. For more information on the IPPC visit **www.ippc.int**.

Table 9. *Import condition summary for cotton listed in ICON (as at August 2014)*[62]

Commodity	End use	Import status	Import permit	Additional comments
Cotton - Processed	All uses other than as animal foods, fertilisers or for growing purposes	Permitted	Not required	Condition applies to processed cotton including combed or carded cotton fibre, articles stuffed with combed or carded cotton fibre, spun cotton and cotton fabric from all countries.
Cotton - Unprocessed	All uses other than as animal foods, fertilisers or for growing purposes	Permitted	Not required (non-commercial quantities) Required (commercial quantities)	Condition applies to unprocessed cotton including raw or seed cotton, cotton lint, linters, cotton waste and cotton stuffing from all countries. *Non-commercial* Import permit is not required. Consignment will be inspected to verify it is free of seeds, insects, etc. and will require mandatory treatment with ethylene oxide fumigation or gamma irradiation. *Commercial* An Import Permit is required. Consignment must be free from cotton trash, cotton and other seed, live insects and other quarantine risk material. Consignment will require mandatory treatment with ethylene oxide fumigation or gamma irradiation. If live insects are found consignment will need to be fumigated with methyl bromide

[62] This is a summary only and should not be used as a substitute for consulting the ICON database (**http://apps.daff.gov.au/icon32/asp/ex_querycontent.asp**) or the Department of Agriculture directly to confirm the details of import conditions and any recent changes

Commodity	End use	Import status	Import permit	Additional comments
Gossypium herbaceum, Dried - [Herb] *Gossypium hirsutum*, Dried - [Herb]	All uses other than as animal foods, fertilisers or for growing purposes	Permitted	Not required	Conditions apply to consignments from all countries. *Non-commercial* All material in the consignment must be labelled with full botanical names i.e. genus and species. All material in the consignment must be thoroughly dried and not capable of propagation. consignment will be subject to an inspection to verify that it is free of prohibited seeds, bark, live insects, soil and other quarantine risk material *Commercial* All material in the consignment must be thoroughly dried and not capable of propagation, free from seed (unless that seed is a permitted species) and free from other quarantine risk material prior to arrival in Australia. All consignments require a full unpack and inspection at a Quarantine approved premises to verify that the material is commercially packaged in clean packages, labelled, dried and is free of other quarantine risk material. All fruit must be inspected for the presence of seed; fruit containing prohibited or restricted seeds will be ordered for moist heat treatment, gamma irradiation, re-export or destruction. Plant parts which are not sufficiently broken into pieces to allow a thorough inspection, are subject to mandatory treatment by fumigation with methyl bromide, heat treatment or cold storage prior to release. If live insects are found during the inspection they will be identified by a Department of Agriculture entomologist and the consignment will be treated with methyl bromide fumigation or cold storage.
Gossypium spp.	Seeds for sowing	Permitted	Required	Conditions apply to consignments from all countries. Seed must be free of live insects, soil, disease symptoms, prohibited seeds, other plant material, animal material etc. Each shipment must be packed in clean, new packaging, clearly labelled with the full botanical name. All seed must be grown in a closed quarantine facility

State and regional level – movement restrictions

The ability to control movement of materials that can carry and spread cotton pests is of high importance. Each state/territory has quarantine legislation in place to control the importation of cotton material interstate and intrastate, and to manage agreed pests if an incursion occurs (refer to Table 10). Further regulations have been put in place in response to specific pest threats and these are regularly reviewed and updated by state/territory authorities and the Subcommittee for Domestic Quarantine and Market Access (SDQMA).

Moving plant material between states/territories generally requires permits from the appropriate authority, depending on the plant species and which state/territory the material is being transferred to/from. Moving plant material intrastate may also require a permit from the appropriate authority. Information on pre-importation inspection, certification and treatments and/or certification requirements for movement of cotton (plants and fruit) can be obtained by contacting your local state or territory agriculture agency directly (see Table 10), or through the SDQMA website **www.domesticquarantine.org.au** which lists relevant contacts in each state/territory as well as Interstate Certification Assurance (ICA) documents relating to each state/territory.

The movement of farm vehicles and equipment between states is also restricted because of the high risk of inadvertently spreading pests. Each state/territory has quarantine legislation in place governing the movement of machinery, equipment and other potential sources of pest contamination. Information on vehicle and equipment movement restrictions can be obtained by contacting your local state/territory department of agriculture (Table 10).

Table 10. *Interstate and interregional movement of plant products – legislation, quarantine manuals and contact numbers*

State	Administering authority	Legislation	Links to quarantine manual[63]	Phone
ACT	Environment ACT **www.environment.act.gov.au**	*Plant Disease Act 2002* *Pest Plants and Animals Act 2005*	See NSW conditions	13 22 81
NSW	Department of Primary Industries **www.dpi.nsw.gov.au**	*Plant Diseases Act 1924* *Plant Diseases Regulation 2008* *Noxious Weeds Act 1993* *Noxious Weeds Regulation 2008*	**www.dpi.nsw.gov.au/biosecurity/plant**[64]	02 6391 3384
NT	Department of Primary Industry and Fisheries **www.nt.gov.au/d/Primary_Industry**	*Plant Health Act 2008* *Plant Health Regulations 2011*	**www.nt.gov.au/d/Primary_Industry/index.cfm?newscat1=&newscat2=&header=NT%20Quarantine**	08 8999 2118
Qld	Biosecurity Queensland, a part of the Department of Agriculture and Fisheries, Queensland **www.daf.qld.gov.au/biosecurity**	*Plant Protection Act 1989* *Plant Protection Regulation 2002*	**www.daf.qld.gov.au/plants/moving-plants-and-plant-products**	132 523[65] 07 3404 6999[66]
SA	Primary Industries and Regions SA **www.pir.sa.gov.au**	*Plant Health Act 2009* *Plant Health Regulations 2010*	**www.pir.sa.gov.au/biosecurity/plant_health/importing_commercial_plants_and_plant_products_into_south_australia**	08 8207 7820
Tas	Department of Primary Industries, Parks, Water and Environment **www.dpipwe.tas.gov.au**	*Plant Quarantine Act 1997* *Weed Management Act 1999*	**http://dpipwe.tas.gov.au/biosecurity/quarantine-tasmania/importing-plants/plant-quarantine-manual-2014**	1300 368 550
Vic	Department of Economic Development, Jobs, Transport and Resources **http://economicdevelopment.vic.gov.au/**	*Plant Biosecurity Act 2010* *Plant Biosecurity Regulations 2012*	**www.depi.vic.gov.au/psb**	136 186
WA	Department of Agriculture and Food **www.agric.wa.gov.au**	*Biosecurity and Agricultural Management Act 2007*	**www.agric.wa.gov.au/qtine/default.asp**	08 9334 1800

[63] If the link does not work, the relevant documents can be found by going to the department home page and checking the quarantine section of each website
[64] Click on the link to the Plant Quarantine Manual
[65] Within Qld
[66] Interstate

The following section includes information relevant to the movement of cotton plants, plant parts and/or fruit into each state/territory.

New South Wales

Information on pre-importation inspection, certification and treatment requirements may be obtained from NSW DPI Regulatory Services by phone 02 6391 3384 or by visiting the NSW Department of Primary Industries website **www.dpi.nsw.gov.au/biosecurity/plant** and clicking on the link to the Plant Quarantine Manual.

Northern Territory

Administrative authority for regional quarantine in the Northern Territory (NT) is vested in the Department of Primary Industry and Fisheries (DPIF) under the *Plant Health Act 2008* and *Plant Health Regulations 2011*. The Act enables notifiable pests to be gazetted, quarantine areas to be declared and inspectors appointed to carry out wide ranging control and/or eradication measures. Plant import requirements for particular pests, plants or plant related materials are identified in the Regulations. Further information on NT import requirements and treatments can be obtained by contacting NT Quarantine on (08) 8999 2118 or email **quarantine@nt.gov.au.**

For more information refer to the DPIF website (**www.nt.gov.au/d/Primary_Industry**) or the Plant Health Manual (see link in Table 10).

Queensland

Information on specific pre-importation inspection, treatments and/or certification requirements for movement of any fruit or plant material into Queensland, as well as maps of pest quarantine areas, may be obtained from the Biosecurity Queensland part of the DAF Queensland website (**www.daf.qld.gov.au/plants/moving-plants-and-plant-products**). Further details can be obtained from the DAF Queensland Customer Service Centre (13 25 23 within Queensland, or phone 07 3404 6999 or fax 07 3404 6900 interstate).

South Australia

Information on pre-importation inspection, certification and treatments and/or certification requirements for movement of fruit or plant material in South Australia (SA) may be obtained

from Biosecurity SA - Plant Health by phone (08) 8207 7820 or fax (08) 8207 7844. Further information can be found at **www.pir.sa.gov.au/biosecurity/plant_health**.

Primary Industries and Regions South Australia (PIRSA) have strict regulations and requirements regarding the entry of plant material (fruit, vegetables, flowers, plants, soil and seeds) into the State.

For further information on import conditions consult the Plant Quarantine Standard (**www.pir.sa.gov.au/biosecurity/plant_health/importing_commercial_plants_and_plant_products_into_south_australia**).

Tasmania

Information on specific pre-importation inspection, treatments and/or certification requirements for movement of any fruit or plant material into Tasmania may be obtained from the Department of Primary Industries, Parks, Water and Environment (DPIPWE) Biosecurity website (**www.dpipwe.tas.gov.au/biosecurity**) or by phoning 1300 368 550.

General and specific import conditions apply to the importation of plant material into Tasmania to prevent the introduction of pests and diseases into the State. Plants and plant products must not be imported into Tasmania unless State import requirements are met and a Notice of Intention to import has been provided to a Quarantine Tasmania inspector not less than 24 hours prior to the importation. All consignments must be accompanied by a Plant Health Certificate or Plant Health Assurance Certificate. For further information on import conditions consult the Plant Quarantine Manual (see link in Table 10).

Victoria

The movement into Victoria of plants and plant products may be subject to a prohibition, or to one or more conditions which may include chemical treatments. These prohibitions and conditions are described on the Department of Economic Development, Jobs, Transport and Resources (DEDJTR) website (see link in Table 10). Some items may need to be presented to a DEDJTR inspector or an accredited business, for checking of details such as correct certification, labelling or treatment.

Further information on pre-importation inspection, certification and treatments and/or certification requirements for movement of fruit or plant material into or within Victoria may be obtained from DEDJTR on the web at **www.depi.vic.gov.au/psb** or by phone 136 186.

Western Australia

Western Australia is naturally free from a large number of pests and diseases that are present in many other parts of the world. WA's geographical isolation in conjunction with a robust plant biosecurity system including border and intrastate regulations, industry and public awareness campaigns and surveillance programs maintains this status.

There are general and specific legislative requirements which underpin Western Australian plant biosecurity. Amongst other things the legislation regulates movement of potential carriers (such as plant material, honey, machinery, seeds, etc.) into and within the state.

General conditions include (but are not limited to the following):

- The requirement for all potential carriers to be presented to an inspector for inspection upon arrival in WA.
- Soil is prohibited entry and imported goods, including containers, must be free from soil.
- Freedom from pests and diseases of quarantine concern to WA.
- In addition to the general requirements, specific requirements are in place for movement into and within the state.

For further information on requirements contact Quarantine WA on (08) 9334 1800 or fax (08) 9334 1880.

Farm level – exclusion activities

A significant risk of spreading pests onto farms arises when propagation material, people, machinery and equipment move from property to property and from region to region. It is the responsibility of the industry and the owner/manager of each property to ensure these risks are minimised.

It is in the interests of industry to encourage and monitor the management of risk at the farm level, as this will reduce the probability of an incursion and increase the probability of early

detection. This should in turn reduce the likelihood of a costly incident response, thereby reducing costs to industry, government and the community.

One major way this can be achieved is through management of industry biosecurity at the farm level using exclusion practices. Further detail on potential strategies is included in the Farm Biosecurity section (Page 84). The cotton industry is already a strong supporter of farm biosecurity with its 'Come clean. Go clean' message; but should continue to further extend this message of promoting good farm hygiene in a wide range of ways.

Surveillance

Surveys enhance prospects for early detection, minimise costs of eradication and are necessary to meet the treaty obligations of the WTO SPS Agreement with respect to the area freedom status of Australia's states, territories and regions.

The SPS Agreement gives WTO members the right to impose SPS measures to protect human, animal and plant life health provided such measures do not serve as technical barriers to trade. In other words, for countries (such as Australia) that have signed the SPS Agreement, imports of food, including fresh fruit and vegetables, can only be restricted on proper, science-based quarantine grounds. Where quarantine conditions are imposed, these will be the least trade restrictive measures available that meet Australia's appropriate level of quarantine protection. The Agreement also stipulates that claims of area freedom must be supported by appropriate information, including evidence from surveillance and monitoring activities. This is termed "evidence of absence" data and is used to provide support that we have actively looked for pests and not found them.

ISPM 6 (**www.ippc.int/sites/default/files/documents/20140528/spec_61_revispm6_2014-05-28_201405281352--150.18%20KB.pdf**) provides international guidelines for structured pest surveys. Structured pest survey planning and implementation depends on the risk involved, the resources available, and the requirements of trading partners (particularly when Australia wishes to access overseas markets). The intensity and timing of surveys also depend on the spread characteristics of the pest and the costs of eradication.

Early detection of an exotic incursion can significantly increase the likelihood of a successful eradication campaign, and reduce the associated costs. Effective surveillance plays a critical role in working toward this goal. Surveillance can be either targeted toward specific pests, or general in nature. General non-targeted surveillance is based on recognising normal versus suspect plant material. Targeted surveillance is important for establishing whether particular pests are present in each state or region, and if so, where these occur.

Industry personnel can provide very effective early detection of new or unusual symptoms through their normal management practices (i.e. 'passive surveillance'), provided individuals are aware of what to look for and of reporting procedures. Consultants and crop scouts can provide valuable information as they are regularly in the field, and hence can observe any unusual pest activity or symptoms on plants.

National surveillance programs

The Department of Agriculture maintains barrier quarantine services at all international ports and in the Torres Strait region. The Department of Agriculture also surveys the northern coast of Australia, offshore islands and neighbouring countries for exotic pests that may have reached the country through other channels (e.g. illegal vessel landings in remote areas, bird migrations, wind currents) as part of the Northern Australia Quarantine Strategy (NAQS). Department of Agriculture (NAQS) surveillance programs relevant to the cotton industry are listed in Table 11.

State surveillance programs

State level surveillance depends on the participation of all stakeholder groups, particularly state/territory agriculture agencies, industry representative groups, agri-business and growers.

The state/territory agriculture agency can provide:

- planning and auditing surveillance systems
- coordination of surveillance activities between industry and interstate groups
- diagnostic services
- field diagnosticians for special field surveillance
- surveillance on non-commercial sites
- liaison services with industry members
- communication, training and extension strategies with industry

- biosecurity training
- reporting services to all interested parties (Department of Agriculture, national bodies, trading partners and industry).

Various pest surveillance programs are managed by the Department of Agriculture and the state/territory agriculture departments. Many state/territory departments run general surveillance programs whereby suspect samples can be forwarded and diagnosed for the presence of exotic pests free of charge. Official surveillance programs that target pests of the cotton industry (exotic or those under official control in a region or state/territory) are shown in Table 11.

Table 11. *Official surveillance programs that target pests of the cotton industry (as at December 2014)*[67]

Surveillance program	Pests targeted	Hosts targeted
Australian Government		
Department of Agriculture (NAQS) pest and disease surveys	157 high priority exotic pests. including the Cotton jassid (*Amrasca devastans*), Citrus locust(*Chondracris rosea*), Gold dust weevil (*Hypomeces squamosus*)	Tropical horticultural and agricultural species
New South Wales		
Aphids	Multiple species	Field crops, Horticulture
Diseases of cotton	Exotic strains of Bacterial blight (*Xanthomonas campestris*), Cotton blue disease (*Cotton leafroll dwarf virus*) Cotton leaf curl virus, Texas root rot (*Phymatotrichum omnivorum*), Exotic strain Verticillium wilt (*Verticillium dahliae*), Exotic strains Fusarium wilt (*Fusarium oxysporum* f. sp. *vasinfectum*)	Cotton
Grains farm biosecurity program	Various, including Khapra beetle (*Trogoderma granarium*)	Grains
Melon thrips	Melon thrips (*Thrips palmi*)	Field crops, horticulture

[67] Information presented has been taken from the National Plant Health Status Report 2014 and confirmed or updated in January 2015 by the Subcommittee on National Plant Health Surveillance (sub-committee of the Plant Health Committee)

Surveillance program	Pests targeted	Hosts targeted
Urban hazard site surveillance	Various including: Spiralling whitefly (*Aleurodicus dispersus*), exotic whiteflies, Solenopsis mealybug (*Phenacoccus solenopsis*), exotic aphids, exotic leaf miners (*Liriomyza* spp)	Multiple urban hosts
Northern Territory		
Thrips surveillance	Melon thrips (*Thrips palmi*) and Western flower thrips (*Frankliniella occidentalis*)	Vegetables
Whitefly surveillance	Silverleaf whitefly (*Bemisia tabaci* B type) and Spiralling Whitefly (*Aleurodicus dispersus*)	Nursery stock
Queensland		
Coffee berry borer surveillance	Coffee berry borer (*Hypothenemus hampei*)	Coffee
Endemic and exotic diseases of cotton surveys	Endemic cotton diseases (*Fusarium* and *Verticillium*. Cotton bunchy top virus). Exotic cotton diseases (Cotton leafroll dwarf virus (Blue disease), Cotton leaf curl disease and all other exotics)	Cotton
Grains Farm Biosecurity Program	Various, including Khapra beetle (*Trogoderma granarium*)	Grains
Grains On-farm & Grains packers /processors/exporters	Various stored grain pests including Khapra beetle (*Trogoderma granarium*)	Stored grains
Grain bulk handling	Various, including Khapra beetle (*Trogoderma granarium*)	Grains
Melon thrips surveillance	Melon thrips (*Thrips palmi*)	Multiple
Silverleaf whitefly resistance management	Silverleaf whitefly (*Bemisia tabaci* B type)	Cotton
Sucking pest management in cotton	Solenopsis mealybug	Multiple

Surveillance program	Pests targeted	Hosts targeted
Plant Pest Diagnostic Service (Broadacre side)	All pathogens that can affect broadacre (grain, cotton, pastures) crops	A wide variety of broadacre crops are sent to the Plant Pest Diagnostic service
Urban surveillance program	A range of pests and diseases	Ornamentals and fruit and vegetables including banana, citrus, and mango
Tasmania		
Brown marmorated stink bug	Brown marmorated stink bug (*Halyomorpha halys*)	Fruit trees, woody ornamentals and some field crops
Silverleaf whitefly	Silverleaf whitefly (*Bemisia tabaci*)	Nursery stock host plants
Western Australia		
GrainGuard passive surveillance	Multiple species (passive surveillance only)	Grain crops
HortGuard passive surveillance	Multiple species (passive surveillance only)	Horticultural crops
Joint DAFWA-NAQS survey in ORIA	Multiple species, including the Cotton jassid (*Amrasca devastans*), Citrus locust (*Chondracris rosea*), Gold dust weevil (*Hypomeces squamosus*)	Grains crops

Farm surveillance activities

Farm level surveillance involves the participation and interaction of growers, agribusiness and industry representative groups. Examples of the surveillance activities that can be carried out by each of these groups are outlined in Figure 3. Conducting regular surveys of farms provides the best chance of spotting new pests early and implementing eradication or management responses.

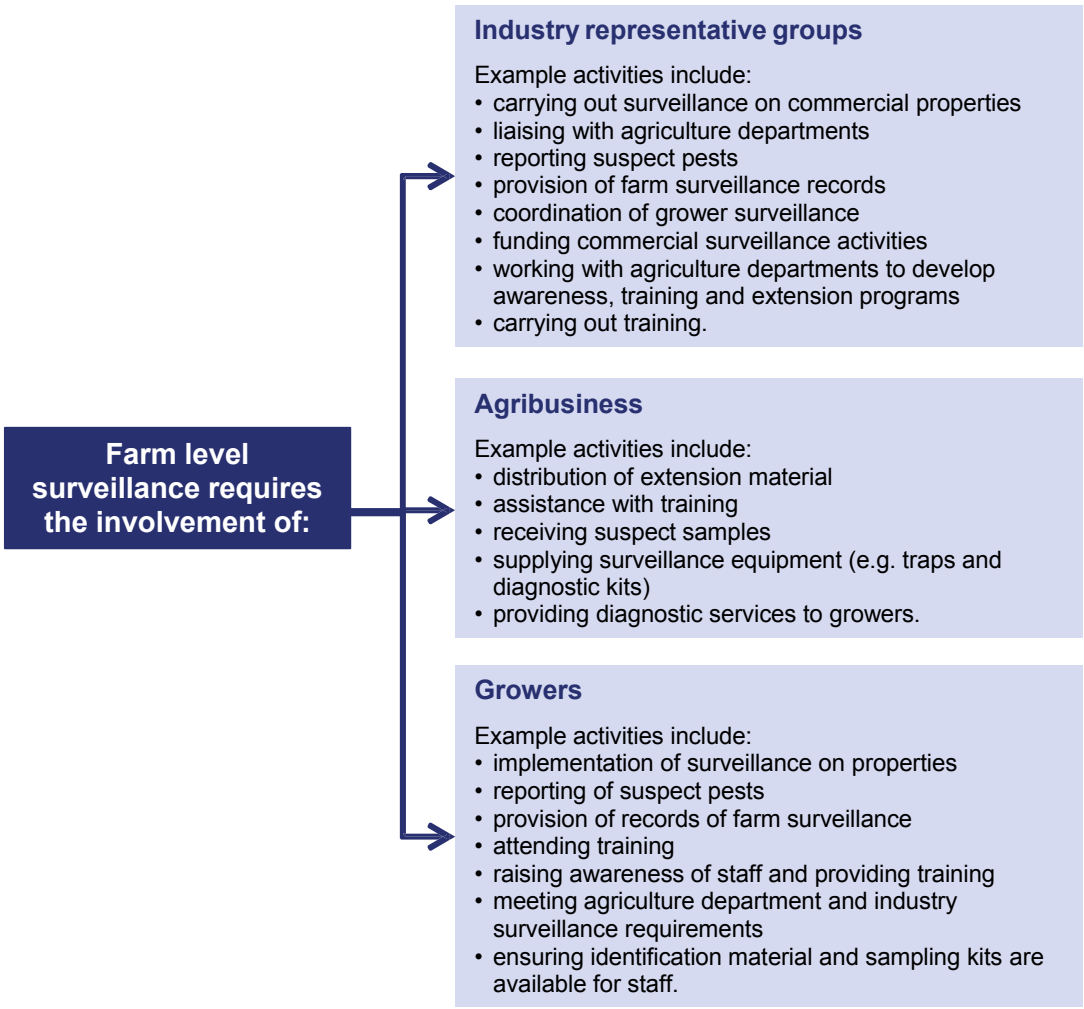


Figure 3. *Examples of farm level surveillance activities*

Training

A key component of biosecurity preparedness is ensuring suitable personnel are engaged, and effectively trained for their designated roles. Biosecurity preparedness training is the responsibility of all parties, government and industry, involved in the biosecurity system.

National EPP Training Program

PHA supports members in training personnel through the delivery of the National EPP Training Program. This program is focussed on ensuring personnel have the skills and knowledge to effectively fulfil the roles and responsibilities of parties under the EPPRD. This covers a range of areas, from representatives on the national decision making committees (i.e. the Consultative Committee on Emergency Plant Pests and the National Management Group) through to industry liaison personnel in the Local Control Centre.

In addition to face to face training delivered to members and the provision of simulation exercises, PHA also offers biosecurity training through BOLT, an online training platform. Access to BOLT is free and open to any stakeholder interested in biosecurity, and is available through **www.planthealthaustralia.com.au/bolt**.

For more information on the National EPP Training program, refer to **www.planthealthaustralia.com.au/training**.

Awareness

Early reporting enhances the chance of effective control and eradication. Awareness activities (such as the manual shown in Figure 4) raise the profile of biosecurity and exotic pest threats to the cotton industry, which increases the chance of early detection and reporting of suspect pests. Responsibility for awareness material lies with industry and government, with assistance from PHA as appropriate. Any unusual plant pest should be reported immediately to the relevant state/territory agriculture agency.

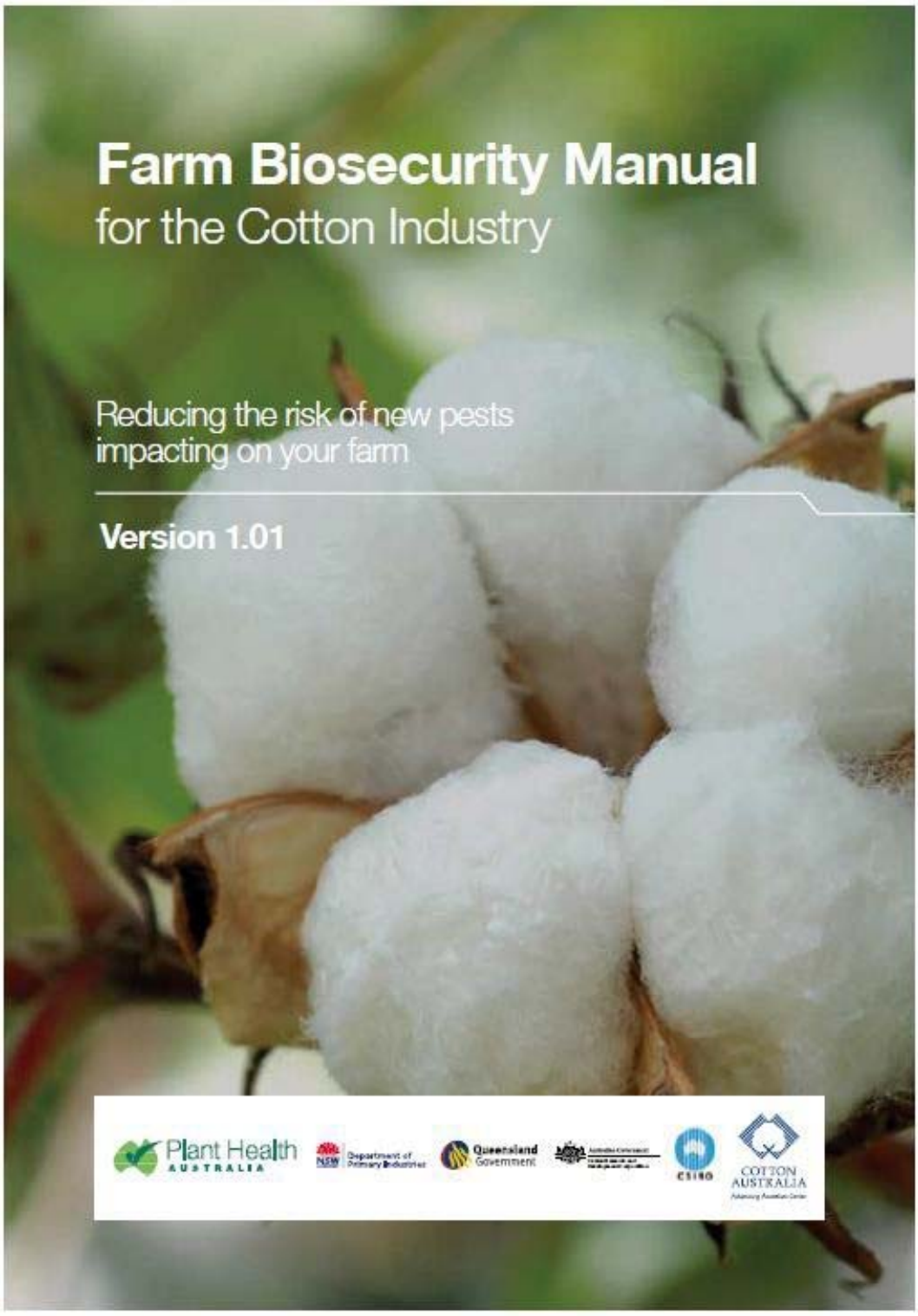


Figure 4. *Examples of awareness material developed for the cotton industry*

High priority plant pest threat-related documents

Pests listed in Table 5 have been identified as high priority threats to the cotton industry by members of the IBG. They have been assessed as having high entry, establishment and spread potentials and/or a high economic impact. This list should provide the basis for the development of awareness material for the industry.

Further information on High Priority Pests

In addition to the fact sheets listed in Table 15, the websites listed below (Table 12) contain information on pests across most plant industries, including the cotton industry.

Table 12. *Sources of information on High Priority Pest threats for the cotton industry*

Source	Website
Department of Agriculture	**www.agriculture.gov.au**
Pest and Disease Image Library (PaDIL)	**www.padil.gov.au**
DAF Queensland A-Z list of significant plant pests and diseases	**www.daf.qld.gov.au/plants/health-pests-diseases/a-z-significant**
University of California Statewide Integrated Pest Management (IPM) Program	**www.ipm.ucdavis.edu/EXOTIC/exoticpestsmenu.html**
European and Mediterranean Plant Protection Organization (EPPO)	**www.eppo.int/DATABASES/pqr/pqr.htm**
ID tools	**www.idtools.org/**

Further information/relevant web sites

A range of government and grower organisation details and websites are provided below (Table 13) for persons seeking further information on cotton industry biosecurity.

Table 13. *Relevant sources of further biosecurity information for the cotton industry*

Agency	Website/email	Phone	Address
National			
Cotton Australia	**http://cottonaustralia.com.au/**	(02) 9669 5222	Suite 4.01, 247 Coward St Mascot NSW 2020
Cotton Research and Development Corporation	**www.crdc.com.au/**	(02) 6792 4088	2 Lloyd Street Narrabri NSW 2390
Australian Government Department of Agriculture	**www.agriculture.gov.au**	(02) 6272 3933 1800 020 504	GPO Box 858 Canberra, ACT 2601
Plant Health Australia	**www.planthealthaustralia.com.au** **biosecurity@phau.com.au**	(02) 6215 7700	Level 1, 1 Phipps Cl Deakin, ACT 2600
New South Wales			
Department of Primary Industries	**www.dpi.nsw.gov.au/biosecurity/plant**	(02) 6391 3535	Locked Bag 21 Orange, NSW 2800
Queensland			
Biosecurity Queensland, a part of the Department of Agriculture and Fisheries, Queensland	**www.daf.qld.gov.au/biosecurity** **callweb@daf.qld.gov.au**	13 25 23[68] 07 3404 6999[69]	80 Ann Street Brisbane, QLD 4000

[68] Within Qld
[69] Interstate

Agency	Website/email	Phone	Address
Northern Territory			
Department of Primary Industry and Fisheries	**www.nt.gov.au/d/Primary_Industry** **info.DPIF@nt.gov.au**	(08) 8999 5511	Berrimah Farm, Makagon Road Berrimah, NT 0828
South Australia			
Primary Industries and Regions SA	**www.pir.sa.gov.auhttp:///**	(08) 8226 0900	GPO Box 1671 Adelaide, SA 5001
Biosecurity SA-Plant Health	**www.pir.sa.gov.au/biosecuritysa/planthealth** **PIRSA.planthealth@sa.gov.au**	(08) 8207 7820	33 Flemington Street Glenside, SA 5065
Biosecurity SA-Plant Health Market access and Interstate Certification Assurance	**IRSA.planthealthmarketaccess@sa.gov.au**	(08) 8207 7814	
Biosecurity SA-Plant Health Transport manifest lodgement	**pirsa.planthealthmanifest@sa.gov.au**	Fax: (08) 8124 1467	
South Australian Research and Development Institute	**www.sardi.sa.gov.au** **sardi@sa.gov.au**	(08) 8303 9400	2b Hartley Grove Urrbrae, SA 5064
Tasmania			
Department of Primary Industries, Parks, Water and Environment	**www.dpipwe.tas.gov.au** **BPI.Enquiries@dpipwe.tas.gov.au**	1300 368 550	GPO Box 44, Hobart, TAS 7001
Victoria			
Department of Economic Development, Jobs, Transport and Resources	**http://economicdevelopment.vic.gov.au/**	136 186	Plant Biosecurity and Product Integrity Private bag 15 Ferntree Gully Delivery Centre, Vic 3156

Agency	Website/email	Phone	Address
Western Australia			
Department of Agriculture and Food	**www.agric.wa.gov.au** **enquiries@agric.wa.gov.au**	(08) 9368 3333	DAFWA 3 Baron-Hay Court South Perth, WA 6151

Farm biosecurity

Introduction

Plant pests can have a major impact on production if not managed effectively. This includes pests already present in Australia and a number of serious pests of cotton that Australia does not have.

Farm biosecurity measures can be used to minimise the spread of such pests before their presence is known or after they are identified, and therefore can greatly increase the likelihood that they could be eradicated. PHA, in conjunction with Cotton Australia, has developed a Farm Biosecurity Manual for the Cotton Industry (**www.planthealthaustralia.com.au/industries/cotton**) which outlines farm biosecurity and hygiene measures that help reduce the impact of pests on the industry. The manual covers biosecurity aspects such as:

- recognising the HPPs of the cotton industry
- monitoring for the presence of pests
- reporting anything unusual
- the use of high health status farm inputs such as certified propagation material
- quality and hygiene Best Management Practices
- disposal of waste fruit and plant material
- maintenance of records for trace-back and trace-forward purposes
- safe use of chemicals
- managing the movement of people
- visiting overseas farms – what to watch out for when you return
- the use of warning and information signs
- managing the movements of vehicles and machinery
- wash down facilities and designated parking areas.

Reporting suspect pests

Any unusual plant pest should be reported immediately to the relevant state/territory agriculture agency through the Exotic Plant Pest Hotline (1800 084 881). Early reporting enhances the chance of effective control and eradication.

Reporting an exotic plant pest carries serious implications and should be done only via the Exotic Plant Pest Hotline. Careless use of information, particularly if a pest has not been confirmed, can result in extreme stress for individuals and communities, and possibly damaging and unwarranted trade restrictions.

If you suspect a new pest, 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 the department of agriculture from the state of origin of the call, who will ask some questions about what you have seen and may arrange to collect a sample. Every report will be taken seriously, checked out and treated confidentially.

In some states and territories, the Exotic Plant Pest Hotline only operates during business hours. Where this is the case, and calls are made out of hours, callers should leave a message including contact details and staff from the department of agriculture will return the call the following business day.

Some cotton pests are notifiable under each state or territory's quarantine legislation. The complete list of notifiable pests can be downloaded from the PHA website[70]; however, each state's list of notifiable pests are subject to change over time so contacting your local state/territory agricultural agency (details in Table 10) will ensure information is up to date. Landowners and consultants have a legal obligation to notify the relevant state/territory agriculture agency of the presence of those pests within a defined timeframe (Table 14).

[70] Available from **www.planthealthaustralia.com.au/biosecurity/notifiable-pests**

Table 14. *Timeframe for reporting of notifiable pests as defined in state/territory legislation*

State/territory	Notifiable pest must be reported within
NSW	24 hours
NT	24 hours
Qld	24 hours
SA	Immediately
Tas	As soon as possible
Vic	Without delay
WA	24 hours

Suspect material should not generally be moved or collected without seeking advice from the relevant state/territory agriculture agency, as incorrect handling of samples could spread the pest or render the samples unsuitable for diagnostic purposes. State/territory agriculture officers will usually be responsible for sampling and identification of pests.

Pest-specific emergency response and information documents

As part of the implementation of the IBP, pest-specific information and emergency response documents, such as fact sheets and contingency plans should be developed over time for all medium to high risk pests listed in the TSTs (Appendix 1). Currently, a number of documents have been developed for pests of the cotton industry (Table 15) and are available for download from the Pest Information Document Database (PIDD) at **www.planthealthaustralia.com.au/pidd**.

Fact sheets

Fact sheets or information sheets are a key activity of biosecurity extension and education with growers. Fact sheets provide summary information about the pest, its biology, what it looks like and what symptoms it may cause. They also contain detailed images. For a list of current fact sheets available from PHA for cotton producers see Table 15.

Contingency Plans

Contingency Plans provide background information on the pest biology and available control measures to assist with preparedness for incursions of a specific pest into Australia. The contingency plan provides guidelines for steps to be undertaken and considered when developing a Response Plan to that pest. Any Response Plan developed using information in whole or in part from this Contingency Plan must follow procedures as set out in PLANTPLAN and be endorsed by the National Management Group prior to implementation.

As a part of contingency planning, biological and chemical control options are considered as are options for breeding for pest resistance. Through this planning process, it may be discovered that there are gaps in knowledge. Such gaps should be identified and consequently be considered as RD&E needs to be met within the implementation table. For a list of current contingency plans and dossiers developed for the cotton industry see Table 15.

Table 15. *Pest-specific information documents for the cotton industry*[71]

Scientific name	Common name	Fact sheet	Contingency plan
Amrasca devastans	Indian green jassid	✓[72, 73]	
Anthonomus grandis	Cotton boll weevil	✓[72, 73]	
Aphis gossypii (exotic strains)	Cotton aphid	✓[72]	
Cotton leaf curl virus (Begomovirus)	Cotton leaf curl disease	✓[72, 73]	
Cotton leafroll dwarf virus (*Polerovirus*)	Cotton blue disease	✓[72, 73]	
Fusarium oxysporum f. sp. *vasinfectum* (exotic races)	Fusarium wilt	✓[72]	
Liriomyza sativae	Vegetable leaf miner	✓[74, 75, 76]	✓[75]
Liriomyza trifolii	American serpentine leaf miner	✓ [74, 75]	✓[75]

[71] Copies of these documents are available from **www.planthealthaustralia.com.au/pidd** or by contacting the relevant state/territory agriculture agency.
[72] Developed for the cotton industry.
[73] NSW DPI has also produced an Exotic pest alert sheet for this species (available from: **www.dpi.nsw.gov.au/biosecurity/plant/exotic-pest-alerts#Cotton**).
[74] Developed for the vegetable industry.
[75] Developed for the grains industry.
[76] Developed for the onion industry.

Scientific name	Common name	Fact sheet	Contingency plan
Lygus hesperus	Western plant bug	✓[77]	
Lygus lineolaris	Tarnished plant bug	✓[78, 79, 80]	✓[81]
Lymantria dispar	Asian gypsy moth	✓[81, 82]	✓[81]
Paracoccus marginatus	Papaya mealy bug	✓[83]	✓[83]
Phymatotrichum omnivorum	Texas root rot	✓[78,80, 84]	
Platynota stultana	Omnivorous leaf roller	✓[84]	
Tetranychus pacificus	Pacific spider mite	✓[78]	
Tetranychus turkestani	Strawberry spider mite	✓[78, 80]	
Tetranychus truncatus	Cassava spider mite	✓[85]	
Thaumatotibia leucotreta (syn. *Cryptophlebia leucotreta*)	False codling moth	✓[86]	✓[75]
Thrips palmi	Melon thrips	✓[87]	
Verticillium dahliae (defoliating strain	Verticillium wilt	✓[78]	
Xanthomonas citri subsp. *malvacearum*	Bacterial blight; Angular leaf spot (exotic/hypervirulent races)	✓[78]	

National Diagnostic Protocols

Diagnostic protocols are documents that contain information about a specific plant pest, or related group of pests, relevant to its diagnosis. National Diagnostic Protocols (NDPs) are diagnostic protocols for the unambiguous taxonomic identification of a pest in a manner consistent with ISPM No. 27 – Diagnostic Protocols for Regulated Pests. NDPs include diagnostic procedures and data on the pest, its hosts, taxonomic information, detection and identification.

[77] Developed for the strawberry industry.
[78] Developed for the cotton industry.
[79] Developed by PHA for the strawberry industry.
[80] NSW DPI has also produced an Exotic pest alert sheet for this species (available from: **www.dpi.nsw.gov.au/biosecurity/plant/exotic-pest-alerts#Cotton**).
[81] Developed for the nursery and garden industry.
[82] Developed for the apple and pear industry.
[83] Developed for the papaya industry
[84] Developed for the viticulture industry.
[85] Developed for the papaya industry.
[86] Developed for the summerfruit industry.
[87] Developed for the vegetable industry.

Australia has a coherent and effective system for the development of NDPs for plant pests managed by the Subcommittee on Plant Health Diagnostics (SPHD). NDPs are peer reviewed and verified before being endorsed by the Plant Health Committee.

Endorsed NDPs are available on the National Plant Biosecurity Diagnostic Network (NPBDN) website (**www.plantbiosecuritydiagnostics.net.au**), together with additional information regarding their development and endorsement. Thus far, no NDPs relevant to the cotton industry have been endorsed, however a number are under development for key pathogens such as:

- Verticillium wilt (*Verticillium dahliae* (defoliating strain))
- Bacterial blight (*Xanthomonas citri* subsp. *malvacearum*) (exotic/hypervirulent races)
- Blue disease (*Cotton leafroll dwarf virus* (*Polerovirus*))
- Cotton leaf curl virus (*Cotton leaf curl virus complex* (*Begomovirus*))

Diagnostic information for some cotton pests is available from the EPPO, North American Plant Protection Organization and PaDIL websites (see Table 16) or through draft protocols available from the PHA website (**www.planthealthaustralia.com.au/pidd**; see Table 16).

Table 16. *Cotton pests for which draft diagnostic protocols or diagnostic information exists*

Scientific name	Common name	Document link
Bemisia tabaci (exotic strains)	Silver leaf white fly	OEPP/EPPO (2004) Diagnostic protocols for regulated pests: Bemisia tabaci. Bulletin OEPP/EPPO Bulletin 34: 155 –157. Available from: **http://archives.eppo.int/EPPOStandards/PM7_DIAGNOS/pm7-35(1).pdf**
Cotton leaf curl virus complex (Begomovirus)	Cotton leaf curl virus	Draft NDP see: **http://plantbiosecuritydiagnostics.net.au/resource-hub/high-priority-pest-list/**
Cotton leafroll dwarf virus (Polerovirus)	Blue disease	Draft NDP under development
Liriomyza trifolii	American serpentine leaf miner	Draft diagnostic protocol available from: **www.planthealthaustralia.com.au/wp-content/uploads/2013/03/American-serpentine-leafminer-DP-2005-draft.pdf**.
Tetranychus pacificus	Pacific spider mite	Draft Diagnostic Protocol is available from: **www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Spider-mites-DP-2005.pdf**.
Tetranychus turkestani	Strawberry spider mite	Draft Diagnostic Protocol is available from: **www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Spider-mites-DP-2005.pdf**.

Scientific name	Common name	Document link
Verticillium dahliae (defoliating strain)	Verticillium wilt	Draft NDP see: **http://plantbiosecuritydiagnostics.net.au/resource-hub/high-priority-pest-list/**
Xanthomonas citri subsp. *malvacearum*)(exotic/ hypervirulent races)	Bacterial blight	Draft NDP see: **http://plantbiosecuritydiagnostics.net.au/resource-hub/high-priority-pest-list/**

Research, Development and Extension

Research, development and extension – linking biosecurity outcomes to priorities

Through the biosecurity planning process, gaps in knowledge or extension of knowledge will have been identified and need to be documented in the implementation table. Some of these gaps will require further research and development (e.g. understanding risk pathways, developing surveillance programs or diagnostic protocols, developing tools to facilitate preparedness and response, developing IPM or resistance breeding strategies), other gaps will require communication or extension of that knowledge to various target audiences (developing awareness raising materials, undertaking training exercises, running workshops, consideration of broader target audiences).

It is important that the research, development and extension (RD&E) gaps identified through this plan feed directly into the normal annual RD&E priority setting and strategic planning activities that an industry undertakes. This is fundamental if an industry is to progress biosecurity preparedness and response throughout the life of the Industry Biosecurity Plan.

Reference

Department of Agriculture, Fisheries and Forestry (2011) Import Risk Analysis Handbook 2011. Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

National Plant Biosecurity Status Report (2014). Plant Health Australia, Canberra, ACT.

RESPONSE MANAGEMENT

Introduction

Gathering information, developing procedures, and defining roles and responsibilities during an emergency can be extremely difficult. To address this area, PHA coordinated the development of PLANTPLAN, a national set of incursion response guidelines for the plant sector, detailing the procedures required and the roles and responsibilities of all Parties involved in an incursion response.

The following section includes key contact details and communication procedures that should be used in the event of an incursion in the cotton industry. Additionally, a listing of pest-specific emergency response and information documents are provided that may support a response. Over time, as more of these documents are produced for pests of the cotton industry they will be included in this document and made available through the PHA website.

The Emergency Plant Pest Response Deed

The Emergency Plant Pest Response Deed (EPPRD) has been negotiated between government and industry members of PHA to cover the management and funding arrangements of eradication responses to Emergency Plant Pest (EPP) Incidents. The EPPRD came into effect on October 26, 2005 and is a formal legally binding agreement between PHA, the Australian Government, all state and territory governments and 29 plant industry signatories, including Cotton Australia. The EPPRD is based on the following key principles:

- cost minimisation for all Parties
- reimbursement to growers whose crops or property are directly damaged or destroyed as a result of implementing an approved Response Plan
- early detection and response
- rapid responses to EPPs (excluding weeds)
- decisions to eradicate are based on appropriate criteria (e.g. eradication must be technically feasible and cost beneficial)
- an industry commitment to biosecurity and risk mitigation and a government commitment to best management practice

- Cost Sharing of eligible costs
- an Agreed Limit for Cost Sharing (calculated as 2 % of the local value of production for one year of the Affected Industry Party or as defined in Schedule 14 of the EPPRD). The Agreed Limit can be exceeded with the agreement of Affected Parties.
- an effective industry/government decision-making process.

For further information on the EPPRD, including copies of the EPPRD, Fact Sheets or Frequently Asked Questions, visit **www.planthealthaustralia.com.au/epprd** and **www.planthealthaustralia.com.au/epprd-qa**.

PLANTPLAN

Underpinning the EPPRD is PLANTPLAN, the agreed technical response plan for an emergency plant pest incident. It provides nationally consistent guidelines for response procedures, outlining the phases of an incursion (investigation and alert, operational and stand down[88]), as well as the key roles and responsibilities of industry and government during each of the phases.

PLANTPLAN also provides a description of the management structures and information flow systems for the handling of a plant pest emergency at national, state/territory and district levels as well as guidelines, SOPs, forms/templates and jobcards. Guidance is provided for the operation of control centres, as well as outlining principles for the chain of responsibility, functions of sections, and role descriptions. PLANTPLAN is a general manual for use by all Government and Industry Parties during Plant Pest emergencies. PLANTPLAN incorporates best practice in emergency plant pest responses, and is updated regularly to incorporate new information or address gaps identified by the outcomes of incident reviews.

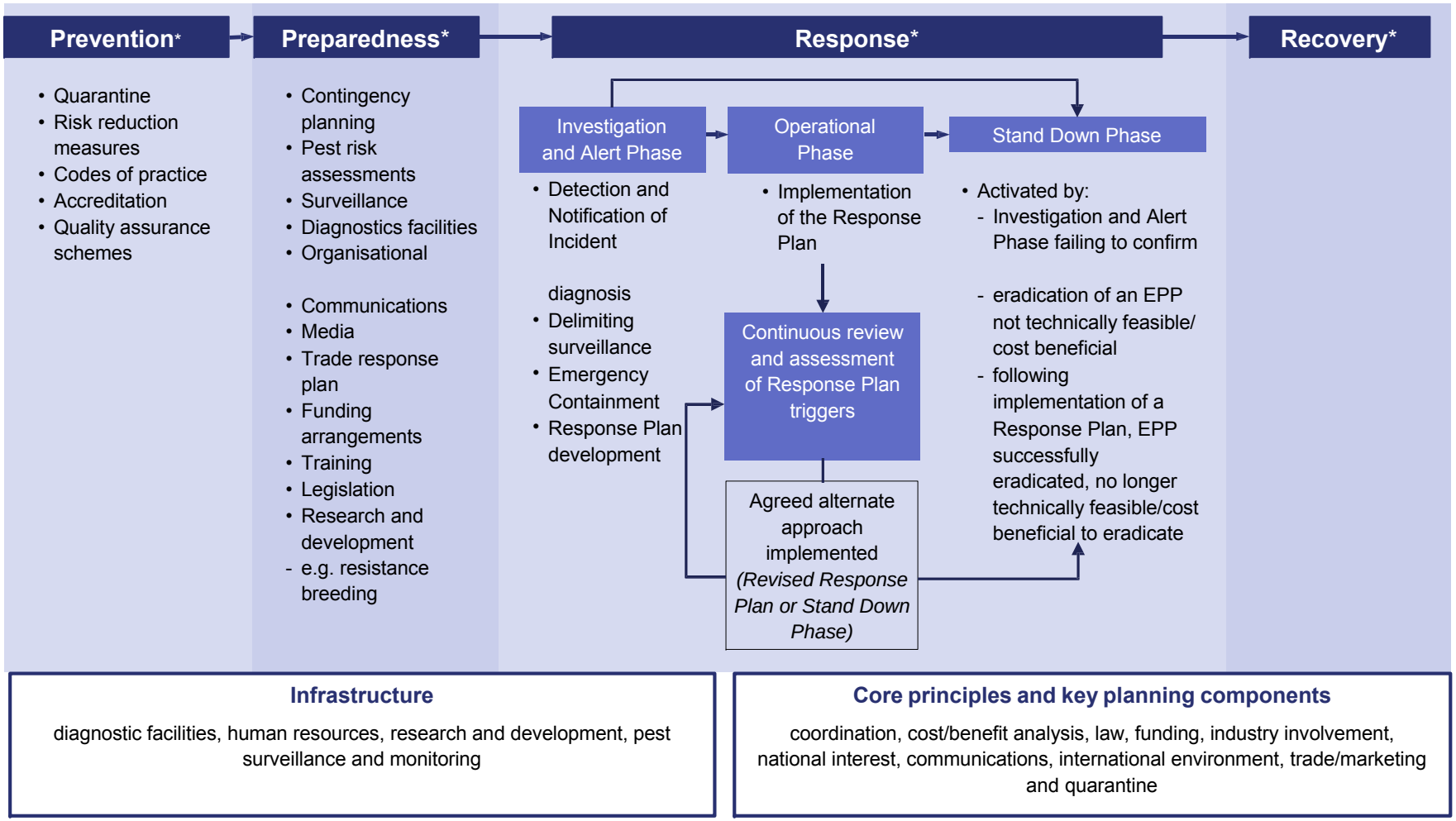
PLANTPLAN is an appendix to the Emergency Plant Pest Response Deed and is endorsed by all signatories. PLANTPLAN is supported by individual industry biosecurity planning that covers industry and pest specific information, risk mitigation activities and contingency plans. It

[88] As of December 2014, the inclusion of Transition to Management programs is currently being assessed for inclusion into the EPPRD and PLANTPLAN.

also provides a focus for training personnel in operational response and preparedness procedures. This ensures that the best possible guidance is provided to plant industries and governments in responding to serious Plant Pests.

The incursion management plan from PLANTPLAN (2014) has been summarised in Figure 5.

For more information about PLANTPLAN visit
www.planthealthaustralia.com.au/biosecurity/incursion-management/plantplan/



* stages of 'all hazards' approach adopted by Emergency Management Australia

Figure 5. *Summary of incursion management for plant industries according to PLANTPLAN (2014)*

Formal Categorisation of pests for inclusion in the EPPRD

The following section outlines one aspect of the EPPRD – the categorisation of EPPs.

A copy of the EPPRD can be downloaded from the PHA website (**www.planthealthaustralia.com.au/epprd**).

Pest categorisation

The EPPRD outlines a mechanism whereby Industry and Government Parties will contribute to the total cost of a response to an EPP Incident based on agreed Categories. These Categories determine the ratio each Party will pay under a Response Plan, based on the relative public and private benefits of EPP eradication. Four Categories are included in the EPPRD.

Categorisation of a Plant Pest is carried out to determine the Parties that are Affected and who will therefore be the beneficiaries of an eradication response. It does not indicate its likelihood of eradication or its overall importance i.e. an EPP listed as Category 1 is not deemed to be any more or less important than an EPP listed as Category 4.

Any Plant Pest considered by a Party to meet the definition of an EPP can be put forward for categorisation and inclusion in Schedule 13 of the EPPRD. Pests listed in the HPP threat list (Table 5) may provide a starting point for Industry to prioritise development of Categorisation requests as they have been determined to be of high priority to the Industry. Other pests identified in TSTs or identified via other means as being priority pests, may also be categorised if required. The process for requesting categorisation of a pest is set out in Schedule 3 of the EPPRD and the Guidelines for the Preparation of a Categorisation Request will be available from the PHA website **www.planthealthaustralia.com.au**. Additional information can also be found at: **www.planthealthaustralia.com.au/biosecurity/emergency-plant-pests/pest-categorisation/**

Cotton EPPs categorised to date

EPPs for the cotton industry that have received formal pest categorisation (included within Schedule 13 of the EPPRD) are listed in Table 17. For the latest version of Schedule 13, refer to the EPPRD version found at **www.planthealthaustralia.com.au/epprd**.

Table 17. *Formal categories for pests of the cotton industry as listed in the EPPRD (as at 18 December, 2014)*[89]

Formal Category	Scientific name	Common name
3	*Anthonomus grandis*	Cotton boll weevil
3	*Begomovirus Cotton leaf curl virus*	Cotton leaf curl disease
2	*Cryptophlebia leucotreta*[90]	False codling moth
3	*Liriomyza sativae*	Vegetable leaf miner
4	*Lygus hesperus*	Western plant bug
2	*Phymatotrichum omnivorum*	Texas root rot
2	*Trogoderma granarium*	Khapra beetle
3	*Verticillium dahliae*	Verticillium wilt (defoliating strain)
3	*Xanthomonas axonopodis pv. malvacearum*	Bacterial blight, Bacterial blight, angular leaf spot

How to respond to a suspect EPP

Following the detection of a suspect EPP, the relevant state agency should be immediately notified either directly or through the Exotic Plant Pest Hotline. Within 24 hours of the initial identification, the agency, through the State Chief Plant Health Manager (CPHM), will inform the Australian Chief Plant Protection Office (ACPPO) who will notify all state agencies, relevant industry representatives and PHA (this process is outlined in Figure 6).

[89] Note scientific and common names are listed as they appear in the EPPRD

[90] *Cryptophlebia leucotreta* is how this species appears in the EPPRD. The preferred name is now *Thaumatotibia leucotreta*, with *Cryptophlebia leucotreta* as a synonym.

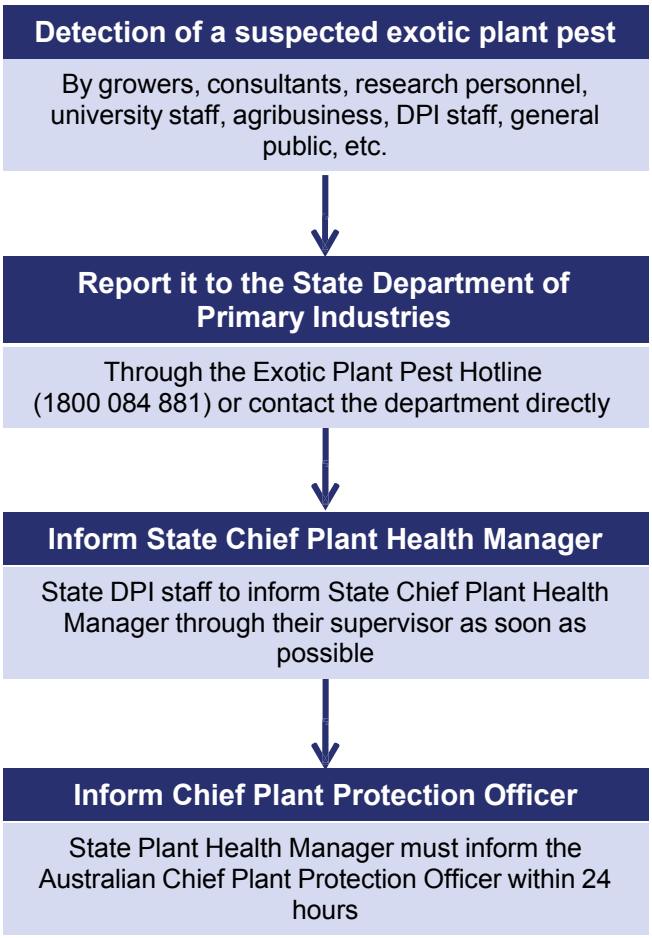


Figure 6 *Suspect exotic plant pest detection reporting flowchart*

Following the detection or reporting of the pest, the relevant state/territory agriculture agency will seek a confirmatory diagnosis from another laboratory, usually within a different jurisdiction. If the pest is suspected to be an EPP (meeting one of the four main criteria within the EPPRD), the general process (as described in PLANTPLAN) is as outlined in Figure 7.

If the pest is considered potentially serious and/or suspected to be an EPP, the relevant state/territory agriculture department will usually adopt precautionary emergency containment measures. These measures, depending on the Plant Pest, may include:

- restriction of operations in the area
- disinfection and withdrawal of people, vehicles and machinery from the area
- restricted access to the area
- control or containment measures.

If an EPP is confirmed, technical and economic considerations are reviewed, and a decision made on whether to eradicate (managed under the EPPRD and a Response Plan) or take another course of action (potentially to contain or do nothing - long term management). Under the EPPRD all decisions are made by Committees with government and industry representation. At the Consultative Committee on Emergency Plant Pests (CCEPP) level, these decisions relate to the technical feasibility of eradication of the EPP in question. From a National Management Group (NMG) perspective, they relate to technical advice from the CCEPP as well as financial considerations.

During the Investigation and Alert Phase (Figure 7), the Affected area will be placed under quarantine until a decision is made on whether to eradicate the pest or not. If a decision has been made to pursue eradication and a Response Plan under the EPPRD is approved by the NMG, efforts enter the Operational Phase (Figure 7). Eradication methods used will vary according to the nature of the EPP involved and infested/infected material will be destroyed where necessary. All on ground response operations are undertaken by the relevant state agricultural department(s) in accord with the approved Response Plan and the relevant state/territory legislation.

In the Stand Down Phase (Figure 7), all operations are wound down. Where a plant pest emergency is not confirmed, those involved will be advised that the threat no longer exists. Where the EPP is successfully eradicated, the situation should begin to return to ‘normal’. Where the EPP is not able to be eradicated, future long term management and control options may be investigated. In all cases, the response is reviewed and any lessons learnt will be used to improve the system for the future.

Owner Reimbursement Costs

To encourage early reporting and increase the chance of successful eradication, the EPPRD allows for payments to growers who have demonstrated losses or costs incurred during an EPP eradication effort. Owner Reimbursement Costs (ORCs) cover certain costs associated with Response Plan actions including the destruction of crops, enforced fallow periods and additional chemical treatments. Their purpose is to reduce the financial impact of the eradication response on growers.

ORCs apply only to approved Response Plans aimed at eradication, and only to industries that are signatories to the EPPRD, like the cotton industry.

Further information about ORCs is available from **www.planthealthaustralia.com.au/biosecurity/incursion-management/owner-reimbursement-costs/**

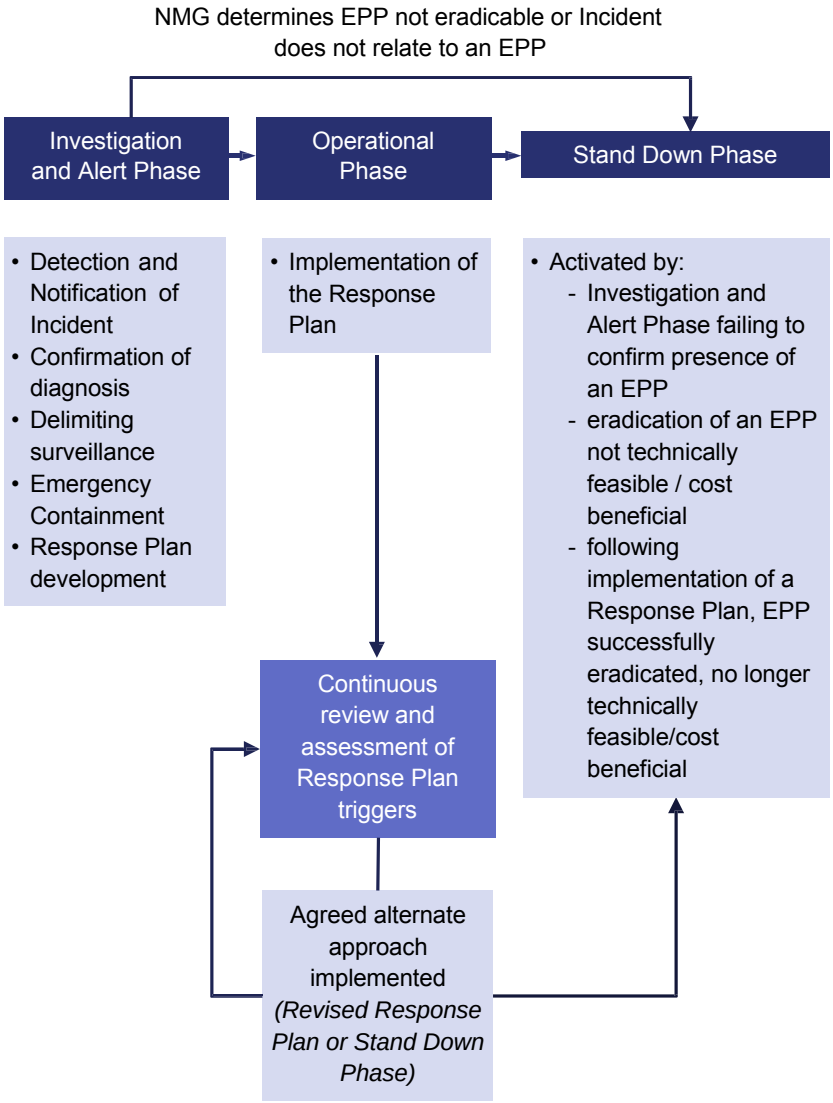


Figure 7. *General decision making and communication chain for a plant pest emergency response*

Industry specific response procedures

Industry communication

Cotton Australia will be the key industry contact point if an incursion Affecting the cotton industry is detected, and will have responsibility for relevant industry communication and media relations (see PLANTPLAN for information on approved communications during an incursion). The contacts nominated for the CCEPP and the NMG by Cotton Australia should be contacted immediately (Table 18) regarding any meetings of the CCEPP or NMG. It is important that all Parties to the EPPRD ensure their contacts for these committees are nominated to PHA and updated swiftly when personnel change.

Close cooperation is required between relevant government and industry bodies to ensure the effective development and implementation of a pest response, and management of media/communication and trade issues. Readers should refer to PLANTPLAN for further information.

Table 18. *Contact details for Cotton Australia*

Website	**http://cottonaustralia.com.au/**
Postal address	Suite 4.01, 247 Coward St Mascot NSW 2020
Email	**talktous@cotton.org.au**
Phone	02 9669 5222

Reference

Plant Health Australia (2014) PLANTPLAN: Australian Emergency Plant Pest Response Plan. Version 2.0. Plant Health Australia, Canberra, ACT. (**www.planthealthaustralia.com.au/plantplan**)

APPENDIX 1: PROFILE OF THE AUSTRALIAN COTTON INDUSTRY

Profile of the Australian Cotton Industry

Cotton is grown in Australia in most of the major inland river valleys of eastern Australia, in a belt stretching from central Queensland in the north to the Menindee Lakes and Hay in southwest New South Wales. Cotton is generally grown as an irrigated crop in fertile alluvial floodplain soils, although in recent years there has been increasing interest in dryland cotton.

Cotton seeds were first brought to Australia with the First Fleet but it wasn't until the 1960s that commercial production of irrigated cotton began in Queensland and New South Wales. Since then the production of cotton has grown into a $2 billion industry (ABARES 2014). Today cotton is a major crop in a number of regions. Major town centres associated with the cotton industry include Emerald, Dalby, Goondiwindi and St George in Queensland, and Moree, Narrabri, Gunnedah, Bourke and Warren in New South Wales. There is also interest in growing cotton in the Ord River Irrigation Area and Burdekin-Bowen Basin.

Australia grows the highest yielding and highest quality cotton in the world. Production has increased dramatically since the 1960s (Figure 8), although production fluctuates from year to year dependent on the availability of irrigation water, expected prices and weather during the growing season. In the 10 years from 2003-04 to 2012-13 an average of ~ca. 363, 000 ha was planted to produce ~ca. 820, 000 t/seed and ~ca. 586, 000 t/lint. NSW is responsible for around 60-70% of this production, with Queensland being the other major producer of the crop.

The vast majority of the Australian cotton crop is exported, primarily to spinning mills in Asia, with China and Indonesia being Australia's main cotton export destinations. Australian cotton commands a premium on world markets due to its high quality and low levels of contamination.

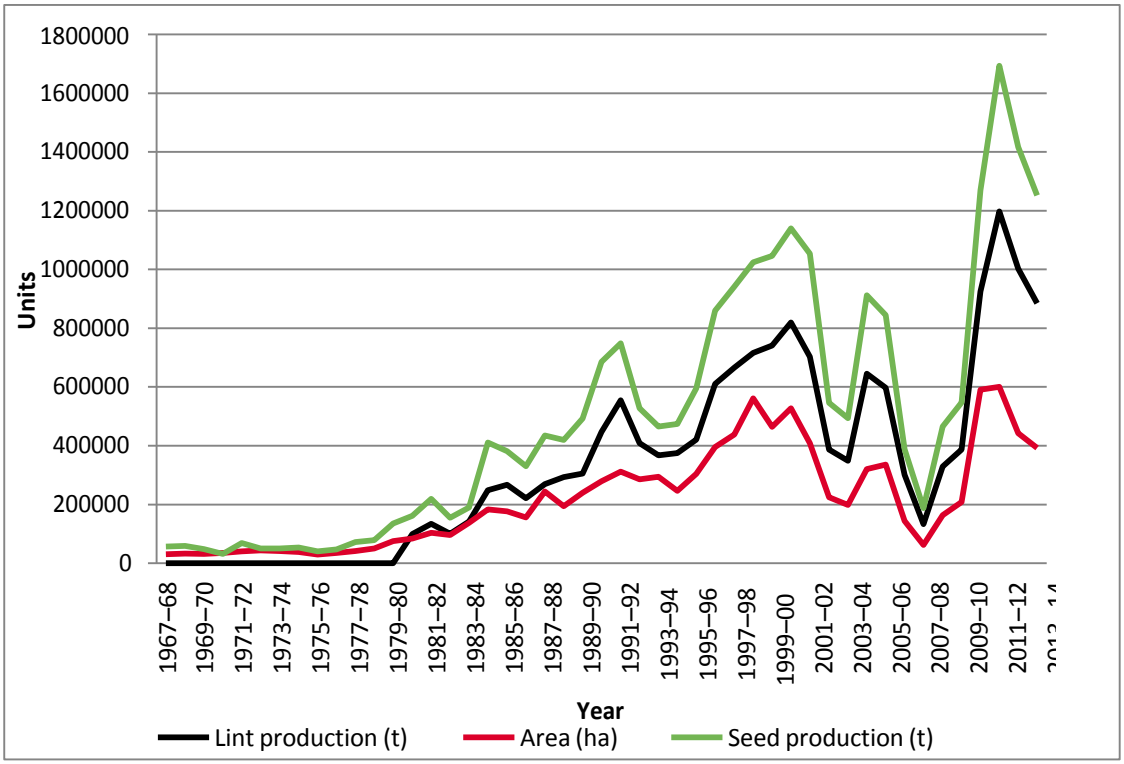


Figure 8 *Cotton production statistics (Source: ABARES 2014)*

Cotton crops in Australia are attacked by a wide range of pests, including the Cotton boll worm (*Helicoverpa armigera*), Native budworm (*H. punctigera*), Green mirids (*Creontiades dilutis*), cotton aphids (*Aphis gossypii*), Two-spotted spider mites (*Tetranychus urticae*) and the Silverleaf whitefly (*Bemisia tabaci*). The introduction of transgenic cotton, which has an insecticidal protein (from *Bacillus thuringiensis*, Bt) inserted into its genome, has dramatically reduced the need to control the major insect pests, *Helicoverpa* spp. Nevertheless, many of the major insect pests of cotton that are not controlled by Bt varieties are still absent in Australia. There are also exotic, Bt tolerant, strains of endemic pests such as *H. armigera* (which are becoming tolerant to Cry1Ac in China (Li et al., 2007)) that would have a significant effect on Australia's cotton industry if they were to become established in Australia.

Cotton is also subjected to a number of pathogens in Australia, most noticeably Verticillium wilt (*Verticillium dahliae*) and Fusarium wilt (*Fusarium oxysporum* f. sp. *vasinfectum*). To counter these and other pests, the industry has developed a range of best management practices and is a leader in farm hygiene, promoting the message 'Come clean. Go clean'.

References

ABARES (2014) Agricultural commodity statistics 2014, Australian Bureau of Agricultural and Resource Economics and Sciences, December, Canberra. Available from: **http://data.daff.gov.au/data/warehouse/agcstd9abcc002/agcstd9abcc0022014/ACS_2014_1.0.0.pdf**

Li GP, Wu KM, Gould F, Wang JK, Miao J, Gao XW, Gou YY (2007) Increasing tolerance to Cry1Ac cotton from cotton bollworm, *Helicoverpa armigera*, was confirmed in Bt cotton farming area of China. *Economical Entomology* 32: 366-375.

APPENDIX 2: COTTON THREAT SUMMARY TABLES

Cotton industry threat summary tables

The information provided in the TSTs (invertebrates, Table 19; pathogens and nematodes, Table 20) is an overview of exotic plant pest threats to the cotton industry. Summarised information on entry, establishment, spread potentials and economic consequences of establishment are provided where available. Pests under official control[91] or eradication may be included in these tables where appropriate. However, cotton pests that are endemic but regionalised within Australia are not covered by IBPs, but may be assessed in state biosecurity plans. Assessments may change given more detailed research, and will be reviewed with the biosecurity plan.

Full descriptions of the risk rating terms can be found on Page 39. An explanation of the method used for calculating the overall risk can be found on the PHA website[92]. Additional information on a number of the pests listed in the TSTs can be found in pest-specific information documents (Table 15).

[91] Official control defined in ISPM No. 5 as the active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests.
[92] Available from **www.planthealthaustralia.com.au/biosecurity/risk-mitigation.**

Invertebrates

Table 19: *Cotton invertebrate threat summary table*

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
ACARI (Mites e.g. spider and gall mites)								
Acalitus gossypii	Cotton blister mite	Cotton	Leaves	MEDIUM[93]	MEDIUM	MEDIUM	LOW	**VERY LOW**
***Brevipalpus* spp.**	False spider mites	Various hosts including: cotton	Leaves	MEDIUM	MEDIUM	MEDIUM	LOW	**VERY LOW**
Raoiella indica	Red palm mite	Palms, infestations in cotton from nearby palms. Also affects banana	Leaves	MEDIUM[94]	MEDIUM	MEDIUM	LOW	**VERY LOW**
Tetranychus canadensis	Canadian spider mite; four spotted spider mite	Wide range of plants including: cotton, red clover, common bean, barley, rye, maize, wheat	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	**VERY LOW**
Tetranychus pacificus	Pacific spider mite	Cotton, melon, soybean, common bean, stone fruit, Japanese plum, grapevine	Leaves	MEDIUM	MEDIUM	MEDIUM	LOW	**VERY LOW**
Tetranychus truncatus	Cassava spider mite	Cotton, cassava, maize, melons	Leaves	MEDIUM	MEDIUM	MEDIUM	LOW	**VERY LOW**
Tetranychus turkestani	Strawberry spider mite	Cotton, roses, peppers, sword lily, soybean, oleander, almond, peach, maize	Leaves	MEDIUM	MEDIUM	MEDIUM	LOW[95]	**VERY LOW**

[93] Occurs in India, North, South and Central America.
[94] First reported from India. This pest has spread to the central America. Most likely to spread on plant material.
[95] More damaging than the endemic Two spotted mite (*Tetranychus urticae*) but would be managed in the same way as endemics.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Tetranychus yusti	Spider mite	Wide host range including: cotton, common bean, wheat, millet, cowpea, maize, peanut, barley, soybean, sunflower, pigeon pea, , *Musa* spp., *Xanthosoma sagittifolium*	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	**VERY LOW**
COLEOPTERA (Beetles, weevils, etc.)								
Amorphoidea lata	Cotton flower weevil	Cotton	Flowers, anthers, petals	MEDIUM[96]	MEDIUM	MEDIUM	MEDIUM[97]	**LOW**
Apion soleatum	Cotton stem weevil	Cotton	Stems	LOW[98]	MEDIUM	MEDIUM	MEDIUM[99]	**LOW**
Anthonomus grandis	Boll weevil	Cotton (*Gossypium barbadense, G. hirsutum*) and related *Gossypium* species. Rose of Sharon (*Hibiscus syriacus*) has also been reported as an alternative host (CABI and EPPO date of publication unknown A) other Malvaceae can also act as hosts.	Bolls	MEDIUM[100]	HIGH[101]	HIGH	HIGH[102]	**HIGH**
Hypomeces squamosus	Gold dust weevil; Green weevil	Various including: cotton, sunflower, maize	Above ground (adult). Below ground (larvae)	MEDIUM[103]	MEDIUM	MEDIUM	LOW[104]	**VERY LOW**

[96] Present in Southeast Asia.
[97] Described by Rustico and Jose (1993) as being a significant pest of the Philippine cotton industry.
[98] Confined to Africa.
[99] A potentially serious pest of South African cotton (Bennett and Nel 1990).
[100] Could enter on crop debris (e.g. on machinery). Pest present in North and South America.
[101] Based on this species distribution in the United States, Australian cotton growing areas would be suitable for its establishment. Cotton volunteers present in Australian growing regions would allow establishment and have been a problem in the USA. Native Malvaceae may also have the ability to act as hosts as Malvaceae plants act as hosts overseas.
[102] Would have large impact on the industry through yield losses and additional chemical control costs.
[103] Occurs in southern Asia from Pakistan east to Indonesia.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Hypothenemus hampei	Coffee berry borer	Coffee, maize, pigeon pea (main hosts). Cotton, pea, lima bean, peanut, *Acacia* spp. (minor/less preferred hosts)	Seeds and seed pods	MEDIUM[105]	MEDIUM[106]	MEDIUM[107]	LOW[108]	**VERY LOW**
Mylabris pustulata	Arhap blister beetle	Range of hosts including: cotton, pigeon pea, peanut, sorghum, soybean	Flowers	MEDIUM[109]	MEDIUM	MEDIUM	LOW[110]	**VERY LOW**
Myllocerus discolor	Grey weevil	Cotton, pigeon pea and a range of other plants	Above ground (adult). Below ground (larvae)	LOW[111]	MEDIUM	MEDIUM	LOW[112]	**VERY LOW**
Ostrinia nubilalis	European maize borer	Maize (main host). cotton, sorghum, Johnson grass, millet, oat, sunflower, cowpea, peanut, soybean, barley, wheat, common bean (minor hosts)	Above ground plant parts	MEDIUM[113]	MEDIUM[114]	HIGH	LOW[115]	**VERY LOW**
Pharaxanotha kirschi	Mexican grain beetle	Stored products including: maize, wheat, cotton	Stored seed[116]	LOW[117]	MEDIUM	MEDIUM	LOW	**VERY LOW**

[104] Minor pest on cotton.
[105] Widespread, occurs in most coffee producing countries including Indonesia (but not in Papua New Guinea or Hawaii). Spread with infected coffee seeds.
[106] Reproduces on primary hosts, several readily available in Australia. Occurs in tropical and sub-tropical climates. Northern growing areas likely to be more suitable than southern areas.
[107] Adults capable of flight. Also spread with seed.
[108] Mostly a pest of coffee (Damon 2000).
[109] Occurs in India, Bangladesh and Indonesia.
[110] Minor pest on cotton.
[111] Occurs in India and Bangladesh.
[112] Very few references to this pest in cotton – so conclude the risk is probably low.
[113] Occurs in Europe and North America.
[114] Wide host range so establishment potential is considered to be Medium.
[115] Mostly a pest of maize, but also affects other hosts such as cotton. Pest of cotton in North Carolina – but tends to be controlled by the Bt proteins. Some survival does occur though.
[116] Therefore only impact on cotton seed not lint.
[117] Confined to Mexico and the USA (DAFF 1999).

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
***Phyllophaga* spp.** (exotic species such as: *P. cuyabana*)	White grubs; May beetles (exotic species)	Wide range of plants including cotton, grains, etc.	Below ground, seedlings	LOW	HIGH[118]	MEDIUM	LOW	**VERY LOW**
Trogoderma granarium	Khapra beetle	Wide range of stored products, including cotton seed, grain, powdered milk	Stored seed[116]	HIGH[119]	HIGH	HIGH[120]	LOW[121]	**LOW**
DIPTERA (Flies and midges)								
Acrosticta apicalis	Otidid fly	Peanut, cotton, aubergine, sweet potato	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	**VERY LOW**
Contarinia gossypii	Cotton gall midge	Cotton	Above ground plant parts	MEDIUM[122]	MEDIUM	MEDIUM	LOW	**VERY LOW**
Liriomyza sativae	Vegetable leaf miner	Prefers Solanaceae and Fabaceae but has been reported on 7 other plant families. Affects wide range of plants including cotton[123]	Leaves	HIGH[124]	HIGH[125]	MEDIUM	LOW[126]	**LOW**
Liriomyza trifolii	American serpentine leaf miner	25 plant families including: cotton, peanut, soybean, lentil, lupin, faba bean and chickpea	Leaves	MEDIUM	MEDIUM	MEDIUM	LOW	**VERY LOW**

[118] Some species of this genera already occur in Australia.
[119] Could enter as a contaminate of grain or other material from overseas.
[120] Easily spread with grain moved between areas.
[121] Will feed on cotton seed.
[122] Occurs in India and the USA (Hill 1987).
[123] See: CABI and EPPO (date of publication unknown B) and McGregor (1914).
[124] Present in islands to the north of Australia. Therefore there is a chance of it entering.
[125] Wide host range means there is a high chance of establishment.
[126] Cotton is not a main host of this species.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
HEMIPTERA (Stink bugs, aphids, mealybugs, scale, whiteflies and hoppers)								
Acrosternum hilare	Green stink bug	Wide host range including: cotton, soybean, strawberry, okra	Bolls, developing seeds	MEDIUM	MEDIUM[127]	MEDIUM	MEDIUM[128]	**LOW**
Acyrthosiphon gossypii	Aphid	Cotton, also affects legumes and plants in the Zygophyllaceae family	Leaves, bolls	MEDIUM[129]	LOW	LOW	LOW[130]	**NEGLIGIBLE**
Aphis gossypii (exotic strains)	Cotton aphid (exotic strains)	Wide host range including: cotton, cucumber, pumpkin, melon, faba bean and eggplant.	Above ground plant parts	MEDIUM	HIGH	HIGH	HIGH[131]	**HIGH**
Amrasca devastans (syn. *Amrasca biguttula biguttula*)	Indian cotton jassid; Indian green jassid	Wide range of host plants including: okra, peanut, soybean, cotton, sunflower, cowpea, mung bean, maize	Above ground plant parts	MEDIUM	HIGH[132]	MEDIUM	HIGH[133]	**MEDIUM**
Aphis fabae	Black bean aphid	Wide host range including: faba bean, common bean, sunflower, soybean, lentil, lucerne, field pea, maize, soybean, vetch and a number of other plants	Above ground plant parts	MEDIUM[134]	HIGH[135]	HIGH	VERY LOW[136]	**VERY LOW**

[127] Occurs in Pakistan, Canada and the USA, these climates suggest it could establish in Australian cotton growing areas.
[128] Found to cause damage to transgenic cotton in the USA (Greene and Turnipseed 1996). Important pest of cotton in the more northern United States cotton regions such as Tennessee. It would likely be a pest on cotton in Australia if it became established. However the natural suite of predators and parasites that already contribute to control of other bug pests, such as *Nezara viridula* would probably also help control this pest and our environment and cropping system isn't very conducive to build up of big populations except perhaps in more diverse cropping areas (e.g. Downs, Griffith, Upper Namoi). Good insecticide options are available.
[129] Occurs in northern Africa, southern Europe and much of Asia (Blackman and Eastop 2006).
[130] Pest of cotton in central Asia (Gao et al., 2013). Current management practices for Cotton aphid (*Aphis gossypii*) may manage this species. Tends to be a cooler season species (Gao at al,, 2013) and tends to be declining in areas where temperature is increasing.
[131] Exotic strains may have different insecticide resistance profiles or cause differing levels of damage on cotton than strains already in Australia. Cotton aphids cause honey dew on lint and act as potential vectors of cotton various viruses (e.g. the exotic *Cotton anthocyanosis virus* (*Luteovirus*)).
[132] Similar to endemic jassids (such as Vegetable Leafhopper, (*Austroasca viridigrisea*) and the Cotton Leafhopper, (*Amrasca terraereginae*).
[133] Feeding can damage leaves (hopper burn) and cause stunted growth. Feeding can also cause honeydew to develop on the lint.
[134] Widespread overseas in North and South America, Africa, Europe and Asia.
[135] Wide host range and ability to establish in a range of climates overseas suggests there is a high probability of establishment in Australia.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Aphis maidiradicis	Corn root aphid	Maize, cotton	Root system	LOW[137]	MEDIUM	MEDIUM	LOW[138]	**VERY LOW**
Asterolecanium pustulans	Oleander pit scale; akee fringed scale	Pigeon pea, akee, coconut, coffee, silky oak, mango, eggplant, cocoa, cotton	Stems, leaves and branches	MEDIUM[139]	MEDIUM	MEDIUM	LOW	**VERY LOW**
Bemisia tabaci (Biotypes other than B and AN)[140]	Silverleaf whitefly (exotic biotypes)	Broad host range including cotton, vegetables & ornamentals	Leaves, honeydew on lint	MEDIUM	HIGH	HIGH	MEDIUM - HIGH[141]	**MEDIUM - HIGH**
***Calidea* spp.** (including *Calidea dregii*)	Blue bug	Cotton. Also affect sorghum, sunflower, citrus, hibiscus and other plants	Seeds, developing bolls, stains lint	LOW[142]	HIGH	HIGH	HIGH[143]	**MEDIUM**
Corythucha gossypii	Cotton lacebug	Wide host range including: okra, cotton, peanut, pigeon pea, cassava	Foliage	MEDIUM[144]	MEDIUM	MEDIUM	LOW	**VERY LOW**
Creontiades pallidus	Boll shedder bug; bud shredder bug	Cotton. Occasionally sorghum can harbour the pest	Bolls	MEDIUM[145]	MEDIUM[146]	MEDIUM	MEDIUM[147]	**LOW**
Creontiades signatus	Verde plant bug	Cotton	Bolls	LOW[148]	HIGH	HIGH[149]	LOW[150]	**VERY LOW**

[136] Reported on cotton in the USA (Stoetzel et al., 1996). But only a minor pest. Australia has good aphid management in place to manage endemic aphids so its impact on cotton is likely to be minimal.
[137] Occurs in the USA, Brazil and Jamaica (Stoetzel et al., 1996).
[138] Mostly a maize pest, but will also affect cotton (Stoetzel et al., 1996).
[139] Occurs in North America and South America.
[140] Bemisia tabaci is recognized as a cryptic species complex, as such biotypes B and AN are recognized as separate species. Exotic biotypes of Bemisia tabaci are therefore now recognized as exotic species of this species complex, see: De Barro et al., (2011). Biotypes B and AN, occur in Australia (see: DAFF Qld 2012). Exotic biotypes may have different insecticide resistance profiles or cause differing levels of damage on cotton than biotypes already in Australia.
[141] Can have a significant impact on lint yield when plants are heavily infested (Naranjo et al., 1996).
[142] Only occur in Africa (Hill 2008).
[143] *Calidea* spp. usually enter crops as bolls mature, can damage lint and cause boll drop (Hill 2008).
[144] Occurs in the Caribbean, southern USA and Central America (Schaefer and Panizzi 2000).
[145] Occurs in the Mediterranean, central Africa, Brazil and Middle East (Schaefer and Panizzi 2000).
[146] There are a number of endemic *Creontiade* species in Australia.
[147] Cotton can usually compensate for early losses of squares (Schaefer and Panizzi 2000).
[148] Occurs in the south east of the United States
[149] Likely to establish based on behaviour overseas.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
***Dysdercus* spp.** (including: *D. honestus, D. maurus, D. suturellus* (American species))	Cotton stainer; red bugs	Cotton, green sorghum, okra, Malvaceae, boab	Bolls, seeds	MEDIUM[151]	HIGH[152]	HIGH	HIGH[153]	**HIGH**
***Dysdercus* spp.** (including: *D. nigrofasciatus* and *D. superstitiosus* (African species))	Cotton stainer; red bugs	Cotton, green sorghum, okra, Malvaceae, boab	Bolls, seeds	LOW[154]	HIGH	HIGH	HIGH	**MEDIUM**
Edessa meditabunda	Green and brown stink bug	Okra, pigeon pea, citrus, soybean, cotton, common bean, sunflower, field pea, lucerne, safflower	Above ground plant parts	MEDIUM[155]	MEDIUM	MEDIUM	LOW	**VERY LOW**
Halyomorpha halys	Brown marmorated stink bug	Wide host range with over 100 species reported as hosts including cotton, sweetcorn, soybeans, vegetables and fruit trees	Bolls	MEDIUM-HIGH[156]	HIGH[157]	HIGH	HIGH[158]	**HIGH**
Helopeltis schoutedeni	Cotton helopeltis; cacao-mosquito	Cotton, cashew, castor bean	Terminals and young bolls	LOW[159]	MEDIUM[160]	MEDIUM	LOW[161]	**VERY LOW**

[150] Pest of cotton in the Rio Grande area of the USA near the Texas - Mexico border, where is has a range of weed hosts. Damage is similar to *C. dilutus* (present already in Australia). Current mirid management practices likely to manage this pest too.
[151] These species occur in North and South America.
[152] There are species in this genus that occur in Australia.
[153] *D. suturellus* is the most damaging of the American species. These bugs feed on bolls and stain the cotton lint a yellow-brown colour. If young bolls are fed on they may not mature (Mead 2005), can also affect mature bolls.
[154] These species occur in Africa. Damage is expected to be similar to American *Dysdercus* species.
[155] Occurs in the Caribbean and South America (Rizzo 1971).
[156] Was recently (late 1990s) introduced from China into North America, where it is spreading rapidly (Kamminga et al., 2014). Spread on cargo from infected areas.
[157] Given the spread of this species in the United States.
[158] This species is spreading into the United States cotton belt and is reported to attack large bolls in preference to small bolls (Kamminga et al., 2014).
[159] Confined to Africa.
[160] Occurs in Tropical and sub-tropical areas of Africa.
[161] Feeding causes lesions to develop. No details on yield losses.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
***Jacobiella* spp.** (including: *Jacobiella facialis*)	Cotton leaf hopper	Cotton and a range of other species	Leaves	LOW[162]	MEDIUM	MEDIUM	MEDIUM[163]	**LOW**
Lygus elisus (syn. *Lygus nigrosignatus*)	Lucerne plant bug	Cotton, canola, lucerne, lupin, common bean, fruit trees can also be affected	Squares, bolls	MEDIUM	HIGH	HIGH	MEDIUM[164]	**MEDIUM**
Lygus hesperus	Western plant bug	Feeds primarily on cotton and strawberry. Also affects a range of other species	Squares, bolls	MEDIUM[165]	HIGH	HIGH	HIGH[166]	**HIGH**
Lygus lineolaris	Tarnished plant bug	Wide host range including: cotton, strawberry, lucerne, peach, common bean, *Rubus* spp., vetch, canola, sunflower, soybeans and maize.	Squares, bolls	MEDIUM	HIGH	HIGH	HIGH[166]	**HIGH**
Lygus lucorum	Cotton lygus bug	Cotton	Squares, bolls	MEDIUM	HIGH	HIGH	MEDIUM[164]	**MEDIUM**
Orosius cellulosus	Leafhopper	Cotton, *Sida cordifolia, S. rhombifolia, Mitracarpus scaber*, sesame	Leaves	LOW	HIGH	HIGH	LOW-HIGH[167]	**MEDIUM**
Oxycarenus laetus	Dusky cotton stainer; Indian dusky cotton bug	Malvaceae, including cotton	Bolls, seeds	LOW[168]	MEDIUM	MEDIUM	LOW[169]	**VERY LOW**

[162] Needs plant material, but eggs can be hidden in plant material.
[163] Controlled with Thiamethoxam seed treatments in Namibia (Syngenta South Africa).
[164] Less damaging than *L. hesperus* and *L. lineolaris*.
[165] Eggs laid in plant material.
[166] Significant pest of cotton overseas. feeding causes damage to squares, feeding on bolls can cause seed and lint damage.
[167] Vectors Cotton phyllody phytoplasma in Mali (Marzachi et al., 2009). If phytoplasma is also present this insect will have a high economic impact. Little information on the impact of this pest on its own, suggesting in the absence of the pathogen it has limited impact on production.
[168] Occurs in southern Asia from India to Thailand
[169] This species causes staining to lint and reduced seed weight and oil content. (Srinivas 2004). It is reported to reduce seed weight and germination (Khan et al., 2014)

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Paurocephala gossypii	Cotton psyllid	Cotton	Lays eggs inside plant tissue	LOW[170]	LOW-MEDIUM[171]	LOW-MEDIUM	LOW[172]	**VERY LOW – NEGLIGIBLE**
Pseudatomoscelis seriatus (syn. *Psallus seriatus*)	Cotton flea hopper	Cotton, lucerne, common bean, soybean, sunflower, water melons. 169 hosts identified	Terminals and young fruit	MEDIUM[173]	MEDIUM	MEDIUM	LOW-MEDIUM[174]	**VERY LOW-LOW**
Scaphytopius albifrons	Leafhopper	Cotton	Above ground	UNKNOWN[175]	UNKNOWN	UNKNOWN	UNKNOWN[176]	**UNKNOWN**
Trialeurodes abutilonea	Banded wing whitefly	Wide host range including: cotton, capsicum, lettuce, cassava and various ornamental plants	Leaves, honeydew on lint	MEDIUM[177]	HIGH	HIGH	MEDIUM[178]	**MEDIUM**
LEPIDOPTERA (Butterflies and moths)								
Autographa gamma	Silver-Y moth	Feeds on 200 species including: cotton, lucerne, chickpea, maize, cowpea, common bean, field pea, soybean, sunflower, wheat	Above ground plant parts	MEDIUM[179]	HIGH[180]	MEDIUM	LOW[181]	**VERY LOW**

[170] Only known in Africa (Mifsud and Burckhardt 2002). Eggs laid in plant material.
[171] Current distribution suggests more likely to establish in the tropics.
[172] Limited information in the literature about this pest, suggesting it is of minor significance.
[173] Occurs in the southern United States. Most likely spread with plant material.
[174] Significant pest in parts of the USA, with 12-34% yield losses reported (Schwartz 1983).
[175] Present in North America.
[176] Vectors Cotton yellow vein disease (an exotic virus see Table 20).
[177] Present in some parts of the United States and in Cuba (Dalmon et al., 2009).
[178] Like other whitefly species this pest produces honey dew that can reduce fibre quality. Not reported as a vector of cotton diseases.
[179] Has been intercepted in the USA on a variety of plant material, including: vegetables and cutflowers (Venette et al., 2003).
[180] Widespread in Europe, northern Africa and Asia (Venette et al., 2003), which suggests it can adapt to a range of climates.
[181] Feeds on the leaves causing defoliation and therefore lost yield.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Alabama argilacea	Cotton leaf worm	Cotton, some other Malvaceae	Leaves	LOW	HIGH[182]	HIGH[183]	LOW-MEDIUM[184]	**VERY LOW-LOW**[185]
Bucculatrix thurberiella	American cotton leaf perforator	Cotton	Leaves	MEDIUM[186]	HIGH	HIGH	LOW-HIGH[187]	**LOW-HIGH**[188]
Chrysodeixis chalcites	Golden twin spot moth; Tomato looper; Green Garden Looper	Wide host range including: soybean, common bean, cotton, tomato, chickpea	Leaves	MEDIUM[189]	MEDIUM	MEDIUM	LOW	**VERY LOW**
Diparopsis castanea	Red boll worm	Cotton, *Gossypium* spp.	Bolls	LOW[190]	HIGH[191]	HIGH	LOW-HIGH[192]	**VERY LOW-MEDIUM**[193]
Diparopsis watersi	Sudan boll worm	Cotton	Bolls	LOW[194]	HIGH	HIGH	LOW-HIGH[195]	**VERY LOW-MEDIUM**[193]
Earias biplaga	Spiny bollworm	Cotton, okra, mallow, other plants in the Malvaceae family and cacao.	Bolls, stems, enclosed areas	LOW[194]	HIGH	HIGH	LOW-HIGH[196]	**VERY LOW-MEDIUM**[193]
Earias cupreoviridis	Cotton green moth	Cotton, and other plants in the Malvaceae family	Bolls, stems, enclosed areas	LOW[197]	HIGH	HIGH	LOW-HIGH[196]	**VERY LOW-MEDIUM**[193]

[182] Occurs over a range of climates from North to South America, suggests it is able to adapt to various climates.
[183] Cotton leaf worm is a migratory species (Silva et al., 2011).
[184] Low on Bt cotton, but medium on conventional. Significant pest of cotton in Brazil rated second in importance after the Cotton boll weevil (*Anthonomus grandis*) (Silva et al., 2011).
[185] Very low on Bt cotton, but low on conventional.
[186] Occurs in North and Central America.
[187] Low on Bt cotton, but high on conventional. Cotton plants can become completely defoliated if heavily infested (Smith and Flint 1977).
[188] Low on Bt cotton, but high on conventional.
[189] Occurs in Africa, Europe, the Middle East and India.
[190] Currently this species is only known to occur in sub-Saharan Africa.
[191] Cotton producing areas of Australia have suitable climates and hosts for the establishment of this pest.
[192] Low on Bt cotton, but high on conventional. Species causes boll damage on susceptible varieties.
[193] Very low on Bt cotton, but medium on conventional.
[194] Currently in Africa.
[195] Low on Bt cotton, but high on conventional.
[196] Low on Bt cotton, but high on conventional.
[197] Occurs in Africa and parts of southern Asia, including Pakistan, India and China.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Elasmopalpus lignosellus	Lesser corn stalk borer	Wide host range including: wheat, oat, rye, peanut, pigeon pea, soybean, common bean, cotton, rice, sugarcane, cowpea, wheat, maize, sorghum	Larvae feed in stems and roots causing wilting, stunting and sometimes plant death	MEDIUM[198]	HIGH	HIGH	LOW	**LOW**
Estigmene acrea	Salt marsh caterpillar	Vegetables and field crops including: cotton, lucerne, soybean, sugar beet and clover	Leaves, seedlings	MEDIUM	MEDIUM	MEDIUM	LOW[199]	**VERY LOW**
Helicoverpa armigera (carrying Bt resistance alleles)	Cotton bollworm; African boll worm	Wide host range including: cotton, maize, chickpea, lucerne, soybean, peanuts	Above ground plant parts	MEDIUM[200]	HIGH[201]	HIGH	HIGH[202]	**HIGH**
Helicoverpa zea[203]	American cotton bollworm; Corn earworm	Wide host range including: cotton, pigeon pea, capsicum, soybean, sunflower, common bean, tomato, sorghum, maize, peanut, chickpea, millet, cowpea	Above ground plant parts	MEDIUM	HIGH[204]	HIGH	MEDIUM[203]	**MEDIUM**
Heliothis peltigera (syn. *Chloridea peltigera*, *Noctua peltigera*)	Bordered straw	Various including: safflower, cotton, sunflower, soybean, maize, chickpea, peanut	Above ground plant parts	MEDIUM[205]	MEDIUM	MEDIUM	MEDIUM	**LOW**

[198] Occurs in North and South America from Chile to the United States.
[199] Occasional pest in the United States (Kerns and Kesey 2009).
[200] Bt tolerant strains occur in China (Li et al., 2007).
[201] Strains already occur in Australia and are well established.
[202] Strains of *H. armigera* are emerging which are becoming tolerant to Bt (Cry1Ac) cotton in China (Li et al., 2007).
[203] May hybridise with Cotton bollworm (*H. armigera*).
[204] Occurs in North and South America from Chile to Canada. This suggests that it is able to adapt to a wide range of climates.
[205] Currently occurs in Africa, Europe and Asia.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Heliothis virescens (syn. *Helicoverpa viriscens*)	Tomato budworm	Wide host range including: cotton, chickpea, maize, sunflower, flax, common beans, pigeon pea, tobacco, tomato, sweet potato, peanuts, soybean, field pea, sorghum, common vetch	Bolls, squares	MEDIUM	HIGH[206]	HIGH	MEDIUM[207]	**MEDIUM**
Loxostege sticticalis	Beet webworm	Wide host range including: peanut, faba bean, wheat, maize, sunflower, soybean, canola, cotton, onion, beets, cucumber, carrot, flax, lucerne, potato	Foliage	MEDIUM[208]	LOW[209]	MEDIUM	LOW	**VERY LOW**
Spodoptera frugiperda	Fall army worm	Wide host range including: cotton, peanut, soybean, lucerne, cereals	Leaves, bolls, squares, flowers	LOW	HIGH	HIGH	MEDIUM[210]	**LOW**
Spodoptera littoralis	Cotton leafworm	Wide host range of 40 families including: peanuts, soybean, sunflower, common bean, lucerne, field pea, faba bean, mung bean, maize, wheat, sorghum, cotton	Foliage, seedlings	MEDIUM	MEDIUM	HIGH	MEDIUM	**LOW**

[206] Occurs in a range of climates from Canada to Chile.
[207] More susceptible to Bt than other Heliothis species.
[208] Occurs in Europe, Asia and Canada.
[209] Distribution suggests the species prefers cooler areas.
[210] Becoming a pest of cotton in Brazil (Barros et al., 2010).

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Thaumatotibia leucotreta (syn. *Cryptophlebia leucotreta*)	False codling moth	Feeds on more than 50 species of plants in over 30 plant families including: cotton, lima bean, common bean, sorghum, maize, cowpea	Bolls, seed	MEDIUM[211]	HIGH	HIGH[211]	HIGH[212]	**HIGH**
Trichoplusia ni	Cabbage semi looper	Wide host range including: cotton, crucifers, beans, and various vegetable crops. Feeds on over 160 species, but cultivated crucifers are preferred	Leaves	MEDIUM[213]	HIGH[214]	HIGH	LOW[215]	**LOW**
ORTHOPTERA (Locusts, grasshoppers, crickets)								
Chondracris rosea	Cotton locust; citrus locust	Wide host range including: cotton, citrus, soybean, rice, sugarcane, maize	Leaves, stems and growing tips	LOW[216]	MEDIUM	MEDIUM	LOW[217]	**VERY LOW**
Nomadacris septemfasciata	Red locust	Leaves, stems	Leaves, stems and growing tips	LOW[218]	HIGH[219]	HIGH[220]	LOW	**VERY LOW**
Zonocerus variegatus	Variegated grasshopper	Wide host range including: citrus, cotton, sunflower, cassava, cowpea, maize	Leaves, stems and growing tips	LOW[218]	MEDIUM[221]	MEDIUM	LOW	**VERY LOW**

[211] Could spread inside fruit, etc.
[212] In Uganda this pest has been reported to cause 20-90% losses in cotton due to boll damage. Late sown crops were most effected (Byaruhanga 1977).
[213] Widespread overseas, found in Africa, Europe, Asia, North America and South America.
[214] Wide distribution overseas. suggests it is able to adapt to a wide range of climates and therefore could become established in Australia.
[215] More of issue on crucifers, not a major pest of cotton.
[216] Occurs in Southeastern Asia. Unlikely to enter on plant material or be blown in to the country.
[217] Not a significant pest of cotton overseas. More of a pest to sugarcane.
[218] African species, unlikely to be spread on plant material or naturally enter Australia.
[219] Occurs in sub-Saharan Africa, Australian climate likely to be suitable for establishment.
[220] Migratory species.
[221] Occurs in tropical Africa.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
THYSANOPTERA (Thrips)								
Caliothrips fasciatus	Bean thrips	Cotton, citrus, grapes, common beans, weeds such as sow thistle	Leaves, flowers, bolls	LOW-MEDIUM	MEDIUM	HIGH[222]	MEDIUM	**LOW**
Caliothrips impurus	African cotton thrips; dark cotton leaf thrips	Cotton, peanuts	Leaves, flowers, bolls	LOW[223]	MEDIUM-HIGH	HIGH[222]	MEDIUM[224]	**LOW**
Frankliniella fusca	Tobacco thrips	Peanut, soybean, maize, cotton, capsicum, cowpeas and Tobacco	Leaves, flowers, bolls	MEDIUM	MEDIUM	HIGH[222]	MEDIUM[224]	**LOW**
Frankliniella intonsa	Flower thrips	Various hosts including: peanut, soybean, cotton, lucerne, common bean, field pea, adzuki bean, asparagus, okra, tomato, strawberries	Leaves, flowers, bolls	MEDIUM[225]	MEDIUM	HIGH[226]	MEDIUM[227]	**LOW**
Kurtomathrips morrilli	-	Cotton, chrysanthemums, beans, lantana, Datura, *Malva rotundifolia*, *Wedelia* spp., *Wisteria* Spp.	Leaves	LOW	MEDIUM[228]	MEDIUM[229]	LOW[230]	**VERY LOW**

[222] Thrips can be spread with plant material (including flowers, nursery plants, etc.) between areas.
[223] Mostly confined to Africa. Could spread on plant material.
[224] Pest of seedlings.
[225] Pest is present in Europe, Asia and North America.
[226] Thrips can be spread with plant material (including flowers, nursery plants, etc.) between areas.
[227] High populations of Flower thrips causes the young bolls to drop from the plant. It is becoming an emerging pest in Turkey (Atakan and Ozgur 2001).
[228] Suitable hosts occur in Australia.
[229] Could be transported by nursery's, can fly and possibly be wind-blown.
[230] Generally later season damage to cotton leaves only in certain (warmer) seasonal conditions. Can be controlled with insecticides. Emerging pest species in the southwestern USA (Kerns and Anderson 2012).

Pathogens and nematodes

Table 20. *Cotton pathogen and nematode threat summary table*

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
BACTERIA (including phytoplasma)								
Cotton virescence phytoplasm (16SrII)[231]	Cotton phyllody phytoplasma; Cotton phyllody; Cotton flower virescence; Phyllody	Cotton. *Sida cordifolia, S. rhombifolia, Mitracarpus scaber*, sesame Also dodder, periwinkle (experimentally)	Leaves, flowers, stems	LOW[232]	LOW[233] (without vector) HIGH (With vector)	LOW (without vector) HIGH (With vector)	HIGH[234]	**LOW** (without vector) **MEDIUM** (with vector)
***Cotton little leaf Phytoplasma* (16SrI)**[235]	Little leaf of cotton	Cotton and luffer	Leaves	UNKNOWN[236]	UNKNOWN	UNKNOWN	UNKNOWN[237]	**UNKNOWN**

[231] It appears that the 16SrII group members reported by Martini et al., (2007) (Burkina Faso) and Marzachi et al., (2009) (Mali) may cause cotton virescence.
[232] Only known from western Africa (Kirkpatrick and Rothrock 2001).
[233] *Orosius cellulosus* (exotic leafhopper) acts as a vector of this pathogen (Kirkpatrick and Rothrock 2001).
[234] Causes damage to flowers (petals become leaf like structures), reduced leaf size, yellowing and reddening of leaves and plant stunting (Kirkpatrick and Rothrock 2001; Marzachi et al., 2009)). There are reports of 30% of plants being infected in parts of Africa (Desmidts et al., 1973).
[235] It appears that the 16SrI member reported by Kumar et al., (2010) (India) may cause cotton little leaf.
[236] Reported from India in February 2010 (Kumar et al., 2010).
[237] Causes leaves to reduce in size to approximately 1/3 full size (Kumar et al., 2010).

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Xanthomonas citri* subsp. *malvacearum (Syn. *X. axonopodis* pv. *malvacearum;* *X. campestris* pv. *malvacearum*) (exotic/hypervirulent races)[238]	Bacterial blight; Angular leaf spot (exotic/hypervirulent races)	Cotton	Leaves, stem and bolls	MEDIUM	HIGH	HIGH[239]	HIGH[240]	**HIGH**
FUNGI								
Fusarium oxysporum* f. sp. *vasinfectum (exotic races)[241]	Fusarium wilt (exotic races)	Cotton	Roots, stem, leaves, whole plant	MEDIUM[242]	HIGH	HIGH[243]	EXTREME	**EXTREME**
Colletotrichum gossypii* f. sp. *cephalosporioides) (Syn. *Glomerella gossypii)*	Ramulose; Escobilla[244]	Cotton	Above ground parts (stems, leaves, bolls, etc.)	MEDIUM[245]	MEDIUM	MEDIUM[246]	HIGH[247]	**MEDIUM**
Harpophora maydis (syn. *Cephalosporium maydis*, *Acremonium maydis*)	Late wilt, slow wilt	Maize, cotton, lupin	Leaves and stems	HIGH[248]	HIGH	HIGH[249]	LOW[250]	**LOW**

[238] There are at least 32 races of this pathogen (Madani et al., 2010). Races, 1, 2, 3, 4, 5, 7, 9, 10 and 18 (the most common race affecting Australian cotton) occur in Australia (Allen and West 1991). Exotic races refers to all races of the pathogen other than the 9 known to occur in Australia.
[239] Seed, plant debris, rain splash. Symptomless epiphyte.
[240] One of the most damaging pathogens affecting cotton (Madani et al., 2010).
[241] To date 8 races have been classified (Skovgaard et al., 2001). The Australian race appears to be similar to race 6 (Davis et al., 1996). The Australian isolates belong to Vegetative Compatible Groups (VCG) 01111 and 01112 (Wang et al., 2006) as well as the Mungindi strain.
[242] Present in North America, China, Africa.
[243] Soil-borne, and on plant debris (Kirkpatrick and Rothrock 2001).
[244] Ramulose and Esconilla of cotton (*Colletotrichum gossypii* f. sp. *cephalosporioides*) are more virulent forms of Cotton anthracnose (*C. gossypii*) that occur in South America (Brazil and Venezuela) (Kirkpatrick and Rothrock 2001).
[245] Ramulose and Esconilla of cotton occur in South America (Brazil and Venezuela) (Kirkpatrick and Rothrock 2001). *C. gossypii* is not recorded in Australia (see: APPD).
[246] Seed-borne, and on plant debris (Kirkpatrick and Rothrock 2001).
[247] More of a problem in areas with high humidity and rainfall (Kirkpatrick and Rothrock 2001). Ramulose causes death of the apical meristem and results in lateral bud sprouting, stunting and shortened internode distances (Nascimento et al., 2006).
[248] Pathogen is soil and seed-borne.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Mycosphaerella areola (Ana. *Ramulariopsis gossypii*, Syn. *Cercosporella gossypii; Ramularia areolata*)	False mildew; grey mildew; areolate mildew or Ramularia frosty blight	Cotton	Leaves, bolls may open prematurely	LOW[251]	LOW	MEDIUM[252]	LOW[253]	**NEGLIGIBLE**
Phymatotrichopsis omnivora (Syn. *Phymatotrichum omnivorum*)	Texas root rot; Phymatotrichum root rot; cotton root rot	Cotton, peanuts, soybeans, common beans, lucerne and approx. 2000 other plants	Root, whole plant	MEDIUM[254]	MEDIUM	MEDIUM[255]	EXTREME[256]	**HIGH**
Puccinia cacabata (Syn. *Puccinia stakmanii*)	Southwestern cotton rust; Cotton rust	Cotton, several species of grama grass (*Bouteloua* spp.)	Leaves, bracts, bolls	LOW[257]	MEDIUM	HIGH[258]	HIGH[259]	**MEDIUM**
Verticillium dahliae (defoliating strain)[260]	Verticillium wilt (defoliating strain)	Cotton, olives, artichoke[261]. Cotton and olives are the most severely affected hosts	Whole plant	MEDIUM[262]	HIGH[263]	HIGH[264]	HIGH[265]	**HIGH**

[249] Can survive as sclerotia on debris.
[250] The pathogen is associated with the formation of dark red lesions on the roots of the cotton plant but as the plant ages the root hardens and the lesions disappear. The pathogen has also been associated with an increase in the number of lateral roots produced by the cotton plant. (Sabet et al., 1966).
[251] Present in Africa, Asia (Kirkpatrick and Rothrock 2001).
[252] Spread by wind and rain splash (Kirkpatrick and Rothrock 2001).
[253] Causes necrotic leaf lesions (Kirkpatrick and Rothrock 2001). More of issue in humid conditions.
[254] Present in North America.
[255] Spread with soil, plant debris, etc.
[256] Symptoms are not usually obvious until flowering. Infections cause wilting and plant death (Kirkpatrick and Rothrock 2001). Due to long lived spores infected areas would likely be unable to grow cotton again.
[257] Present in North and South America (Kirkpatrick and Rothrock 2001). Alternative host is absent.
[258] Spread by wind.
[259] Causes defoliation, dwarfing of bolls, premature opening of bolls all causing reduced yields. Losses in the United States have been reported of up to 75% and losses in Mexico of up to 100% have been reported (Kirkpatrick and Rothrock 2001).
[260] Non-defoliating strains of *Verticillium dahliae* occur in Australia. The defoliating strain VCG 1A is known to occur in Australia and is currently under review.
[261] See: Jimenez-Diaz et al., (2006) and Mercado-Blanco et al., (2003) for further information.
[262] Present in the United States, Russia, Peru and Uganda (El Zik 1985).
[263] Defoliating strain has a higher temperature requirement than non-defoliating strains.
[264] Soil, plant debris, etc. can spread the pathogen.
[265] Causes defoliation and shedding of bolls (El Zik 1985).

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
NEMATODES								
Belonolaimus longicaudatus	Sting nematode	Wide host range including: cotton, strawberry, *Brassica* spp., carrots, and soybeans	Root system	LOW[266]	MEDIUM	LOW	MEDIUM-HIGH[267]	**LOW - VERY LOW**
Hoplolaimus aegypti	Lance nematode	Cotton, maize, soybean	Root system	LOW[268]	MEDIUM	LOW[269]	LOW[270]	**NEGLIGBLE**
Hoplolaimus columbus	Columbia lance nematode	Cotton, soybean, sugarcane	Root system	LOW[271]	MEDIUM[272]	LOW[269]	LOW[273]	**NEGLIGBLE**
Hoplolaimus galeatus	Lance nematode	Various hosts including: cotton, turf grass species	Root system	LOW[274]	MEDIUM	LOW[269]	LOW[275]	**NEGLIGBLE**
Hoplolaimus indicus	Lance nematode	Rice (preferred host). cotton, maize, peanut, field pea, sorghum, wheat, pigeon pea, finger millet, mungbean, black gram, sugarcane (less preferred hosts)	Root system	LOW[276]	LOW-MEDIUM[277]	LOW[269]	NEGLIGIBLE[278]	**NEGLIGIBLE**
Hoplolaimus magnistylus	Lance nematode	Soybean, cotton, maize	Root system	LOW[274]	MEDIUM[279]	LOW[269]	LOW[275]	**NEGLIGBLE**

[266] Could be introduced with soil. This species occurs in North America, and has been reported from Pakistan, Saudi Arabia and Turkey.
[267] Even low populations of Sting nematodes can have a significant impact on cotton production. Infected plants show wilting, leaf chlorosis and stunting (Kirkpatrick and Rothrock 2001).
[268] Could enter in soil contaminating seed or equipment. Reported from Egypt.
[269] Spread with soil on machinery, etc.
[270] Can cause mild stunting and chlorosis (Kirkpatrick and Rothrock 2001).
[271] Could enter in soil contaminating seed or equipment. Reported from United States, India, Pakistan and Egypt.
[272] Hosts are widespread, produces several generations per year.
[273] Can cause mild stunting and chlorosis (Kirkpatrick and Rothrock 2001). Lewis et al., (1976) suggest that this pest may also increase the incidence of Fusarium wilt due to root damage.
[274] Could enter in soil contaminating seed or equipment. Reported from United States.
[275] Similar impact to other Lance nematodes.
[276] Could enter in soil contaminating seed or equipment. Currently restricted to India.
[277] Highest chance of establishment would occur if it was to enter a rice growing region, as rice is this pest's main host.
[278] Rice is this species preferred host.
[279] Hosts are widespread, produces several generations per year.

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Meloidogyne acronea	African cotton root nematode	Cotton (main host), also affects sorghum, various other grasses	Root system	LOW[280]	MEDIUM[281]	LOW[282]	MEDIUM[283]	**VERY LOW**
Pratylenchus delattrei	Lesion nematode	Cotton, sugarcane, pigeon pea, peanut, common bean, maize, weeping lovegrass, Rhodes grass, oats, pearl millet and wheat	Root system	LOW[284]	MEDIUM	LOW[285]	LOW[286]	**NEGLIGBLE**
VIRUSES and VIROIDS								
***African cotton mosaic virus* (*Begomovirus*)** (Syn. Cotton yellow mosaic virus)	African cotton mosaic disease	Cotton, *Gossypium barbadense, Hibiscus cannabinus, Abelmoschus esculentus, Sida rhombifolia, S. micrantha*	Leaves symptomatic, reduces yield	LOW[287]	HIGH[288]	HIGH[288]	LOW[289]	**VERY LOW**
***Cotton anthocyanosis virus* (presumed *Luteovirus*)**	Cotton anthocyanosis; Vermelhao disease; Reddening disease	Cotton. Experimental host range also includes *Sida micrantha*, kenaf (*Hibiscus cannabinus*) and okra	Leaves symptomatic also causes plant stunting	LOW[290]	HIGH[288]	HIGH[291]	HIGH[292]	**MEDIUM**

[280] Could enter in soil contaminating seed or equipment. Reported from South Africa and Malawi.
[281] Strong preference for alluvial over vertisol soils (Page 1984).
[282] Spread with soil on machinery, etc.
[283] Causes stunting, chlorosis and wilting. Also reported to delay flowering and cause significant yield losses (Page 1984)
[284] Could enter in soil contaminating seed or equipment. Reported from: Iran, South Korea, Pakistan, Oman, India and Madagascar (Majd Taheri et al., 2013).
[285] Spread with soil on machinery, etc.
[286] Limited information other than reported from cotton in Madagascar (Majd Taheri et al., 2013).
[287] Present in central and western Africa. It is not seed-borne (Alegbejo et al., 2008).
[288] Vectored by Silverleaf whitefly (*Bemisia tabaci*) (Kirkpatrick and Rothrock 2001).
[289] Not generally a severe disease (Kirkpatrick and Rothrock 2001). Infected plants show yellow mosaic or mottling on leaves, leaf deformities, are stunted, have reduced canopy, have fewer flowers and shed bolls. Sever infections result in 30-50% yield losses (Alegbejo et al., 2008).
[290] Only known from Brazil (Kirkpatrick and Rothrock 2001). Not reported to be seed transmitted.
[291] Vectored by Cotton aphid (*Aphis gossypii*) but not by Green peach aphid (*Myzus persicae*), thrips or whiteflies (Costa 1956; Kirkpatrick and Rothrock 2001).
[292] Losses of up to 35% reported from Brazil when infected very early. Up to 100 % incidence in crops but usually low yield losses (Kirkpatrick and Rothrock 2001; Costa 1956).

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
***Cotton leaf crumple virus* (*Begomovirus*)**	Cotton leaf crumple	Cotton, common bean (*Phaseolus vulgaris*) and Small-flowered mallow (*Malva parviflora*)	Leaves and stunting	LOW[293]	HIGH[294]	MEDIUM[295]	LOW[296]	**VERY LOW**
***Cotton leafroll dwarf virus* (*Polerovirus*)**	Cotton blue disease	Cotton, Pima cotton (*Gossypium barbadense*) and chickpea[297], *Hibiscus sabdariffa*, *Sida acuta*.	Causes stunting, leaf damage, reduced flowering, boll sheading, whole plant affected	MEDIUM[298]	HIGH	HIGH[299]	HIGH[300]	**HIGH**

[293] Occurs in Mexico, Guatemala and the United States. This virus is not seed borne (Kirkpatrick and Rothrock 2001; Idris and Brown 2004).
[294] White fly vectors and weed hosts present.
[295] Silverleaf whitefly (*Bemisia tabaci*) transmitted. Not seed borne (Kirkpatrick and Rothrock 2001).
[296] Causes stunting of plants, crumpling/curling of leaves and mosaic patterns on leaves. 16-85% have been reported in the US (Brown, 1992). However in most years in the southern United States it doesn't cause significant yield problems as infections occur late in the season.
[297] See: CottonInfo (2014)
[298] Occurs in parts of South America, Africa and Asia (Distefano et al., 2010). Reported from several African countries (Cauquil 1977; Dyck 1979), India (Mukherjee et al 2012), South East Asia (Kaowsiri 1982; Quyen et al 2008; Sharman et al., 2015), East Timor (Ray et al 2014), Brazil (Correa et al 2005) and Argentina (Distefano et al., 2010). Synonymous virus, Chickpea stunt disease associated virus (CpSDaV) appears to be the same virus; naturally infects chickpea and other experimental legume hosts in India (Naidu et al 1997; Reddy and Kumar 2004). It is not seed borne.
[299] Vector (*Aphis gossypii*) and hosts present in all cotton growing regions of Australia.
[300] Most important cotton virus affecting crops in South America (Brazil and Argentina) and SE Asia (Distefano et al., 2010; Kaowsiri 1982; Quyen et al 2008). Atypical strain affects resistant varieties. Considered the second most damaging cotton disease after Cotton leaf curl disease (CottonInfo 2014).

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
***Cotton leaf curl virus complex* (*Begomovirus*)**	Cotton leaf curl Alabad virus (India/Pakistan); Cotton leaf curl Bangalore virus; Cotton leaf curl Gezira virus (Africa); Cotton leaf curl Kokhran virus (India/Pakistan); Cotton leaf curl Multan virus (India/Pakistan/ China); Cotton leaf curl Rajasthan virus (India); Cotton leaf curl Shahdapur virus; Papaya leaf curl virus (India/Pakistan); Tomato leaf curl Bangalore virus (India/Pakistan); Okra enation leaf curl virus (Pakistan)	Cotton. Additional hosts include Hibiscus, okra, tobacco, radish, tomato, French bean, chilli, papaya and many weeds	Leaves symptomatic, whole plant affected	MEDIUM[301]	HIGH	HIGH[302]	EXTREME[303]	**EXTREME**
Cotton terminal stunt virus (Unclassified)	Cotton terminal stunt virus	Cotton	Leaves, xylem and stem symptomatic. Whole plant affected	UNKNOWN[304]	UNKNOWN	UNKNOWN[305]	MEDIUM[306]	**LOW-NEGLIGIBLE**

[301] The virus is graft transmitted but is not mechanically or seed-transmitted (USDA 2013). Could enter on live ornamental or horticultural hosts.
[302] Spread by White fly (*Bemisia tabaci*) (USDA 2013; Kirkpatrick and Rothrock 2001).
[303] Early season infections can result in total crop loss (USDA 2013). Thought to be the most damaging cotton disease.
[304] Occurs in United States, first reported in Texas in the 1960s (Sleeth et al., 1963). Affected 400,000 acres (160,000 ha) in Texas in 1962 (Sleeth et al., 1963), limited information, suggests it is no longer a significant issue in the United States. No information found to suggest it is seed borne. Distribution in crops suggest aerial vector of a virus agent.
[305] Vector not known (Kirkpatrick and Rothrock 2001).
[306] Causes leaf mottling, shortening of internodes, and xylem discolouration (Reddall et al.,2002; Sleeth et al., 1963). Up to 50% of plants in some fields infected and substantial yield losses reported (Kirkpatrick and Rothrock 2001).

Scientific name	Common name	Host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Chickpea chlorotic dwarf virus (Mastrevirus)	Chickpea chlorotic dwarf virus	Chickpea, cotton[307], lentil, sugar beet and the weeds *Sesbania bi-spinosa*, and *Xanthium strumarium*. Experimental hosts include legumes, tobacco, tomato, *Datura stramonium*	Infected cotton plants showed only typical leaf curl disease symptoms	LOW[308]	HIGH[309]	HIGH[310]	LOW[311]	**VERY LOW**
***Cotton yellow vein virus* (*Unclassified*)**	Cotton yellow vein disease; Texas cotton vein-clearing	Cotton	Leaves symptomatic	LOW[312]	LOW[313]	LOW[314]	LOW[315]	**NEGLIGIBLE**
UNKNOWN								
Flavescence[316]	Flavescence	Cotton	Leaves, stems	UNKNOWN[317]	UNKNOWN	UNKNOWN[318]	UNKNOWN[319]	**UNKNOWN**
Unknown **suspected phytoplasma**	Small leaf	Cotton	Leaves, flowers, stems	UNKNOWN[320]	UNKNOWN	UNKNOWN[321]	UNKNOWN[322]	**UNKNOWN**

[307] Found in a mixed infection with Cotton leaf curl virus, causing cotton leaf curl disease in Pakistan (Manzoor et al., 2014). Is found in chickpea in India, Middle East, North Africa, and the Arabian Peninsula.
[308] Reported on cotton plants that were also infected with Cotton leaf curl disease in Pakistan (Manzoor et al., 2014).
[309] The vector, Orosius orientalis, is present in Australia (Horn et al 1993; Trębicki et al 2010).
[310] No information on insect vector as yet, most likely the vector is leafhopper (as for all Mastrevirus), there is potential it may also be transmitted by *Bemisia tabaci* (trans-encapsidation when present as a co-infection with a Begomovirus). The Endemic Common brown leaf hopper (*Orosius orientalis*) and two species of exotic Leaf hoppers (*O. albicinctus* and *Neolimnus aegyptiacus*) are reported as vectors of this virus in pulse crops (Plant Health Australia Ltd. 2014).
[311] Not previously detected so unlikely to cause significant damage.
[312] Occurs in the United States and Mexico (Kirkpatrick and Rothrock 2001).
[313] Not known to be seed-borne, vector exotic.
[314] Vectored by the exotic Leafhopper (*Scaphytopius albifrons*) (see: Table 19) (Kirkpatrick and Rothrock 2001). Not known to be seed borne.
[315] Causes stunting and vein clearing, therefore reduced yields (Kirkpatrick and Rothrock 2001).
[316] Likely to be caused by a phytoplasma (bacteria) but not confirmed.
[317] Only known from Central African Republic, Benin, Ivory Coast, Mozambique and Upper Volta (Kirkpatrick and Rothrock 2001). May be phytoplasma but causal agent is unknown.
[318] *Margarodes* spp. may spread the disease but have not been confirmed as a vector (Kirkpatrick and Rothrock 2001). There are endemic *Margarodes* spp. but these have not been confirmed as vectors.
[319] Disease affects the leaves, stems and causes plant to become bushy (Kirkpatrick and Rothrock 2001).
[320] Reported from India and Pakistan.
[321] Graft transmittable, not spread with soil or seed (Kirkpatrick and Rothrock 2001).
[322] Plants become stunted, leaves have fewer lobes and small. Flowers also stunted. American (G. hirsutum) and Egyptian (G. barbadense) cotton are not greatly affected but Asian cotton (*G. herbaceum)* varieties are susceptible) (Kirkpatrick and Rothrock 2001).

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APPENDIX 3: PIGEON PEA THREATS SUMMARY TABLES

Pigeon pea threats summary tables

Although pigeon pea is a leviable grain crop and is covered in the Grain Industry Biosecurity Plan (developed by PHA for the grains industry (endorsed 2015)), pigeon peas have a significant role in the cotton industry as refuge crops (a requirement of growing Bt cotton).

There is in some cases overlap between exotic pigeon pea and exotic cotton pests, for example Bud and boll shedder bug (*Creontiades pallidus*) and American cotton bollworm (*Helicoverpa zea*) affect both cotton and pigeon peas. This highlights the importance of pigeon peas as a potential habitat for exotic pests and the need to consider the inspection of pigeon pea refuge crops during cotton pest surveillance activities.

As pigeon peas are an important part of cotton agronomy, the TSTs developed for pigeon peas for the Grains IBP (PHA 2005 – version 3, 2015) have been included as an additional appendix to the cotton IBP, see Table 21 and Table 22.

Invertebrates

Table 21 *Pigeon pea invertebrate threat summary table*

Scientific name	Common name	Primary host(s)	Secondary host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
ACARI (Mites e.g. spider and gall mites)									
Tetranychus yusti	Spider mite	Wide host range including: common bean, wheat, millet, cowpea, maize, peanut, barley, soybean, sunflower, pigeon pea, cotton, *Musa* spp., *Xanthosoma sagittifolium*	-	Foliage	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
COLEOPTERA (Beetles, weevils, etc.)									
Acanthoscelides zeteki	-	Pigeon pea	-	Seeds and pods[323]	LOW[324]	MEDIUM[325]	MEDIUM[326]	MEDIUM[327]	LOW
Apion clavipes	Apionidae weevil	Pigeon pea	-	Pods	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Hypothenemus hampei	Coffee berry borer	Coffee, maize, pigeon pea,	Cotton, pea, lima bean, peanut, *Acacia* spp.	Seeds and seed pods	MEDIUM[328]	MEDIUM[329]	MEDIUM[330]	LOW[331]	VERY LOW

[323] Can reproduce in stored grain and in field.
[324] Occurs in Trinidad and Tobago, limited trade between these areas and Australia.
[325] Distribution suggests more adapted to tropics.
[326] Does not breed in stored grain but can be moved in grain.
[327] Some market access issues regarding this pest.
[328] Widespread, occurs in most coffee producing countries including Indonesia. Spread with infected coffee seeds.
[329] Reproduces on primary hosts, several readily available in Australia. Occurs in tropical and sub-tropical climates. Northern grain belt likely to be more suitable than southern areas.
[330] Adults capable of flight. Also spread with seed.
[331] Mostly a pest of coffee (Damon 2000).

Scientific name	Common name	Primary host(s)	Secondary host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Mylabris pustulata	Arhap blister beetle	Peanut, pigeon pea, soybean	-	Foliage	LOW	MEDIUM	MEDIUM	LOW	VERY LOW
***Phyllophaga* spp**. (exotic species including: *Phyllophaga anxia, P. crinita, P. ephilida, P. fusca, P. implicita, P. menetriesii, P. vicina*)	White grubs; May beetles	Wide range of plants including: peanuts, oats, canola, pigeon pea, soybean, sunflower, barley, sugarcane, sorghum, wheat, black gram, mung bean, maize, millet	-	Below ground, seedlings	LOW	HIGH	MEDIUM	LOW	VERY LOW
HEMIPTERA (Stink bugs, aphids, mealybugs, scale, whiteflies and hoppers)									
Agallia albidula	Agalliin leaf hopper	Pigeon pea, sunflower, carrots, linseed and other plants	-	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Anoplocnemis phasiana	Coreid bug	Peanut, pigeon pea, cowpea, mung bean	-	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Corythuca gossypii	Cotton lacebug	Wide host range including: okra, cotton, peanut, pigeon pea, cassava	-	Foliage	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Creontiades pallidus	Bud and boll shedder bug	Various including: cotton, sorghum, maize, pigeon pea	-	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW
Edessa meditabunda	Green and brown stink bug	Okra, pigeon pea, citrus, soybean, cotton, common bean, sunflower, field pea, lucerne, safflower	-	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW

Scientific name	Common name	Primary host(s)	Secondary host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Hortensia similis	Common green sugarcane leaf hopper	Pigeon pea, rice, common bean, sugarcane, maize	-	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Piezodorus guildinii	Stink bug	Soybean, lentil, lucerne, common bean, field pea, pigeon pea	-	Foliage	LOW	MEDIUM	MEDIUM	MEDIUM-LOW	LOW-VERY LOW
Riptortus dentipes	Pod sucking bug	Fabaceae including: cowpea, mung bean, black gram, common bean, soybean, pigeon pea (cowpea is the most preferred host)	Sorghum, Macadamia	Flowers and pods	MEDIUM	HIGH	HIGH[332]	MEDIUM	MEDIUM
ISOPTERA (Termites)									
Microtermes obesi	Termite	Various including: peanut, sugarcane, maize, wheat, pigeon pea	-	Whole plant - termite feeds on roots and stems	LOW	MEDIUM	MEDIUM	LOW	VERY LOW
LEPIDOPTERA (Butterflies and moths)									
Agrotis repleta	Cutworm	Wide host range including: peanut, soybean, common bean, pigeon pea	-	Seedlings	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Amsacta moorei	Tiger moth	Peanut, pigeon pea, soybean, pearl millet, black gram, mungbean, cowpea	Safflower, maize, sorghum	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Anticarsia gemmatalis	Soybean or Velvet bean caterpillar	Legumes including: peanut, pigeon pea, soybean, common bean, cowpea	-	Foliage	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW

[332] Adults are strong flyers (Singh and Allen 1979).

Scientific name	Common name	Primary host(s)	Secondary host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Elasmopalpus lignosellus	Lesser corn stalk borer	Wide host range including: wheat, oat, rye, peanut, pigeon pea, soybean, common bean, cotton, rice, sugarcane, cowpea, wheat, maize, sorghum	-	Larvae feed in stems and roots causing wilting, stunting and sometimes plant death	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Exelastis atomosa	Pigeon pea leaf webber; Plume moth	Pigeon pea, chickpea, hyacinth bean	-	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Helicoverpa zea	Corn earworm; American cotton bollworm	Pigeon pea, capsicum, cotton, soybean, sunflower, common bean, tomato, sorghum, maize	Peanut, chickpea, millet, cowpea	Flowers and pods	LOW	HIGH	HIGH	MEDIUM	LOW
Heliothis virescens (syn. *Helicoverpa viriscens*)	Tomato budworm	Wide host range including: chickpea, maize, sunflower, flax, common beans, pigeon pea, cotton, tobacco, tomato, sweet potato	Peanuts, soybean, field pea, sorghum, common vetch	Above ground plant parts	LOW	HIGH	HIGH	MEDIUM	LOW
Homona nubiferana	Tortricid	Peanut, pigeon pea, Citrus, Crotalaria, tephrosia, cocoa	-	Foliage	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Mocis undata	Noctuid	Pigeon pea, peanut, soybean, Hoang pea, velvet beans	-	Foliage	LOW	MEDIUM	MEDIUM	LOW	VERY LOW
Orgyia turbata	Tussock moth	Peanut, pigeon pea	Sorghum, maize	Foliage	LOW	MEDIUM	MEDIUM	LOW	VERY LOW

Scientific name	Common name	Primary host(s)	Secondary host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
ORTHOPTERA (Locusts and grasshoppers)									
Chrotogonus trachypterus	Surface grasshopper	Wide host range including: sunflower, wheat, barley, maize, rice, pigeon pea and other plants	-	Above ground plant parts	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
Schistocerca gregaria	Desert locust	Wide host range including: maize, pigeon pea, barley, sesame, sorghum, wheat, pearl millet	-	Above ground plant parts	LOW	MEDIUM	MEDIUM	LOW	VERY LOW
THYSANOPTERA (Thrips)									
Megalurothrips sjostedti	Legume flower thrips	Common bean, cowpea, pigeon pea,	-	Pods and flowers	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW

Pathogens and nematodes

Table 22 *Pigeon pea pathogen and nematode threat summary table*

Scientific name	Common name	Primary host(s)	Secondary host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
FUNGI									
Fusarium oxysporum* f. sp. *ciceris	Chickpea wilt; Fusarium wilt	Chickpea	Lentil, field pea, pigeon pea	Whole plant, roots and stems affected. Plant wilts	MEDIUM[333]	HIGH	HIGH	HIGH	HIGH
NEMATODE									
Heterodera cajani	Pigeon pea cyst nematode	Cowpea, pigeon pea, mung bean, sesame	-	Root system	MEDIUM[334]	MEDIUM	MEDIUM[335]	MEDIUM	LOW
Heterodera glycines	Soybean cyst nematode	Soybean	Lupin, field pea, adzuki bean, common bean, mung bean, cowpea, common vetch, hairy vetch, pigeon pea	Root system	MEDIUM[334]	MEDIUM	MEDIUM[335]	LOW[336]	VERY LOW
Hoplolaimus indicus	Lance nematode	Rice	Maize, peanut, field pea, sorghum, wheat, pigeon pea, finger millet, cotton, mungbean, black gram, sugarcane	Root system	MEDIUM[337]	HIGH[338]	MEDIUM[339]	NEGLIGIBLE	NEGLIGIBLE

[333] Seed-borne ("hitch-hiker").
[334] Could enter in soil contaminating seed or equipment.
[335] Easily spread in soil as contaminant in equipment and seed.
[336] Soybean is this pest's main host. Pigeon pea not usually affected.
[337] Could enter in soil contaminating seed or equipment.

Scientific name	Common name	Primary host(s)	Secondary host(s)	Affected plant part	Entry potential	Establishment potential	Spread potential	Economic impact	Overall risk
Pratylenchus delattrei	Lesion nematode	Maize, weeping lovegrass, Rhodes grass, oats, pearl millet and wheat (Van Biljon and Meyer 2000). Cotton, sugarcane, pigeon pea, peanut, common bean (Castillo and Vovlas 2007)	-	Root system	MEDIUM[340]	MEDIUM	MEDIUM[341]	MEDIUM	LOW
VIRUS AND VIROIDS[342]									
***Cowpea severe mosaic virus* (*Comovirus*)**	Cowpea severe mosaic virus	Field pea, cowpea, mungbean, pigeon pea, sunnhemp, soybean, common bean, *Vigna* spp. and *Phaseolus* spp.	-	Systemic infection, symptoms appear on foliage	LOW[343]	LOW	LOW[344]	LOW[345]	NEGLIGIBLE
***Mungbean yellow mosaic virus*, *Mungbean yellow mosaic India virus*, *Dolichos yellow mosaic virus* and *Horsegram yellow mosaic virus* (*Begomovirus*)**	Legume yellow mosaic viruses (syn. Legume infecting Begomoviruses)	Lima bean, mungbean, cowpea, black gram, pigeon pea, common bean, lablab, soybean	-	Systemic infection. Symptoms appear on foliage	LOW[346]	HIGH[347]	HIGH	HIGH	MEDIUM

[338] Highest chance of establishment would occur if introduced to a rice growing area.
[339] Easily spread in soil as contaminant in equipment and seed.
[340] Could enter in soil contaminating seed or equipment.
[341] Easily spread in soil as contaminant in equipment and seed.
[342]
[343] Not known to be seed-borne. Occurs in North, South and Central America, vectors exotic.
[344] Not known to be seed-borne, spread by exotic beetles (e.g. *Ceratoma* spp., *Diabrotica* spp. including: *D. undecimpunctata howardii*). Expect greater spread if virus entered with vector.
[345] Not economically important (Freeman 2011).
[346] Occurs in South America and India. Low entry potential due to isolation and limited trade in susceptible material between Australia and the infected countries.
[347] The Silverleaf whitefly (*Bemisia tabaci*) acts as a vector of this virus and is present in Australia.

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