

# **Nursery Environmental & Technical Research and Extension**

Dr Anthony Kachenko  
Nursery & Garden Industry Australia (NGIA)

Project Number: NY10005

## **NY10005**

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**Final Report**

**HAL Project: NY10005**

**Completion Date: 19 August 2011**

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| <p><b>Nursery Environmental &amp; Technical Research and<br/>Extension 10/11</b></p> |
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**Dr. Anthony Kachenko and Mr. Robert Prince**  
Nursery & Garden Industry Australia

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This Final Report has been written by the Project Leaders as part of the reporting requirements of Horticulture Australia Limited (HAL). This project has been funded by HAL using the Nursery industry levy and matched funds from the Australian Government.

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# MEDIA SUMMARY

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Project *NY10005 – Nursery Environmental & Technical Research and Extension* consists of several research and development sub projects that address key environmental issues which include climate change, biosecurity and quarantine, pest and disease management and natural resource management. Each sub project was developed using input from whole of industry through a consultation process which involved State/Territory Associations to ensure relevance of issues in relation to industry needs and expectations as well as alignment with the Nursery Industry 2010–2015 Strategic Plan.

This project was overseen by the independent direction of the Environment Committee which met twice during the project (12 November 2010 and 28 June 2011). This Committee also provided input on future research, development and extension (RD&E) opportunities and challenges with discussion covering growth of the urban forest, energy and climate change adaption by industry and future investment in biosecurity to safeguard the nursery and garden industry (NGI). These discussions were mindful of the boundaries and direction outlined within the Nursery Industry 2010–2015 Strategic Plan.

An integral aspect of this project was developing the skill and knowledge base of the Industry Development Officer (IDO) network. This network is a key conduit of the extension of research and development outputs arising from this project and serves the NGI by representation at a regional level on key national environmental and technical issues such as biosecurity and quarantine. This representation supports the Nursery & Garden Industry Australia National Environmental & Technical Policy Manager (NETPM) to ensure the NGI is adequately represented in areas that may impact on its long term sustainability.

Several outcomes relating to other sub projects within this project include:

- Development of four key pest contingency plans for high risk biosecurity pests of the NGI.
- Completion of three university student projects that addressed key environmental issues whilst educating tomorrow's future industry leaders.
- A review that investigated controlled atmosphere on plant growth as a possible phytosanitary measure for market access.
- Submission of seven minor use permit applications to the Australian Pesticide and Veterinary Medicines Authority for industry access of key pesticides.
- Development of an online Water Management Toolbox calculator - <http://watertoolbox.ngi.org.au>.
- A searchable database of all Final Reports arising from levy funded projects - [http://www.ngia.com.au/Section?Action=View&Section\\_id=473](http://www.ngia.com.au/Section?Action=View&Section_id=473).
- Updated 'Appendix 13 Nursery Industry Water Management Best Practice Guidelines' for incorporation into the Nursery Industry Accreditation Scheme Australia (NIASA) program.

# TECHNICAL SUMMARY

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Project *NY10005 – Nursery Environmental & Technical Research and Extension* aligns with the strategic direction of the Australian nursery and garden industry (NGI) Strategic Plan 2010-2015 by investing in research, development and extension projects (RD&E) that address key environmental issues impacting on the long term health and sustainability of the industry. This project aims to build on the successful achievements of earlier NGI Environmental and Technical RD&E projects (namely NY06014, NY07006, NY08002 and NY09016) to ensure the NGI maintains a proactive and coordinated approach in addressing environmental issues across whole of industry.

In order to achieve the above, this project consists of several technical sub projects that address key environmental issues that are disparate yet interconnected and thus warrant the inclusion under a single umbrella project. This approach provides industry with a coordinated response and the ability to address multiple environmental issues efficiently utilising available resources. Key environmental issues specifically addressed through research & development (R&D) sub projects within this umbrella project included; climate change, biosecurity and quarantine, pest and disease management and natural resource management. Each sub project was developed using input from whole of industry through a consultation process which involved State/Territory Associations to ensure relevance of issues in relation to industry needs and expectations as well as alignment with the Nursery Industry 2010–2015 Strategic Plan.

This project was overseen by the independent direction of the Environment Committee. The Committee met twice during the project (12 November 2010 and 28 June 2011). This Committee also provided input on future RD&E opportunities and challenges with discussion covering growth of the urban forest, energy and climate change adaption by industry and future investment in biosecurity to safeguard the NGI. These discussions were mindful of the boundaries and direction outlined within the Nursery Industry 2010–2015 Strategic Plan. Minutes and recommendations arising from these meetings were circulated to all stakeholders.

An integral aspect of this project was developing the skill and knowledge base of the Industry Development Officer (IDO) network. The IDO network is a key conduit of the extension of research and development outputs arising from this project. The IDO network also serves the NGI by representation at a regional level on key national environmental and technical issues such as biosecurity and quarantine. This representation supports the NGIA National Environmental & Technical Policy Manager (NETPM) to ensure the NGI is adequately represented in areas that may impact on its long term sustainability. An important example to note is NGI representation on multiple Consultative Committee meetings in relation to Myrtle Rust management once the Emergency Plant Pest Response Deed (EPPRD) had been enacted. The industry was also represented by the IDO network at the 2011 International Plant Propagators Society Conference held in Sydney 27–29 May.

Seven sub projects were investigated as part of this umbrella project. This report details the outcomes relating to these with the following having been achieved:

- Development of four key pest contingency plans for high risk biosecurity pests of the NGI to ensure the industry can appropriately manage these pests should there be an incursion. Contingency plans were developed for:
  - o Thrips transmitted viruses - Tospovirus (include Chrysanthemum stem necrosis tospovirus; Impatiens necrotic ringspot tospovirus; Tomato spotted wilt tospovirus).
  - o Aphid transmitted viruses - Potyviridae (include Plum pox potyvirus; Asparagus potyvirus).
  - o Pierce's disease (*Xyella fastidiosa*) with link to the Glassy winged sharp shooter contingency plan.

- o Tarnished plant bug (*Lygus lineolaris*).
- Completion of three university student projects that addressed key environmental issues whilst educating tomorrow's future industry leaders. Projects undertaken and successfully completed during this project included:
  - o **Beyond Plastic – Future Options for the Nursery Industry** – Griffith University, Queensland.
  - o **Domestic Outdoor Water Use – Pilot Program and Case Studies** – Griffith University, Queensland.
  - o **The Thermal Load Reduction of Buildings from Urban Tree Shade – PHASE 2** – University of Melbourne.
- A literature review that investigated controlled atmosphere on plant growth as a possible phytosanitary measure for market access.
- Submission of seven minor use permit (MUP) applications to the Australian Pesticide and Veterinary Medicines Authority (APVMA) for industry access of key pesticides.
- Development of an online Water Management Toolbox calculator that consolidates existing NGI water management calculators into an online resource for growers to access in order to better manage nursery water (<http://watertoolbox.ngi.org.au>).
- A searchable database on the NGIA website that provides growers with access to the final reports of all completed industry RD&E and marketing projects ([http://www.ngia.com.au/Section?Action=View&Section\\_id=473](http://www.ngia.com.au/Section?Action=View&Section_id=473)).
- Updated 'Appendix 13 Nursery Industry Water Management Best Practice Guidelines' for incorporation into the Nursery Industry Accreditation Scheme Australia (NIASA) program that incorporates R&D outcomes arising from NGI research post the prior update in 2005.

# INTRODUCTION

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NGIA, with the State and Territory Associations, represents all sectors of the industry including producers, wholesalers, retailers, allied traders and consultants. The total NGI supply chain is worth over 5.5 billion dollars and employs over 45,000 FTE in more than 25,000 small to medium sized businesses. The NGI is involved in the production of plants for amenity, forestry, revegetation/landcare, landscapers, fruit orchardists, cut flower and vegetable sectors. Over 26,000 plant types are grown on a daily basis which is moved across all Australian jurisdictions. The industry is geographically diverse with businesses located in urban, peri-urban and regional locations across Australia.

The NGI is a unique horticultural industry due to its size, scale, location, end user and supply chain characteristics. Consequently, it is subject to a significant array of environmental issues that requires input from RD&E activities to address. For example, the industry is at risk of a number of exotic plant pests that requires industry to be cognisant of, and more importantly, prepared for, should they reach Australian soils. Based on the Nursery and Garden Industry Biosecurity Plan, there is a clear stated outcome to provide NGI with Pest Contingency Plans of major plant pests that offer a significant potential risk to the industry. These contingency plans cover pest biology, host range and distribution, identification, controls and eradication methods and monitoring techniques to provide technical input into the emergency plant pest response, if an emergency plant pest is detected in Australia. The development of contingency plans builds on previous projects where contingency plans for key pests have been developed (e.g. NY08002 and NY09016). It should be noted that over the past decade, biosecurity has emerged as a high priority area for NGI and continues to command significant investment through development of resources, tools and time allocated through the IDO network and NGIA staff.

Another key issue impacting on the sustainability of the NGI is access to safe, reliable and efficacious pesticides to meet grower needs whilst being mindful of the environment. In order to facilitate access to these pesticides, investment in minor use permits (MUP) is required as there are few pesticides registered for the NGI due to unfavourable economic returns by pesticide manufacturers. These permits may also assist in meeting regulatory requirements relating to chemical treatment for plant consignments moving across State/Territory borders. The industry has invested in MUP for a number of years directly through HAL, however in 2009, it was decided that this program would be undertaken by NGIA.

When it comes to domestic and international market access, the NGI is faced with significant hurdles. In 2010 under NY10005, the NGI investigated the feasibility of low dose gamma irradiation for use as a quarantine treatment for living nursery plants with the desire to use this technology for interstate market access. The study indicated that the practical and economic costs associated with using such a method, once developed, were too high and the logistics of such an operation impractical. The study called for a thorough desktop review of other technologies, namely controlled atmosphere, as a possible phytosanitary measure for market access.

Managing water remains as a key priority investment area for the NGI. Although the drought has broken across large expanses of Australia, driving water efficiency within the production environment is paramount particularly as rainfall patterns are expected to change under a changing climate. Over the past decade, the NGI has invested in a multitude of studies, and through these, has developed a number of tools and resources to assist growers better manage water on-farm. There is a need to consolidate these studies together in an updated Industry Water Management Best Practice Guidelines, last updated in 2005. There is also the need for all tools and resources arising from these projects to be consolidated into a repository that can be utilised and accessed by whole of industry.

The IDO network provides the NGI with a vehicle to extend RD&E outcomes. The skills and knowledge base of the IDO network is also used to represent the industry at a regional level on key national environmental issues and supports the National Environmental & Technical Policy Manager (NETPM) to ensure the

industry is across the key environmental issues. The NGI also utilised Nursery Papers, Clippings, Facebook and the NGIA website to communicate RD&E outcomes to whole of industry.

The aforementioned environmental issues are listed in the National Rural Research and Development Priorities outlined by Department of Agriculture, Fisheries and Forestry (DAFF) and align with the four objectives of the Horticulture Australia Limited (HAL) Strategic Plan 2010–2015. They also align with the Nursery Industry 2010–2015 Strategic Plan to ensure the Australian nursery industry has the capacity to respond to growth opportunities and challenges that impact on its growth and sustainable development. It is therefore imperative that these challenges are suitably addressed to ensure the industry maintains on the front foot in demonstrating a real commitment to the industry’s long term sustainability in the interest of its members and the nation. To assist in addressing this, the Environment Committee provides independent direction and input into the industry RD&E programs including this project. This has occurred since 17 August 2006 which has enabled whole of industry to feed RD&E proposals for consideration to NGI for future investment, and also review progress of current RD&E projects.

# MATERIALS AND METHODS

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The approach taken by the Australian NGI whereby a suite of environmental and technical R&D sub projects are consolidated under one umbrella project was continued in this project. This integrated and holistic approach has been followed for the past five years due to the breadth of interconnected environmental issues requiring a centrally coordinated response.

This project consists of seven sub projects that are managed by the National Environmental & Technical Policy Manager (NETPM). Independent direction provided by the national Environment Committee has supported the NETPM in facilitating these sub projects and is also funded by this project. The aim of the Environment Committee was to provide leadership and independent direction in addressing sub projects within this project, evaluating current environmental and technical issues and monitoring the future R&D direction of the Australian Industry in relation to the NGI 2010 – 2015 Strategic Plan. The Environment Committee consisted of 4 industry representatives and NGIA representatives (Dr Anthony Kachenko and Robert Prince, NGIA CEO). The committee was chaired by NGIA Board Director Glenn Fenton.

At the time of the report, the Committee had the following members:

- Glenn Fenton (Chairman), Managing Director, Nationwide Trees, NGIA Board Member, NGIV President, Victoria
- John Bunker, Managing Director, Redlands Nursery Pty Ltd, Queensland
- Steve Burdette, Business Development & Nursery Manager, Agriexchange, Renmark, South Australia
- Sean O'Brien, Horticultural Manager, Hunter Valley Gardens, New South Wales

Two national Environment Committee meetings were facilitated during the life of this project (12 November 2010 and 28 June 2011). Sub projects within this project were submitted by the IDO network to this Committee prior to the November 2009 lodgement date for RD&E project to HAL. The Committee reviewed these submissions based on a process whereby each State/Territory Association ranked projects for relevance. This proved a valuable vehicle to ensure whole of industry input into the industry RD&E direction as well as a process to assess projects on merit prior to lodgement and evaluation by the Industry Advisory Committee.

A total of \$11,000 was allocated to facilitate these meetings.

The skills and knowledge base of the IDO network in representing the industry at a regional level on key national environmental issues was a significant component of this project. This provided industry with an opportunity to enhance the industries representation with key environmental issues while increasing the opportunity for skill development within this resource. When an IDO represented industry at an event (e.g. meetings, conferences, workshops etc.), a meeting report was submitted to the NETPM summarising the nature of the event, outputs arising from the event and future direction. All reports were then circulated to the NETPM for wider distribution to all State and Territory Associations to ensure communications reached all stakeholders. A total of \$42,000 was allocated to this project cover conference/meeting attendance costs including travel and accommodation for the IDO network.

An additional \$30,000 was allocated to Nursery & Garden Industry Queensland (NGIQ) to fund human resource support for the QLD Industry Development Manager (IDM). This funding recognises the added responsibility the Queensland IDM has in relation to maintaining the NGIs biosecurity commitments which includes attendance to all meetings associated with the EPPRD. This was heightened during the project due to the incursion response management relating to Myrtle Rust.

The remaining sub projects are discussed below:

### **1. Development of Key Pest Contingency Plans**

Plant Health Australia (PHA) were engaged in this sub project as they had developed contingency plan templates to ensure information provided was consistent and met a minimum set of requirements. In order to determine pests to investigate as part of this sub-project, the Nursery Industry Biosecurity Plan was consulted. This plan lists priority pest species and their level of risk to industry. High priority pests were targeted owing to their impact on the Australian NGI as well as the wider Australian environment. This sub project used the PHA templates to develop four Contingency Plans specific to the NGI for the following pests:

- o Thrips transmitted viruses - Tospovirus (include Chrysanthemum stem necrosis tospovirus; Impatiens necrotic ringspot tospovirus; Tomato spotted wilt tospovirus).
- o Aphid transmitted viruses - Potyviridae (include Plum pox potyvirus; Asparagus potyvirus).
- o Pierce's disease (*Xyella fastidiosa*) with link to the Glassy winged sharp shooter contingency plan.
- o Tarnished plant bug (*Lygus lineolaris*).

This sub project was undertaken by a consultant within Plant Health Australia and valued at \$45,000.

### **2. Industry Research Linkage – Support for Honours Research Projects**

This sub project provided funding for several research projects in Australian Universities to enhance research linkages between industry and academia, enhance industry capacity for innovation and make a positive contribution towards the education of tomorrow's industry professionals. Projects were developed in consultation with whole of industry and the relevant academic institution had to show progress of innovation relevant to industry needs in alignment with the NGI 2010 – 2015 Strategic Plan. This approach continued the direction of the NGI over the past two years where funds allocated to this project were used to exclusively support the costs associated with research overheads to enable successful fulfilment of the research objectives. This sub project was undertaken by three Universities across Australia and valued at \$50,000.

The following research projects were undertaken and successfully completed during this project:

1. **Beyond Plastic – Future Options for the Nursery Industry** – Griffith University, Queensland. Masters research project undertaken by student Andrew McNamara and supervised by David Hunt, Department of Employment, Economic Development and Innovation (DEEDI).
2. **Domestic Outdoor Water Use – Pilot Program and Case Studies** – Griffith University, Queensland. Masters research project undertaken by student Morgan Walker and supervised by Dr Rachel Poulter, DEEDI.
3. **The Thermal Load Reduction of Buildings from Urban Tree Shade – PHASE 2** – University of Melbourne. Masters research projects supervised by Dr Steven Livesley, Dr Dominique Hes, Dr Lu Aye and Dr Nicholas Williams.



### **3. Evaluate controlled atmosphere on plant growth as a possible phytosanitary measure for market access**

This sub project reviewed literature surrounding how modified and controlled atmosphere treatments could be successfully implemented as quarantine treatments for the Australian NGI. Published scientific literature and reliable web-based literature (government and academic sites) was summarised focusing on information most relevant to the nursery industry, including beneficial aspects of each treatment and areas of risk. Experts in the post-harvest research were contacted for their thoughts on the advantages and disadvantages of each treatment and their opinion of the feasibility of use on living plants. The researcher in charge of this work was Senior Entomologist Dr Andrew Manners, DEEDI. A total of \$50,000 was allocated to this project as it was envisaged that it would also fund a replicated experiment. This direction was not supported by IAC, who recommended a literature review/case study be undertaken first before investing further in an experiment.

### **4. Provide access to seven Minor Use Permits (MUP) for industry**

This sub project invests in the development of seven MUP following consultation with growers for priority products to submit under the MUP program for nursery stock. This sub project has been in operation for three years to enable the registration of MUP required by the NGI with APVMA. A total of \$15,000 was allocated to this project to facilitate this process. The following products were submitted to APVMA as part of this sub project by Peter Del Santo, AgAware consulting.

| Product (active)                     | Target Pest                                                                                                                                                                                                         |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Admiral (pyriproxyfen)               | Whiteflies, fungus gnats, shore flies                                                                                                                                                                               |
| Movento (spirotetramat)              | Aphids, thrips, whitefly, scale                                                                                                                                                                                     |
| Regent (fipronil)                    | Aphids, Thrips, Mites, Locusts, Grasshoppers, Wireworms, Leaf minors, Lace bugs, Weevils, Diamondback moth, Cabbage white butterfly, Cabbage cluster caterpillar, Fungus gnats/shore flies, Sugarcane weevil borer. |
| Dominex 100 EC (alpha-cypermethrin)  | Aphids, Caterpillars, Mites, Rutherglen bug, Thrips, Cutworms, Locusts, Grasshoppers.                                                                                                                               |
| Pristine (boscalid + pyraclostrobin) | Anthrachnose, Botrytis, Leaf spot, Powdery mildew                                                                                                                                                                   |
| Nimrod (bupirimate)                  | Powdery mildew                                                                                                                                                                                                      |
| Switch (cyprodinil + fludioxonil)    | Rhizoctonia, Sclerotinia, Botrytis, Colletotrichum, Aspergillus                                                                                                                                                     |

## **5. Develop of water management calculators for managing water in production nurseries**

This sub project aimed to develop an online resource/tool that comprised simple calculators for growers to manage nursery water. Calculators included within this resource were based off the popular Industry book 'Managing Water in Plant Nurseries'. Formulae contained in this book were converted into simple calculators guiding growers with their on-farm decision making processes. Existing Excel calculators that were associated with the popular Waterwork workshop training program and those that have been developed in previous R&D projects were also be incorporated within this project. This project was undertaken by National Centre for Engineering in Agriculture (NCEA) Queensland and valued at \$15,000.

## **6. Update Nursery Industry Water Management Guidelines**

The Nursery Industry Water Management Guidelines were last updated in 2005. Since then, Industry has delivered on several projects relating to water management that need to be incorporated into a future update of these guidelines. It should be noted that these guidelines are highly regarded by industry, external stakeholders and internationally and are a key component of the Nursery Industry Accreditation Scheme Australia (NIASA) BMP guidelines. This project aimed to update these guidelines incorporating these changes and circulate an updated hardcopy to all current NIASA guideline holders.

The existing Water BMP was reviewed by consultant Chris Rolfe and Bill Yiasoumi from NSW Department of Primary Industries (formally Industry & Investment NSW). The updates were printed through Stonecrop Print Management Services. This sub project was valued at \$20,000.

## **7. Develop a database and summary 'fact sheets' of existing research and development projects**

The aim of this project was to provide stakeholders with readily accessible data to enhance the transfer of research and technical project outcomes. This project extracted all relevant information from completed levy funded projects and developed a searchable database on the NGIA national website. Technical support through the appointment of a casual administration staff member consolidated this information and developed the database. It was envisaged that the extracted information would also be developed into relevant fact sheets, including, but not limited to supply chain logistics, however there was insufficient funds in the project budget to facilitate this. This sub project was valued at \$11,000.

A further sub project was initially approved as part of the umbrella project titled '*Evaluating energy efficiencies in nursery production*'. The project aimed to investigate the various systems used in a nursery production environment in order to calculate the energy efficiency based on kilowatt cost per square meter and cost per unit produced per square meter plus the infrastructural cost of the system. It was envisaged that this project would develop a simple financial management calculator to evaluate the cost/benefit of new and existing technologies in production nurseries. In scoping this project, it was discovered that NCEA had previously developed a similar tool that could be adopted by the NGI. The tool referred to as EnergyCalc was a simple to use online calculator that was designed to assess direct on-farm energy use, costs and the greenhouse gas emissions (GHGs) associated with diesel, petrol, LPG and electricity consumption. It could also examine energy use across key processes within a production system and could be used to evaluate farming practices such as heating, spraying, irrigation etc. This calculator has been specifically designed for property and process level energy end-use calculations. A link to EnergyCalc is provided on the NGIA website [http://www.ngia.com.au/Category?Action=View&Category\\_id=573](http://www.ngia.com.au/Category?Action=View&Category_id=573) Owing to this, this project did not go ahead. This sub project was valued at \$15,000.

# RESULTS AND DISCUSSION

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The Environment Committee met formerly on two occasions (2/11/11 and 28/06/11). Meeting minutes arising from these meetings were circulated to whole of industry to enable awareness of key issues discussed. The minutes from these meetings are provided in Appendix 1. The committee oversaw all activities undertaken in the environmental and technical areas managed by the NETPM, Dr Anthony Kachenko. This included strategic direction to the R&D program based on the Industry Development Needs Assessment and the Nursery Industry 2010-2015 Strategic Plan. The Committee also took a leadership role in addressing supply chain and the implementation of the NGI biosecurity levy. P Melville, IPM, Natural Resources & Climate Portfolio Manager at HAL attended the November meeting in order to brief the Committee on HAL activities, RD&E programs and issues/opportunities in relation to his area within HAL. Other outputs arising from the committee were:

- Review and development of the NGI Environmental Risk Matrix that was used at each meeting to assist in prioritising future RD&E activities. The Environment Risk Matrix is provided in Appendix 2. Key priorities identified in this matrix were water, biosecurity and the impact of climate change.
- Recommended lodgement and input into a successful grant proposal awarded by RIRDC (Rural Industries Research and Development Corporation) under the National Weeds and Productivity Research Program to undertake a research project titled '*Weed Risk Assessment for Australian Nursery & Garden Industries*'. This external project was valued at \$212,059 and will cease in May 2012.

The IDO network continued to prove valuable in representing the industry at a regional level on key national environmental issues. Weekly contact with IDOs via phone links was facilitated and regular information updates via email occurred during the project by the NETPM to cover all key issues within the environmental and technical area. Where an IDO attended an event, a meeting report was circulated to whole of industry through the NETPM to enable awareness of key issues discussed. Through representation of NGI at major meetings with government agencies, regulators and other external stakeholders, the general awareness of industry has raised. An example of a meeting report can be found in Appendix 3.

The IDO network was also involved in identifying and assessing areas of possible R&D for NGI to present to IAC. All projects received by IDOs were discussed and ranked by the entire network prior to submission for funding in 2010/11. The ranking template is provided in Appendix 4. During this process, the NETPM provided guidance with each project received through an independent evaluation and summary provided to the IDO network in relation to each project.

The QLD Nursery IDM, John McDonald was provided with human resource support through this project due to the added responsibility he had in relation to maintaining industry's biosecurity commitments which includes attendance to all meetings associated with the EPPRD. This ensured the industry obligations as signatory to the EPPRD and PHA were addressed. Through this investment, a Myrtle Rust Management Plan to assist the Australian NGI manage Myrtle Rust on ALL plants from the Myrtaceae family was developed. This plan is provided in Appendix 5 and is available for download from [www.ngia.com.au](http://www.ngia.com.au).

## **1. Development of Key Pest Contingency Plans**

Four Pest Contingency Plans of key threatening pest species identified by industry and government as 'high risk' to the NGI were developed as part of this sub project. Each pest was developed in consultation between the Australian NGI with input from State/Territory Associations and staff at PHA in association with the Nursery Industry Biosecurity Plan. The following plans were developed:

- o Thrips transmitted viruses - Tospovirus (include Chrysanthemum stem necrosis tospovirus; Impatiens necrotic ringspot tospovirus; Tomato spotted wilt tospovirus).
- o Aphid transmitted viruses - Potyviridae (include Plum pox potyvirus; Asparagus potyvirus).
- o Pierce's disease (*Xyella fastidiosa*) with link to the Glassy winged sharp shooter contingency plan.
- o Tarnished plant bug (*Lygus lineolaris*).

Each of these plans is provided in Appendix 6 and will be incorporated into the Nursery and Garden Industry Biosecurity Plan during its next update scheduled in 2012.

## **2. Industry Research Linkage – Support for Honours Research Projects**

Three research projects were undertaken across Australian universities and research institutions during this project. Each project was developed in consultation with the NGI and the relevant academic institution and coordinated through the NETPM. Each project had to show progress of innovation relevant to industry needs in alignment with the NGI 2010 – 2015 Strategic Plan. The following projects were successfully commissioned and completed:

1. **Beyond Plastic – Future Options for the Nursery Industry** – This project was developed to perform a situation analysis of pot use and recycling in each State/Territory of Australia. This was completed in consultation with the NETPM. The project identified possible pot recycling model schemes and examined current and emerging commercially available pot options for the Australia nursery industry. These options were examined against an ideal pot criteria i.e. plastic benchmark, to provide performance and cost comparisons. The project's aim was to identify future pot options for the Australian NGI. The report found that there are a number of different recycling initiatives occurring around the world and in Australia. It also discussed numerous bio-containers which have the possibility of replacing and reducing the use of the common plastic containers. It suggested that recycling of plastic pots through organised collection and reprocessing at recycling plants appears to be one of the most economically and environmentally viable options for the nursery industry. It suggested growers should consider biodegradable pot choices wisely due to their physical/chemical traits factoring in cost, strength, water usage and decomposition rate.
2. **Domestic Outdoor Water Use – Pilot Program and Case Studies** – This project had two main components: the collection of actual water use data from participating households through a field study in Queensland and a review of literature, involving both quantitative and qualitative data, respectively. The field study element involved the identification of five trial sites, installation of ten outdoor water meters (two at each site), periodic data collection (including surveys and climate data) and analysis. The literature review concentrated on national and international water use studies, which not only measured residential household water use but partitioned it into both indoor and outdoor consumption. The field study resulted in an average outdoor water use percentage of 2.39% of the total household water use, supporting the review of national and international water use studies which highlighted the difference in water use statistics cited in government documents and actual outdoor water use. The report suggested a more detailed analysis is warranted to evaluate domestic water consumption in greater detail.
3. **The Thermal Load Reduction of Buildings from Urban Tree Shade – PHASE 2** – Two projects were conducted as part of this project that consisted of a field experiment conducted at Burnley Campus, The University of Melbourne using three test buildings were installed with heat flux sensors, infrared sensors, heat pumps and watts-up meters. One building was shaded by evergreen and another by deciduous trees. The third was left as a control. The first project evaluated thermal performance and energy consumption data from all buildings collected continuously with a data

logger. It was found from the measured data that heat losses in buildings with shading from trees were greater than the baseline building. This may be attributed from the cooling effect of the trees and differences in the condition of the buildings. In effort to verify the field measurement data, computer simulation using Transit System Simulation (TRNSYS) software was conducted. Models were built in accordance with field experiment input data. Results were compared with the field measurement data to evaluate the models developed. Field measured data indicated no significant differences in energy consumption for three buildings. This may be due to the slow growth rate of trees. The models seemed to underestimate the actual energy usage. However, computer simulation indicated that substantial potential cooling energy savings can be achieved by trees.

A subsidiary project to quantify the particular water use of the trees in the project to gain a better understanding of the water requirements and economic cost of irrigating urban trees in Melbourne was also conducted. This was imperative given Australia's history of prolonged droughts and the effects of lower annual rainfall predicted under climate change modeling coupled with the notion that many urban trees are situated in areas of high imperviousness. The data yielded from this project was insufficient to yield a clear conclusion regarding water use in urban trees and suggested a larger study was required.

The data from both projects will feed into ongoing projects being funded through future student based projects.

The Abstract from each of these reports is provided in Appendix 7. The full reports will be written up as technical Nursery Papers over the next 12 months for extension to industry. Aspects of these reports have been posted on the NGI Facebook page and written up as Clippings articles.

### **3. Evaluate controlled atmosphere on plant growth as a possible phytosanitary measure for market access**

This sub-project examined twelve disinfestation treatments that could be used as alternatives to standard pesticides to facilitate interstate movement of nursery stock. Half of the treatments were found to be unsuitable, the other half identified as suitable pending further research. Vacuum + heat and controlled atmosphere + heat treatments were ranked as having the highest potential as an alternative treatment to standard pesticides. Both of these options are extremely host/pest specific. It is possible that a fumigant, e.g. phosphine or ethyl formate, could be developed into a relatively broad-spectrum treatment.

The review noted that development of new chemical pesticides would be cheaper and simpler to implement than the fumigants described within the review that require sealed facilities. As such, it seems unlikely that these treatments would be worth developing into a treatment for interstate trade of nursery plants while standard chemical pesticide options remain viable.

Owing to the outcomes denoted within this review, it is unlikely that further research will be directed in this area in the short term. A copy of this report can be found in Appendix 8.

### **4. Provide access to seven Minor Use Permits (MUP) for industry**

The paperwork associated with the seven MUP was lodged with APVMA. At the time of this report, the following three products have had permits issued:

- o PER 12445 - Regent and Dominex
- o PER 12658 - Admiral
- o PER12029 - Avatar

An additional 'emergency' permit PER12156 was also issued as part of this sub project. This permit approved various pesticides for the treatment of Myrtle Rust on nursery stock. These permits have been circulated through the IDO network for extension to industry. The NETPM will receive notification from Peter Del Santo upon the issuing of the remaining permits. The aforementioned permits are provided in Appendix 9.

### **5. Develop of water management calculators for managing water in production nurseries**

A key requirement of this project was the development of an online resource that housed the water management calculators. This resource is referred to as the nursery industry Water Management Toolbox and can be found at <http://watertoolbox.ngi.org.au>. This resource comprises of simple calculators for growers to manage nursery irrigation and drainage water to support sustainable and responsible use of water resources as well as support the industry accreditation, certification and training programs. The calculators were derived from:

- o The popular industry book titled 'Managing Water in Plant Nurseries'
- o The industry training program Waterwork
- o Existing industry programs and Nursery and Garden Industry Queensland

All calculators within the Water Management Toolbox are in Excel format and can be saved individually on the user's computer. Alternatively, the entire Water Management Toolbox can be downloaded as a zip file and accessed offline.

This resource will be available under the RD&E section of the NGIA website from September 2011.

### **6. Update Nursery Industry Water Management Guidelines**

The Nursery Industry Water Management Guidelines were updated and included the following new areas:

- o a new chapter that details irrigation management tools;
- o updated references from levy funded research and development projects;
- o additional information on irrigation systems, irrigation system design and planning; and
- o additional information on water testing and monitoring water quality.

A copy of the updated guidelines is provided in Appendix 10. These guidelines have been printed and circulated to some 500 businesses engaged with the NIASA program.

### **7. Develop a database and summary 'fact sheets' of existing research and development projects**

This project yielded a database with 283 HAL final reports that can now be accessed in full and freely downloaded from [http://ngia.com.au/Section?Action=View&Section\\_id=473](http://ngia.com.au/Section?Action=View&Section_id=473)

Users can simply enter a key word (e.g. water), report title or project number into the search engine in order to find a report.

The database has been communicated to industry via Clippings and State/Territory Associations. This database will prove valuable in providing open access to stakeholders of important levy funded outcomes. The NETPM will update the database once projects are completed and forwarded to NGIA from HAL.

# TECHNOLOGY TRANSFER

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To ensure the direction of this project was in line with industry expectations, whole of industry was provided with an opportunity to provide input into the lodgement of the sub projects discussed above. For example, projects were ranked and evaluated by the IDO network representing each jurisdiction as well as the Environment Committee, with direct linkage to the National Board.

Extension of these projects is crucial in order to ensure maximum return from the investment. The NETPM will work closely with the IDO network to ensure that outcomes of all sub-projects are successfully communicated to whole of industry using a variety of communication channels. This will include Nursery Papers which will no longer be published through NGIA after August 2011. They will instead be included as an insert in Hort Journal increasing the circulation from a current figure of approximately 1,100 to approximately 7,000.

Once approved, this final report will also be available to download from the NGIA website using the database as described above. Ongoing updates to these projects will be communicated to whole of industry through NGIA communications including NGIA website and NGIA Facebook page (<http://www.facebook.com/nurseryandgardenindustry>). Clippings, which have an industry wide circulation of 3,000 (eleven editions per annum) will no longer continue after September 2011 and instead, the NGIA will be moving to a quarterly Levy Update magazine to ensure greater coverage of outcomes to whole of industry.

It is anticipated that the student projects discussed above will be presented as posters at the 2012 Nursery Industry National Conference, Gold Coast, Queensland. These projects have also proved useful in opening up further R&D opportunities with some projects continuing. The NETPM will be providing a presentation at the National Conference in 2012 and it will be expected that the IDO has an active involvement in this conference as well.

The Pest Contingency Plans will be incorporated into Nursery and Garden Industry Biosecurity Plan during its next update scheduled in 2012. In the interim, they have been circulated to regional Associations through the IDO network.

The Nursery Industry Water Management Guidelines have been circulated to 500 businesses and the Water Management Toolbox will be available under the RD&E section of the NGIA website from September 2011.

Other outcomes from the above sub projects, namely the research relating to alternate quarantine treatments will be incorporated where necessary through inclusion in the industry accreditation programs and discussed at the next National NIASA Accreditation Committee meeting in December 2012. An aspect of project NY11000 requires the updating of the industry on-farm biosecurity program BioSecure HACCP, where it is anticipated some of this information will be included.

**NOTE:** *It should be noted that the industry is undergoing a review of communications and it is possible that other vehicles of extension may/will be realised through this process.*

## RECOMMENDATIONS

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This project has delivered a number of critical outputs that address key issues identified following whole of industry consultation with industry to identify these issues. Although several of these projects have already been communicated to industry, it is critical that ALL projects are communicated using multiple mediums to ensure maximum industry awareness of the research. These must also be delivered in a language that can be readily understood by the end user. Mediums will include electronic emails alerts, websites and social media such as Facebook.

With this in mind, future projects should look at new and untapped streams for communicating outcomes with some attention directed to social media as a key communication stream. Outcomes from future research and development projects should be extended using this stream due to intense growth within this area. This may include 'how to' videos in a 'You Tube' format that can be readily posted on social media sites. This should also extract data from existing RD&E projects as an immediate action and priority future investment area.

One of the key issues impacting on the future of the NGI is the looming 'Carbon Tax', which if enacted, will impact on the production sector primarily in the area of increased on-farm inputs such as energy, water and fertilisers. Indeed, there will likely be other flow on effects arising from the 'Carbon Tax' that will impact on the viability of the nursery sector. Future R&D in this area is warranted and should focus on energy efficiencies in nursery production. Existing research outputs should be refined into a Best Management Practice/Guidelines for nursery production that could be integrated into the industry Environmental Management System, EcoHort.

The role of the Australian urban forest will also generate possible RD&E investment in the future. Although it is not recognised under the Kyoto protocol as a carbon sink, there is opportunity for recognition under the federally proposed carbon farming initiative. This could see local councils use their urban forests to offset carbon generated by polluters. The urban forest is an area identified in the Nursery Industry 2010–2015 Strategic Plan for future RD&E focus and aspects of urban forest RD&E should be looked at in future RD&E projects. This may include Best Management Practices for specifying trees in production nurseries and the planting of trees in landscapes, educational resources for production nurseries on the role of the urban forest and future investment in research to portray the multitude of benefits associated with the urban forest.

Linking industry RD&E with universities through the Industry Research Linkage – Support for Honours Research Projects has proved useful in generating interest for nursery industry research within academic institutions across Australia. For many years, this was an area industry had failed to access until this sub project commenced in 2009 under project NY09016. Indeed, when this sub project commenced some two years ago, there was two universities engaged in projects. This has now increased to three, with another three universities involved in projects under NY11000. Ongoing funding is warranted to continue this approach to ensure industry has an opportunity to have leading RD&E undertaken by future industry leaders.



# APPENDICES

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The following appendices relate to the outcomes of the project:

- 1** Minutes of NGIA Environmental Committee meetings held 12/11/10 and 28/06/11.
  - 2** Environmental Risk Matrix.
  - 3** Example of a Meeting Report
  - 4** IDO Ranking Template.
  - 5** NGI Myrtle Rust Management version 1.0.
  - 6** Industry Pest Contingency Plans.
  - 7** University Research Abstracts.
  - 8** Literature Review on controlled atmosphere on plant growth as a possible phytosanitary measure for market access.
  - 9** Minor Use Permits
  - 10** Nursery Industry Water Management Guidelines 2010 Update.
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# Appendix 1



Nursery & Garden Industry  
Australia

# MINUTES

## Environment Committee Meeting

**Date:** Friday 12 November 2010

**Time:** 9.30 am – 2.00 pm

**Location:** NGIA Office, 16-18 Cambridge Street, Epping 2121

**Attendees** Glenn Fenton (Chair), Steve Burdette, Sean O'Brien, Anthony Kachenko, Peter Melville (HAL)

**Apologies** Robert Prince, John Bunker

| ITEM | TOPIC                                                 | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | <b>WELCOME AND APOLOGIES</b>                          | <p>G Fenton formally declared the Environment Committee Meeting open at 9:25 am and extended a warm welcome to Committee Members. G Fenton indicated that he was pleased to be Chair of this Committee and introduced himself as the Managing Director of Nationwide Trees, NGIV President and indicated that he had a long history of working on driving R&amp;D programs. G Fenton indicated that J Bunker was an apology and had provided comments via email to A Kachenko to table throughout the meeting where required. G Fenton noted that an apology for absence had been received from R Prince due to prior commitments.</p> <p>A Kachenko noted that an apology for absence had been received from R Prince.</p>                                                                                                                                                                                                                                                                                     |
| 2    | <b>CONFIRMATION OF MINUTES – MEETING 21 JULY 2010</b> | <p>G Fenton advised that the Minutes from the Meeting held on 21 July 2010 were provided in the Meeting papers and Committee Members were asked to raise any concerns regarding the accuracy of these minutes. Amendments were received from S Burdette. Discussion followed regarding the IP arrangements of the Plant/Life Balance campaign. A Kachenko provided a brief update on where things sat and indicated that the campaign was on track for the 2 March 2011 launch. A Kachenko said that he would follow up with J Gibbs regarding the IP to ensure NGI had the appropriate IP in place. G Fenton indicated that the National Marketing Committee were handing all aspects of this campaign to ensure a smooth delivery of the launch and subsequent campaigns in 2011.</p> <p><b>MOTION: The Environment Committee accept the minutes from the 21 July 2010 Environment Committee meeting as a true and accurate record.</b></p> <p><b>Moved:</b> S Burdette</p> <p><b>Seconded:</b> S O'Brien</p> |

| ITEM | TOPIC | DETAILS |
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***ACTION: A Kachenko to follow up IP arrangements with J Gibbs regarding the Plant/Life Balance marketing campaign.***

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### 3 MATTERS ARISING FROM LAST MEETING

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#### 3.1 Review of Action List

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A Kachenko tabled an Action List arising from the last Meeting. He provided an update on the completed items. The following actions are outstanding:

**A Kachenko to provide the Committee with an update on the progress in relation to the harmonisation of Ag Vet Chemicals.** A Kachenko provided an update on this item and said that Product Safety Integrity Commission (PSIC) endorsed a proposal for a single, national framework at a meeting on 24 February 2010. This proposal was endorsed by Primary Industries Ministerial Council (PIMC) on 23 April 2010 and was agreed by Council of Australian Governments (COAG) out-of-session on 16 August 2010. He noted that his preliminary reading of the 22 page proposal did not appear to have any deleterious impact on the Australian NGL. He noted that the national framework would still have a provision for minor use in certain circumstances or with specific approvals, depending on the risks to be managed. The document indicated that industry expertise may make a direct input into the risk management decision making, leading to an improved capacity to manage the risks (i.e. industry stewardship programs, quality assurance programs etc.). He indicated that he would provide a summary of the changes for circulation to all state Associations.

***ACTION: A Kachenko to provide a snapshot update to state associations on the national policy framework for the assessment, registration and control of use of agricultural and veterinary chemicals.***

**A Kachenko to draft NGIA policy position on Climate Change for discussion at the next Environment Committee Meeting.** A Kachenko noted that a draft was recently endorsed at the combined Presidents, CEO's and Board meeting in Melbourne and would be sent for layout with anticipated launch in 2011.

**A Kachenko to approach J McDonald to conjointly draft NGIA Biosecurity policy position for discussion at the next Environment Committee Meeting.** A Kachenko noted that the recent incursions had continued to delay this action item and that a draft should be ready for discussion at the next Environment Committee meeting.

A Kachenko also provided an update on a proposal developed by J McDonald for submission at the next Across Industry Committee at HAL that would look at implementing an Australian Interstate Plant Movement Portal that would be hosted by Plant Health Australia. The portal would store all interstate plant movement protocols categorised by State/Territory and would be administered/controlled by each jurisdiction through secure password protection (specific to each State/Territory) and updated as per current departmental internal processes applied to their existing websites. The website will be searchable by jurisdiction, crop (e.g. Nursery Stock, Avocados, Citrus, etc.) or pest (e.g. Silverleaf Whitefly, RIFA, etc.) and uniform in design and terminology allowing stakeholders to retrieve data with ease. A Kachenko said that he would update the Committee on the progress of this proposal at the next Committee meeting.

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| ITEM | TOPIC | DETAILS |
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A Kachenko also indicated that a draft proposal for grower registration being developed by AusVeg and NGIA will also be tabled at the next Across Industry Committee. A Kachenko said that he would update the Committee on the progress of this proposal at the next Committee meeting.

***ACTION: A Kachenko and J McDonald to conjointly draft NGIA policy position on Biosecurity for discussion at the next Environment Committee Meeting.***

***ACTION: A Kachenko to keep the Environment Committee updated with further developments to the Biosecurity Across Industry Projects.***

A Kachenko noted that the FarmReady application for BioSecure HACCP was unsuccessful as the course was considered a stand alone technical/operational training activity without link to whole of farm climate change strategy. It was perceived by FarmReady that the training's main focus is on achieving HACCP certification, rather than management-level decision making to improve primary producer resilience to climate change.

G Fenton provided a brief update on developments with regards to the pot levy following in depth discussion at the recent combined Presidents, CEO's and Board meeting in Melbourne. He noted that the levy had been static for a number of years and needed to grow to ensure there was adequate funds to reflect industry growth (i.e. reduce leakage, capture more Levy Payers etc.). Possible options were discussed including a Levy on growing media, labels and ad-valorum. It was noted that changes to the pot Levy would be prudent business practice to spread the risk considering how the Levy is currently collected (i.e. financial risk mitigation). Preliminary modelling had shown that a combination of pot with media was the most feasible option in moving forward (i.e. would be less costly to implement than ad-valorum, capture a wider audience of Levy Payers to spread the risk in managing the collection process etc.). The next step is to carry out more detailed financial modelling with input from key pot and media manufactures. A vote on this is anticipated in early 2011. NGIA Board approval and a road show detailing the proposed changes would need to occur before a vote. The Committee agreed that consultation to the wider industry was mandatory in order to ensure there was little resistance to any proposed changes to the levy.

A Kachenko indicated that he and R Prince had met with Levy Revenue Services (LRS) to discuss proposed changes to the levy as well as the proposed biosecurity levy. He indicated that LRS were supportive and happy to assist with the process in implementing any future levy changes.

***ACTION: G Fenton and A Kachenko to update the Environment Committee with future developments to the Pot Levy and proposed Biosecurity Levy.***

***ACTION: A Kachenko to forward G Fenton's PowerPoint presentation delivered at the recent combined Presidents, CEO's and Board meeting in Melbourne to the Environment Committee.***

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#### 4

#### MATTERS ARISING (NOT ADDRESSED IN THIS AGENDA)

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A Kachenko indicated that J Bunkers comments in his email would be covered off in other Agenda items. There were no further matters arising to discuss.

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| ITEM | TOPIC                                 | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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| 5    | NATIONAL ENVIRONMENTAL PROJECT UPDATE |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|      | 5.1 Update from HAL                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|      |                                       | <p>A Kachenko introduced P Melville who is the Natural Resource and Integrated Pest Management Portfolio Manager at Horticulture Australia Limited. In his introduction, P Melville indicated that he was only new to his role (appointed in August) and had served in public and private sector agricultural roles. P Melville delivered a PowerPoint Presentation that covered key areas including:</p> <ol style="list-style-type: none"> <li>1. HAL Environment Portfolio</li> <li>2. HAL Project Assessment Process</li> <li>3. Across Industry Focus</li> <li>4. Potential opportunities</li> </ol> <p>P Melville began his presentation with an overview of climate change and variability. Discussion followed and indicated that temperature changes, cropping patterns and biosecurity were key issues stemming from climate change and variability.</p> <p>P Melville discussed the HAL Environment Portfolio which covers:</p> <ul style="list-style-type: none"> <li>• Natural Resource Management – water, soils, nutrient, waste, air, energy, biodiversity</li> <li>• Climate change: <ul style="list-style-type: none"> <li>o Adaptation</li> <li>o Mitigation</li> <li>o Communication</li> </ul> </li> <li>• IPM</li> </ul> <p>In discussing the HAL Project Assessment Process, he indicated that projects must align with the Government, HAL and NGI industry priorities/strategic plans. He outlined the HAL assessment process as follows:</p> <ul style="list-style-type: none"> <li>• Proposal submission &amp; review</li> <li>• Portfolio Assessment – Recommendation to IAC</li> <li>• IAC endorsement &amp; feedback</li> <li>• Proposal review process</li> <li>• HAL internal processing <ul style="list-style-type: none"> <li>o Delegations</li> <li>o Board sub Committee - Projects over \$300,000</li> <li>o Board - Projects over \$1,000,000</li> <li>o Contracting</li> </ul> </li> </ul> |

| ITEM | TOPIC | DETAILS |
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- o Milestones and project review - every 6 months – stop-go clause on projects over \$500,000 mid way
- o Reporting - must deliver to whole of industry.

P Melville indicated that market failure was a key consideration when developing proposals for consideration. He also indicated that there needed to be strong scientific rigor and measurable outcomes.

P Melville provided a brief update on the current environmental across industry projects. He outlined the following:

- Horticulture Water Initiative
- National Program for Sustainable Irrigation (NPSI)
- Climate Change Initiative
- Water Initiative and NPSI programs coming to a close
  - o AIC support water programs but looking for a new direction
  - o MDBP – does not affect all industries
- Climate Change Initiative – Ongoing – giving horticulture a voice amongst other agricultural industries
- IPM initiatives – aligned with market failure e.g. chemical withdrawal from market - endosulfan

P Melville provided his thoughts in terms of future R&D areas for the Australian Nursery & Garden Industry. He outlined the following:

- Re-utilising resources – drive into the next technology age
- Reduce cost of production – energy, fuel, fertiliser etc.
- Resources with value will be re-used – biodegradable pots
- Energy efficiency as a result from climate change
- Greenlife products recognition in urban environments e.g. green walls / green roofs
- Water efficiency vs. water restrictions in urban environments – rewarding instead of restricting
- Fertiliser technology – minimising nitrous oxide emissions
- Biosecurity

G Fenton invited P Melville to Victoria to gain a first hand look at some of the industry programs that have been delivered on-ground and take a look at some of the work that has been achieved resulting from levy programs.

***ACTION: A Kachenko to forward P Melville's PowerPoint presentation to the Environment Committee.***

| ITEM | TOPIC                                                    | DETAILS |
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|      | 7.2 11/12 R&D Projects and Future Industry R&D direction |         |

A Kachenko delivered a PowerPoint Presentation that detailed the process in how projects proposals were developed. The process included:

- Detailed timeline circulated to IDO network in December 2009
- Guidance with proposal drafting circulated in December 2009
- Timeline discussed at Darwin IDO Network meeting and NIASA Meeting June 2010
- 42 projects submitted to NGIA from the IDO network
- All projects evaluated by NGIA and sent to IDO network for ranking
- Projects ranked by IDO network based on 4 criteria (urgency, importance, impact and success) and rankings collated by NGIA

He presented a table that detailed the top 14 projects that included:

1. Harmonisation of Interstate Plant Movement Protocols/Procedures
2. Industry Minor Use Program
3. BioSecure *HACCP* - building governance and alignment with government
4. Industry research linkage – supporting university collaboration
5. NIASA Cost/Benefit Analysis and ROI evaluation
6. Modernise the dispatch ideas video – supply chain improvement
7. Plant Health Risk Management, Planning and Capacity building - industry collaboration with state government to deliver a dedicated biosecurity resource for the Australian nursery industry
8. Shade house structures – colours etc. in line with climate change
9. Feasibility of establishing a business management program
10. Benchmarking of Industry – industry size etc.
11. Expand dispatch ideas video – supply chain improvement
12. Plant Logistics and Plant Movement – Practical Solutions
13. Plant Quality Grading – protocols for specifying trees, posts etc.
14. Nutrient budgeting in plant production – decision making tools



| ITEM | TOPIC | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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|      |       | <p>He indicated that the Harmonisation of Interstate Plant Movement Protocols/Procedures project would be integrated into the Across Industry Proposal discussed earlier in the meeting.</p> <p>General discussion followed in terms of how to ensue wide industry consultation with regards to project development and engagement at all levels. A Kachenko to circulate project development timeline to all state/territory Associations as well as how to write a robust proposal. The Committee also asked A Kachenko to forward a summary of the ranked projects to all state/territory associations.</p> <p>A Kachenko provided a brief update on all the projects for submission to HAL on Monday 15 November. These included:</p> <ol style="list-style-type: none"> <li>1. Resource support for the state based Industry Development Officer Network to undertake national policy roles at a regional level. This project continues the approach taken in earlier projects to enhance the industries representation with key policy areas while increasing the opportunity for skill development within this resource. It also funds industry's obligation under the Emergency Plant Pest Response Deed.</li> <li>2. Operational resources for NGIA National Environment Committee and development of NGI policies and procedures. Funds are required to enable travel and accommodation expensed for Committee members to attend meetings. This sub-project will also facilitate the printing and distribution costs associated with industry policies including the development of new policies as well as the recirculation of updated/revised policies</li> <li>3. NGI affiliate and research linkage program. This sub-project builds on the approach taken in 2009/10 and 2010/11 to foster industry innovation and build industry capacity through high calibre R&amp;D linkages with external research and university organisations.</li> <li>4. Investigate controlled atmosphere as a quarantine treatment for the Nursery &amp; Garden Industry – Phase 2. This research project will compare growth rate, phenotype and genotype characteristics of plants exposed to different concentrations of CO<sub>2</sub> or N<sub>2</sub> at an AQIS approved facility. The trial will be conducted by Department of Primary Industries &amp; Fisheries Queensland who is currently undertaking a literature review to determine the feasibility of this research.</li> <li>5. Minor use permits for the Nursery &amp; Garden Industry. This project will develop up to 7 minor use permits that are deemed necessary by the NGI. The funds will be used to develop a comprehensive data package to the APVMA in order for them to process the minor use permit request and grant registration.</li> <li>6. Nutrient budgeting calculators in plant production. This project will develop a web based calculator based off the US GrowCalc software package which includes an alkalinity calculator, a fertilizer calculator, and a plant growth regulator calculator.</li> <li>7. Progressing BioSecure HACCP towards a third market access instrument. This project will develop both the administration and governance protocols that will underpin BioSecure HACCP for it to meet regulatory compliance and competence including updates to the BioSecure HACCP manual and electronic system management.</li> <li>8. NIASA Cost/Benefit Analysis and ROI evaluation. funds are required for a period of 12 months to perform this economic evaluation of the NIASA program.</li> </ol> <p><b>ACTION: A Kachenko to forward the 2012/2013 project development timeline, how to write project proposals and a summary of the ranked proposals to all state associations.</b></p> |

| ITEM | TOPIC | DETAILS |
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The Committee discussed these proposals in great detail. The Committee discussed the possibility of including a project to look at standardising containers to be used to drive greater consistency and driving a national specification, such as NATSPEC, when specifying trees. It may also assist in addressing plant handling and logistics. It was decided that a small allocation of funding would be put forward to convene a meeting to discuss this concept further.

The NGI affiliate and research linkage program was strongly supported and it was suggested to broaden the NGIA National Conference and put a call out for research papers/posters. These projects arising from this work were seen by the Committee as an excellent way to maximise the levy spend, bring academic institutions together in discussing industry research priorities as well as support tomorrow's industry leaders and professionals, integrate them into the industry and generate innovative thinking.

***ACTION: A Kachenko to include funding in the 11/12 round of projects to convene a meeting to discuss standardization of pots.***

**MOTION: In principle support to seek greater input into NGIA National Conference program by calling for oral and poster papers from external stakeholders.**

**Moved:** S Burdette

**Seconded:** G Fenton

A Kachenko provided a further summary of projects that were going to be lodged from external providers. These included:

1. **Greening City - Mitigate Heat Stress with Urban Vegetation.** A Kachenko was working with CSIRO on developing this project. In this project, the potential benefits of urban vegetation in mitigating heat island effect, heat stress and in improving indoor outdoor thermal comfort will be explored in present time and in 2030, 2050 under three climate change scenarios (low, medium and high) exemplified using three Australian capital cities Brisbane, Melbourne and Western Sydney.
2. **Understanding the carbon and pollution mitigation potential of Australia's urban forest.** A Kachenko was working with Macquarie University on developing this project. The project's four main objectives are:
  - estimating the values and benefits associated with tree canopy cover and its spatial distribution at property and neighbourhood scales;
  - researching new and under-utilised areas for tree planting potential on both private and public land;
  - highlighting examples of best practice of urban forestry in local government areas that the industry can use; and
  - contributing to ongoing debates in the urban planning and climate change literature on the advantages of different urban forms, by highlighting the under-researched activity of carbon sequestration and pollution mitigation potential of Australia's urban forest.

| ITEM | TOPIC | DETAILS |
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3. **Plants and media for subtropical green roofs in Australia.** A Kachenko was working with University of Queensland on developing this project. This project aims to provide information on green roof plant selection, substrate choice and water management relevant to subtropical Australia. With a focus on natives, a range of plant species will be assessed under simulated and actual green roof conditions. Different substrate formulations and irrigation regimes will be assessed to sustain plant condition and maintain vegetation cover. "Best-bet" species will be identified along with information on establishment (e.g. media) and management (e.g. irrigation) recommendations.
4. **Plant Health Risk Management, Planning and Capacity Building.** A Kachenko was working with Department of Employment, Economic Development & Innovation, Queensland on developing this project. The aim of this proposal is to provide support to the Australian nursery industry in the identification and management of plant diseases and pests through professional diagnostics, skill enhancement of industry and various resource developments for on-farm biosecurity management. In particular, the project will support a national plant pest and disease diagnostic service that will include the capacity to monitor the occurrence of principal plant pests and pathogens in Australian production nurseries and post-entry quarantine facilities, provide technical support to the industry in the area of biosecurity, assist in the development of plant pest and disease identification packages and evaluate methods for the management of major pests and diseases with reference to the programs that form the Nursery Production Farm Management System (NIASA, EcoHort & BioSecure HACCP).

The Plant Health Risk Management, Planning and Capacity Building project was discussed in detail by the Committee. It was apparent during these discussions that although the project would be based in Queensland, it would service the whole nursery and garden industry. The project duration was four years and it was mentioned that the project would have a stop-go clause at the end of year two. It was noted that this project could be explored by other state government associations should the services they intend to provide benefit the whole of industry. The Environment Committee agreed in principle on the concept of co-investment based on the direction industry was heading with resources being pulled from state government associations.

The *Plants and media for subtropical green roofs in Australia project* was also discussed in detail. It was noted that the project was not regarded as a high priority project and would not service the whole of industry.

A Kachenko also noted that he anticipates developing a climate change workshop in 2011/12 that incorporates all the tools that NGIA have developed including NurseryFootprint as well as the energy efficiency calculators. He also noted that a supply chain workshop would also be considered for development in late 2011 that would cover the topic 'terms of trade'.

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## 5.2 Environment and Technical Project Update

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A Kachenko tabled a summary of the current 10/11 levy funded R&D projects being undertaken by NGIA.

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| ITEM | TOPIC | DETAILS |
|------|-------|---------|
|------|-------|---------|

## PROJECT 1

### **Title: Industry research linkage – support for honours research projects**

The program will support research projects across Australian universities. Projects will be developed in consultation with the NGI and the relevant academic institution and show progress of innovation relevant to Industry needs.

## PROJECT 2

### **Title: NGIA Environment Committee**

The NGIA Environment Committee holds two formal meetings per year with each meeting up to two days in duration. The Committee consists of 4 Industry representatives and NGIA representatives including the National Environmental & Technical Policy Manager and CEO. Additional funds associated with this project cover development of resources.

## PROJECT 3

### **Title: Investigate controlled atmosphere as a quarantine treatment for the Nursery & Garden Industry**

This project builds on the pilot study 'Examine suitability of irradiation as a quarantine treatment in plants' undertaken in 2009/10 to research the suitability of controlled atmosphere (e.g. CO<sub>2</sub> or N<sub>2</sub>) as a quarantine treatment against insect pests of nursery stock. This technology is currently not available to the Australian nursery industry.

This project will entail a literature review to be contracted with Agri-Science Queensland, a service of the Department of Employment, Economic Development and Innovation.

## PROJECT 4

### **Title: Development of Four Industry Specific Contingency Plans**

A key part of preparedness for possible incursion of these high risk pests is the development of Contingency Plans specific to each pest. These plans provide detailed information on the pest life cycles, potential distribution, survival strategies and methods for surveillance and sampling. Contingency Plans form the basis for development of Response Plans in the event of detection of an exotic pest thus assisting with a more rapid emergency response for eradication, containment or management for a pest incursion. Plant Health Australia (PHA) has developed contingency plan templates to ensure information provided is consistent and meets a minimum set of requirements. The plans that will be developed in 10/11 include:

1. Thrips transmitted viruses– Tospovirus
2. Aphids transmitted viruses – Potyviridae
3. *Xyella fastidiosa* (Pierces disease) – Bacterial pathogen and compliment Glassy Winged Sharp Shooter
4. *Lygus lineolaris* (Tarnished plant bug) – We have yet to address a bug.

| ITEM | TOPIC | DETAILS |
|------|-------|---------|
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## PROJECT 5

### Title: Access to minor use permits

This project will provide industry with:

- Access to new chemistry that may have greater efficacy against the target pest(s)
- Pesticides with reduced environmental impact
- Pesticides with lower toxicity to humans or minimal off-target impacts (fish, etc)

This project will invest in the development of the following MUPs with through AgAware Consulting.

| Pesticide                                   | Target Pest                                                                                                                                                                                                         |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Admiral</b> (pyriproxyfen)               | Whiteflies, fungus gnats, shore flies                                                                                                                                                                               |
| <b>Movento</b> (spirotetramat)              | Aphids, thrips, whitefly, scale                                                                                                                                                                                     |
| <b>Regent</b> (fipronil)                    | Aphids, Thrips, Mites, Locusts, Grasshoppers, Wireworms, Leaf minors, Lace bugs, Weevils, Diamondback moth, Cabbage white butterfly, Cabbage cluster caterpillar, Fungus gnats/shore flies, Sugarcane weevil borer. |
| <b>Dominex 100 EC</b> (alpha-cypermethrin)  | Aphids, Caterpillars, Mites, Rutherglen bug, Thrips, Cut worms, Locusts, Grasshoppers.                                                                                                                              |
| <b>Pristine</b> (boscalid + pyraclostrobin) | Anthrachnose, Botrytis, Leaf spot, Powdery mildew                                                                                                                                                                   |
| <b>Nimrod</b> (bupirimate)                  | Powdery mildew                                                                                                                                                                                                      |
| <b>Switch</b> (cyprodinil + fludioxonil)    | Rhizoctonia, Sclerotinia, Botrytis, Colletotrichum, Aspergillus                                                                                                                                                     |

## PROJECT 6

### Title: Evaluating energy efficiencies in nursery production

This project will build on the 'Evaluate co-generation in the nursery Industry' project undertaken in 2009/10 as well as the 'Undertake Industry sector analysis to develop carbon footprint for nursery Industry' undertaken in 2008/09 to identify key areas of energy loss/inefficiency in growing environments and determine where efficiencies can be gained.

This project will investigate the various systems in use and calculate the energy efficiency based on kilowatt cost per square meter and cost per unit produced per square meter plus the infrastructural cost of the system. It will develop a simple financial management calculator to evaluate the cost/benefit of new and existing technologies in production nurseries.

This project will be integrated into the 'Evaluate co-generation in the nursery Industry' and is unlikely to go ahead in 2010/2011. **This project will be incorporated into the existing co-generation project undertaken at the National Centre for Engineering in Agriculture scheduled for completion in December 2010.**

| ITEM | TOPIC | DETAILS |
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## PROJECT 7

### **Title: Develop water management calculators for managing water in production nurseries**

This project will develop simple calculators for growers to manage nursery water. These calculators will be based off a popular Industry book 'Managing Water in Plant Nurseries' which has been available in hardcopy since 2000. All formulae contained in this book will be converted into simple excel calculators guiding growers with their decision making processes.

**This project will be undertaken at the National Centre for Engineering in Agriculture. Scheduled for completion in December 2010.**

## PROJECT 9

### **Title: Technical support to update Nursery Industry Water Management Guidelines and develop a database and summary 'fact sheets' of existing research and development projects**

Technical administration will review and update the Nursery Industry Water Management Guidelines which were last updated in 2005. These guidelines are highly regarded by Industry, external stakeholders and internationally and are a key component of Nursery Industry Accreditation Scheme Australia BMP guidelines.

In addition to updating these guidelines, there is an identified need for readily accessible data to enhance the transfer of research and technical project outcomes to growers. This project will extract all relevant information from completed levy funded projects and develop a searchable database that will be housed on the NGIA national website. Technical support is required to consolidate this information and develop this database. The extracted information will also be developed into relevant fact sheets, including, but not limited to supply chain logistics.

***This project is underway. The existing Water BMP has been reviewed by Chris Rolfe and Bill Yiasoumi and sent to the graphic designers for layout. The guidelines are currently being reviewed before being sent to the IDO network for comment. The final version will be printed in early 2011. In relation to the second part of the project, a student will be contracted over the summer of 2011 to undertake the database development and fact sheets.***

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## 5.3 APVMA/AQIS Export Update

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A Kachenko tabled an update document detailing progress to date regarding the Export Certification Reform Package. He discussed the program and provided a brief update on the proposed Approved Auditor proposal AQIS have developed. This proposal will enable businesses to self certify consignments destined for export markets. Is endorsed by industry, the Approved Auditor arrangements will be rolled out to industry in July 2011. A Kachenko indicated that he had already provided an update on the APVMA in the agenda and no further action was required.

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| ITEM | TOPIC                    | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|      | 5.4 Accreditation Update | <p>A Kachenko noted that sound progress towards meeting the objectives of the 2010/2011 NIASA Annual Operating Plan (AOP). He notes that the NIASA Audit Portal was near completion before being trialled by the IDO network. J McDonald and his team in Queensland had been actively engaged in truthing the tool. A Kachenko thanked J McDonald and his team for input into this aspect of the NAP development. The tool should be in a finished stage at the December 2 NIASA Advisory Committee meeting.</p> <p>A Kachenko indicated that he was planning to submit the Nursery Production Farm Management System (NPFMS) marketing/R&amp;D project on Monday. He provided an overview of the subprojects that would be funded under this proposal including:</p> <ul style="list-style-type: none"> <li>• NAP maintenance</li> <li>• Smart Approved WaterMark licensing fees</li> <li>• AusVeg and NGIA 2012 Conference Exhibitor booth sponsorship</li> <li>• NPFMS Learning Guide</li> <li>• NPFMS Regional Promotion and National Advertising</li> <li>• Grower Marketing Tools</li> <li>• NPFMS Selling Kit Updates</li> <li>• Marketing Coordinator/Committee Expenses</li> </ul> <p>A Kachenko also commented that NGIV had been approached by Bunnings regarding NPFMS and how they could form a closer alliance with Bunnings. He noted that he attended a meeting with S Potts, R Chin and two Bunnings representatives to discuss NPFMS to see if this system can be used as a risk management tool when seeking suppliers. Discussions are continuing with a grower workshop scheduled on 1 December in Melbourne. A Kachenko and R Chin will attend on behalf of industry and present at this workshop. The Committee were very supportive of this development and asked A Kachenko for future updates.</p> <p><b><i>ACTION: A Kachenko to update the Environment Committee with future developments on discussions between NGI and Bunning's.</i></b></p> |
| 6    | OPERATIONAL ISSUES       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|      | 6.1 Review of 09/10 AOP  | <p>The 2010/2011 Annual Operating Plan was tabled for discussion. A Kachenko indicated that the contract for these projects was signed October 1.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

| ITEM | TOPIC                                      | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|      |                                            | <p>A Kachenko provided a brief overview of the 10/11 projects including:</p> <ul style="list-style-type: none"> <li>• Industry research linkage – support for university research projects (to cover honours, masters, PhD research etc. as per 09/10 program)</li> <li>• Investigate controlled atmosphere as a quarantine treatment for the Nursery &amp; Garden Industry – follow on literature review from irradiation project.</li> <li>• Development of key pest contingency plans for high risk biosecurity pests of the Nursery &amp; Garden Industry.</li> <li>• Minor use permits for the Nursery &amp; Garden Industry (Develop 6 permits for submission to APVMA for approval).</li> <li>• IDO network – regional representation to attend meetings and conferences.</li> <li>• Environment Committee expenses.</li> <li>• Evaluating energy efficiencies in nursery production. Continuation of current project with NCEA with possible collaboration with NSW Industry and Investment who are working in this area with AusVeg.</li> <li>• Develop water management calculators for managing water in production nurseries.</li> <li>• Upgrade of NIASA BMP Water Guidelines and development of a database to house existing Final Reports from Levy R&amp;D projects.</li> <li>• R&amp;D Database of projects.</li> </ul> |
| 6.2  | Senate Inquire into Quarantine/Biosecurity | <p>A Kachenko tabled the NGI submission to the inquiry into Biosecurity and Quarantine Arrangements. The Committee congratulated the authors on the proposal and suggested that future submissions should detail industry solutions. A Kachenko indicated that should this inquiry hold a public hearing, NGI would be represented and provide solutions/recommendations to the ailing state of Australia's Quarantine and Biosecurity arrangements. G Fenton asked if a copy of the industry's submission could be forwarded to state NGI Associations for circulation to relevant quarantine and biosecurity contacts.</p> <p><b><i>ACTION: A Kachenko to forward a copy of the NGI submission to the inquiry into Biosecurity and Quarantine Arrangements to state NGI Associations for circulation to relevant quarantine and biosecurity contacts.</i></b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 6.3  | Water Policy Update                        | <p>A Kachenko provided a draft update to the Water Policy for discussion. The Committee agreed that an update to the industry policy position was required and should follow the format of the Garden Industry Alliance WA who released on 22 October a joint policy position statement in response to the tightening of water restrictions in WA. The Committee indicated that the revised policy position should encompass and stress the many socio-economic benefits of gardens and landscapes.</p> <p><b><i>ACTION: A Kachenko to review the NGI Water Policy Position and provide a draft at the next Environment Committee meeting in 2011.</i></b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 6.4  | Climate Change Policy Update               | <p>A Kachenko updated that Committee that this policy was endorsed at the recent at the combined Presidents, CEO's and Board meeting in Melbourne. A one page executive summary document was asked to go with the policy position to make it easier for members to understand.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |



| ITEM | TOPIC               | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6.5  | Supply Chain Update | <p>A Kachenko provided the Committee with a PowerPoint presentation that detailed progress since the comprehensive Stage 1 - Industry Situation Analysis (NY08006) that was presented at 2009 NGIA Conference. He noted that this document highlighted that industry training on supply chain and marketing was warranted to assist with Change Management in order to:</p> <ul style="list-style-type: none"> <li>– Provides awareness of need for change</li> <li>– Identifies capabilities to enable change</li> </ul> <p>A Kachenko noted that G McEvilly and T Rafferty were developing an Initial Foundation Course to compliment existing industry business training workshops. The workshop would cover:</p> <ul style="list-style-type: none"> <li>– Supply chain – starts with the consumer</li> <li>– Changing market environment <ul style="list-style-type: none"> <li>– Opportunities and Threats this poses</li> <li>– Recognising supply chain profit killers</li> <li>– Building capability to manage these</li> </ul> </li> <li>– Case studies</li> <li>– Applying this in your own business</li> <li>– Opportunities for further development</li> </ul> <p>The workshop would be a full day course, interactive and targeting all sectors. It would comprise of</p> <ul style="list-style-type: none"> <li>– Sessions 1-4 ...Industry &amp; market structure: the external environment of industry and what this means to an individual enterprise</li> <li>– Sessions 5-7 ...Understanding the key drivers for enterprise competitiveness and profitability</li> <li>– Sessions 8-10 ...Identifying and engaging with supply chain partners</li> </ul> <p>A Kachenko said the workshop would be finalised by early 2011 and should be ready for delivery by suitably skilled industry representatives shortly thereafter. G Fenton asked if the workshop could be 'trialled' at the NGIV conference in 2011. A Kachenko indicated that he would explore this further to ensure timing etc. would be feasible for this to happen.</p> <p>A Kachenko suggested that this Committee should consider taking on board Supply Chain and given the responsibility of implementing/adjusting the Action Plan detailed in the NY08006 report. The Committee acknowledged this request and said it would give it due consideration at the next meeting.</p> |

## 7

### RESEARCH PROPOSALS AND OPPORTUNITIES

#### 7.1 Environmental risk matrix

A Kachenko provided the Environment Committee with the Environmental Risk Matrix.

| ITEM     | TOPIC                              | DETAILS                                                                                                                                                                                                                                                                                                                                                             |
|----------|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          |                                    | <p>For P Melville's benefit, he explained that is based on the risks associated with a range of issues that impact on the profitability of Australian nursery and garden industry. S Burdette noted several items to update.</p> <p><b><i>ACTION: A Kachenko to update the Environmental Risk Matrix for the next Environment Committee meeting in 2011</i></b></p> |
| <b>8</b> | <b>GENERAL BUSINESS</b>            |                                                                                                                                                                                                                                                                                                                                                                     |
|          |                                    | <p>G Fenton thanked P Melville for attending the meeting on behalf of the Committee. There were no further items to discuss and G Fenton thanked everyone for their participation in 2010 and indicated that he looked forward to working with the Committee in 2011.</p>                                                                                           |
| <b>9</b> | <b>NEXT MEETING – JUNE 28 2011</b> |                                                                                                                                                                                                                                                                                                                                                                     |
|          |                                    | <b>MEETING CLOSED 2:15 PM</b>                                                                                                                                                                                                                                                                                                                                       |

## SUMMARY OF ACTION ITEMS

| ACTIONED ITEMS                                                                                                                                                                                            | RESPONSIBILITY       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| <b>2 CONFIRMATION OF MINUTES</b>                                                                                                                                                                          |                      |
| A Kachenko to follow up IP arrangements with J Gibbs regarding the Plant/Life Balance marketing campaign.                                                                                                 | A Kachenko           |
| <b>3 MATTERS ARISING FROM LAST MEETING</b>                                                                                                                                                                |                      |
| A Kachenko to provide a snapshot update to state associations on the national policy framework for the assessment, registration and control of use of agricultural and veterinary chemicals.              | A Kachenko           |
| A Kachenko and J McDonald to conjointly draft NGIA policy position on Biosecurity for discussion at the next Environment Committee Meeting.                                                               | A Kachenko           |
| A Kachenko to keep the Environment Committee updated with further developments to the Biosecurity Across Industry Projects.                                                                               | A Kachenko           |
| G Fenton and A Kachenko to update the Environment Committee with future developments to the Pot Levy and proposed Biosecurity Levy.                                                                       | G Fenton/ A Kachenko |
| A Kachenko to forward G Fenton's PowerPoint presentation delivered at the recent combined Presidents, CEO's and Board meeting in Melbourne to the Environment Committee.                                  | A Kachenko           |
| <b>5 NATIONAL ENVIRONMENTAL PROJECT UPDATE</b>                                                                                                                                                            |                      |
| A Kachenko to forward P Melville's PowerPoint presentation to the Environment Committee.                                                                                                                  | A Kachenko           |
| A Kachenko to update the Environment Committee with future developments on discussions between NGI and Bunning's.                                                                                         | A Kachenko           |
| <b>6 OPERATIONAL ISSUES</b>                                                                                                                                                                               |                      |
| A Kachenko to forward a copy of the NGI submission to the inquiry into Biosecurity and Quarantine Arrangements to state NGI Associations for circulation to relevant quarantine and biosecurity contacts. | A Kachenko           |
| A Kachenko to review the NGI Water Policy Position and provide a draft at the next Environment Committee meeting in 2011.                                                                                 | A Kachenko           |
| <b>7 RESEARCH PROPOSALS AND OPPORTUNITIES</b>                                                                                                                                                             |                      |
| A Kachenko to update the Environmental Risk Matrix for the next Environment Committee meeting in 2011                                                                                                     | A Kachenko           |



# MINUTES

## Environment Committee Meeting

|                  |                                                                                   |
|------------------|-----------------------------------------------------------------------------------|
| <b>Date:</b>     | Wednesday 28 June 2011                                                            |
| <b>Time:</b>     | 9.30 am – 3.00 pm                                                                 |
| <b>Location:</b> | NGIA Office, 16-18 Cambridge Street, Epping 2121                                  |
| <b>Attendees</b> | Glenn Fenton (Chair), John Bunker, Steve Burdette, Sean O'Brien, Anthony Kachenko |
| <b>Apologies</b> | Robert Prince                                                                     |

| ITEM | TOPIC                                                     | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | <b>WELCOME AND APOLOGIES</b>                              | <p>G Fenton formally declared the Environment Committee Meeting open at 9:25 am and extended a warm welcome to Committee Members. G Fenton noted that an apology for absence had been received from R Prince due to prior commitments.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 2    | <b>CONFIRMATION OF MINUTES – MEETING 12 NOVEMBER 2010</b> | <p>G Fenton advised that the Minutes from the Meeting held on 12 November 2010 were provided in the Meeting papers and Members were asked to raise any concerns regarding the accuracy of these minutes. Amendments were received from S Burdette. No further amendments were received.</p> <p><b>MOTION:</b> The Environment Committee accept the minutes from the 12 November 2010 Environment Committee meeting as a true and accurate record.</p> <p><b>Moved:</b> S Burdette</p> <p><b>Seconded:</b> S O'Brien</p>                                                                                                                                                                             |
| 3    | <b>MATTERS ARISING FROM LAST MEETING</b>                  | <p>3.1 Review of Action List</p> <p>A Kachenko tabled an Action List arising from the last Meeting. He provided an update on the completed items. The following actions are outstanding:</p> <p>A Kachenko to review NGI Water Policy Water Policy Position and provide a draft at the next Environment Committee. A Kachenko advised that due to other commitments he was unable to fulfil this and would keep this item on the Action Plan for subsequent meetings. He indicated that a more pressing objective was to complete the Biosecurity Policy Positions.</p> <p>A Kachenko indicated that other 'outstanding' items on the Action List were covered under other areas in the Agenda.</p> |

| ITEM | TOPIC                                                 | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------|-------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4    | <b>MATTERS ARISING (NOT ADDRESSED IN THIS AGENDA)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                                       | <p>S Burdette asked A Kachenko on progress relating to supply chain related projects. A Kachenko indicated that a workshop had been developed for whole of industry. He indicated that the workshop covered off on the following areas:</p> <ul style="list-style-type: none"> <li>• Overview of Supply Chain Management – Key Concepts</li> <li>• The Market Environment</li> <li>• External Threat &amp; Opportunity Analysis</li> <li>• Competitiveness</li> <li>• Options for Profitability</li> <li>• Capabilities</li> <li>• Supply Chain Case Studies</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 5    | <b>NATIONAL ENVIRONMENTAL PROJECT UPDATE</b>          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      | 5.1                                                   | <p>NY10005 Environment and Technical Project Update</p> <p>A Kachenko tabled a summary of the current 10/11 levy funded R&amp;D projects being undertaken by NGIA under project NY10005. He indicated that NY10005 was contracted in October 2010 for completion in August 2011. All projects would be communicated to State/Territory NGI's, on <a href="http://www.ngia.com.au">www.ngia.com.au</a>, through Nursery Papers and Clippings, National Conference as well as on the NGI Facebook page at the completion. The projects that were tabled and discussed included:</p> <ol style="list-style-type: none"> <li>1. Industry Development Officer (IDO) Regional Representation. A Kachenko indicated that this project supported IDO's attendance to key meetings, workshops and conferences where industry needed to be engaged. A Kachenko indicated that meeting reports must follow attendance to events to secure funding. These reports needed to cover outcomes and next steps in terms of how the issues impact industry. He said that there was little uptake/interest in this project among the IDO network. The Committee agreed that there will need to be greater emphasis on developing IDO skills in the future and suggested that it would also be called IDO professional development. A Kachenko to table this for discussion at the next National NIASA Advisory Committee (NNAC) meeting. He also indicated that the IDO job description would require changes in the next round of HAL application. S Burdette said that this should involve the IDO network to ensure that they were involved in the process.</li> <li>2. Industry Research Linkages – Support for Honours Research Project. A Kachenko indicated that all projects with significant findings would become Nursery Papers. He provided an update on the projects currently underway. The Committee agreed that this project continued to be a valuable vehicle for accessing Research &amp; Development outcomes for the Australian NGI. The committee discussed mechanisms for enhancing extension of these results and other levy projects. The Committee agreed that there was opportunity to alert industry to projects prior to commencement to ensure they understand how the research &amp; development component of the levy is being invested.</li> </ol> |

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3. NGIA Environment Committee Expenses including the development of resources such as the Climate Change Policy Position. A Kachenko indicated that he had sent this policy position to the Cross Party Climate Change Coalition in Canberra and the Federal Coalition outlining the role of Urban Forest in mitigating climate change. He said that Greg Hunt was supportive and invited NGIA to sit on the Coalitions Business Advisory Council to advise the Coalition on the Direct Action Plan for Climate Change where they have agreed to grow the Urban Forest.
4. Investigate controlled atmosphere as a quarantine treatment for the Nursery & Garden Industry. A Kachenko indicated that the study has commenced with a literature review and pending the results of the literature review (due early August), may extend into a possible research project in 2011/2012. A Kachenko indicated that early indications suggest there was minimal gain in this treatment option at present.
5. Access to minor use permits. A Kachenko asked that all IDOs need to provide input into the development of future products for minor use application permits. The permits for development in 2010/2011 include:

| Pesticide                                   | Target Pest                                                                                                                                                                                                         |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Admiral</b> (pyriproxyfen)               | Whiteflies, fungus gnats, shore flies                                                                                                                                                                               |
| <b>Movento</b> (spirotetramat)              | Aphids, thrips, whitefly, scale                                                                                                                                                                                     |
| <b>Regent</b> (fipronil)                    | Aphids, Thrips, Mites, Locusts, Grasshoppers, Wireworms, Leaf minors, Lace bugs, Weevils, Diamondback moth, Cabbage white butterfly, Cabbage cluster caterpillar, Fungus gnats/shore flies, Sugarcane weevil borer. |
| <b>Dominex 100 EC</b> (alpha-cypermethrin)  | Aphids, Caterpillars, Mites, Rutherglen bug, Thrips, Cut worms, Locusts, Grasshoppers.                                                                                                                              |
| <b>Pristine</b> (boscalid + pyraclostrobin) | Anthrachnose, Botrytis, Leaf spot, Powdery mildew                                                                                                                                                                   |
| <b>Nimrod</b> (bupirimate)                  | Powdery mildew                                                                                                                                                                                                      |
| <b>Switch</b> (cyprodinil + fludioxonil)    | Rhizoctonia, Sclerotinia, Botrytis, Colletotrichum, Aspergillus                                                                                                                                                     |

6. Development of Four Industry Specific Contingency Plans. The pests that are being examined include: viruses transmitted by thrips – (tospovirus), viruses transmitted by aphids – (potyviridae), *Xyella fastidiosa* (Pierces disease) – Bacterial pathogen and compliment Glassy Winged Sharp Shooter and *Lygus lineolaris* (Tarnished plant bug). A Kachenko indicated that this project would not continue in 2011 as it would be incorporated under the Plant Health Risk Management, Planning and Capacity Building project (NY11001).
7. Evaluating energy efficiencies in nursery production. A Kachenko indicated that this project has been integrated into the 'Evaluate co-generation in the nursery Industry' project and has not gone any further.

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8. Develop water management calculators for managing water in production nurseries. A Kachenko indicated that this project was undertaken at the National Centre for Engineering in Agriculture in Queensland and is now complete. The website that will host this tool is [www.watertoolbox.ngi.org.au](http://www.watertoolbox.ngi.org.au)
9. Technical support to update Nursery Industry Water Management Guidelines. A Kachenko said that this project is complete and the revised guidelines have been circulated.
10. Technical support to update Nursery Industry Water Management Guidelines and develop a database and summary 'fact sheets' of existing research and development projects. A Kachenko indicated that this project is complete with all levy projects now available online at [www.ngia.com.au](http://www.ngia.com.au)

A Kachenko said that all projects were running within budget and the final report due to HAL would occur on time. The Committee asked about the process of managing funds unspent. A Kachenko indicated that these funds were sent back to HAL for use in future research & development projects.

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## 5.2 RIRDC Weed Assessment Project Update

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A Kachenko tabled an update on this project. He noted that this project is funded by Rural Industries Research and Development Corporation (RIRDC) to the tune of \$130,705 and was awarded to NGIA in January 2011. The project was contracted in March 2011. He said that this project will utilise an existing weed risk assessment system developed for Australia's Botanic Gardens, known as Botanic Gardens Weed Risk Assessment procedure (WRAP), to screen 1,000 common ornamental taxa cultivated in Australian nurseries for sale to the public to ascertain the degree of weed risk associated with each species. The Botanic Gardens WRAP is a relatively simple yet sufficiently robust weed risk assessment model that is being used by Botanic Gardens across Australia to inform decision-making on which plant taxa should be included or excluded from cultivation in Australia's Botanic Gardens. A Kachenko indicated that he was managing the project with support from M Danelon, R Chin from industry, S Charlton and S Johnson from Department of Primary Industries NSW and R Spencer from the Royal Botanic Gardens Melbourne.

Using the EXISTING Botanic Gardens WRAP, it is envisaged that this project will lead to the development of an Australian white list of low risk ornamental taxa, which is a list of safe plants to cultivate for production, distribution and sale to the general public by production nurseries across Australia. A Kachenko indicated that the project will be built into the [www.growmeinstead.com.au](http://www.growmeinstead.com.au) website, into the National Plant Labeling Guidelines and indicated that a presentation will be carried out at the 2012 NGI National Conference. A Nursery Paper will also be written as well as regular updated through Clippings. A Kachenko said that we will own the IP and it could be used to assist growers to screen 'new releases' in the future to provide a 'tick of approval' or 'authorised' status of these plants. He indicated that the tool could become self-funded as it gained momentum with growers subscribing to get their plants assessed.

A Kachenko indicated that the tool once developed will be voluntary and up to growers to embrace. It will not be used by Governments to police plants in Australia.

| ITEM | TOPIC                                                                                                                                  | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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| 5.3  | NGI Urban Forest Research Programs                                                                                                     | <p>A Kachenko tabled an overview of Urban Forest Research NGIA is undertaking in 2011-2013. He indicated that in 2011, NGIA will be undertaking two levy funded projects with outside collaborators.</p> <ul style="list-style-type: none"> <li>• NY11002: Understanding the carbon and pollution mitigation potential of Australian urban forest - USYD and MACQUARIE Universities (\$139,994 over 2 years 11/12 and 12/13). <ul style="list-style-type: none"> <li>o This project's four main objectives are: <ul style="list-style-type: none"> <li>• Estimating the values and benefits associated with tree canopy cover and its spatial distribution at property and neighbourhood scales;</li> <li>• Researching new and under-utilised areas for tree planting potential on both private and public land;</li> <li>• Highlighting examples of best practice of urban forestry in local government areas that the industry can use;</li> <li>• Contributing to ongoing debates in the urban planning and climate change literature on the advantages of different urban forms, by highlighting the under-researched activity of carbon sequestration and pollution mitigation potential of Australia's urban forest.</li> </ul> </li> </ul> </li> <li>• NY11013: Greening City – Mitigate Heat Stress with Urban Vegetation - CSIRO (\$276,000 over 2 years 11/12 and 12/13). <ul style="list-style-type: none"> <li>o In this project, the potential benefits of urban vegetation in mitigating heat island effect, heat stress and in improving indoor outdoor thermal comfort will be explored in present time and in 2030, 2050 under three climate change scenarios (low, medium and high) exemplified using three Australian capital cities Brisbane, Melbourne and Western Sydney.</li> </ul> </li> </ul> <p>A Kachenko indicated that this project will commence a strategic partnership with CSIRO and hopefully eventuate in future collaborative projects.</p> <p>The Committee discussed other funding opportunities, particularly through mining agencies such as Alcoa, BHP etc. A Kachenko said that he would look into this further and report back to the Committee at the next Committee meeting. Discussion also focused on marketing the industry to developers and other relevant sectors.</p> <p><b>ACTION:</b> A Kachenko to provide an update on funding opportunities through the mining industry and report back to the Committee at the next Environment Committee Meeting.</p> |
| 5.4  | NGIA Submission to 'A National Scheme for Assessment, Registration and Control of Use of Agricultural and Veterinary Chemicals' Update | <p>A Kachenko Tabled this submission and provided the Committee with an overview. He indicated that there NGIA provided a response to options for the single national framework with regards to several key areas including:</p> <ul style="list-style-type: none"> <li>• Policy Options and Impacts of Options – Governance</li> <li>• Policy Options and Impacts of Options – Assessment and Registration</li> <li>• Control of Use</li> <li>• Training and Assessment</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |



| ITEM | TOPIC                      | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
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|      |                            | <p>In the response, he indicated that NGIA raised concern regarding the June 2011 deadline for the development of this framework, as it was unlikely that any necessary intergovernmental agreements and a funding model could be achieved in this short period of time with maximum stakeholder input. He indicated that this appears to be the case as there is no progress in relation to this inquiry since he provided the Federal Government with the submission. He indicated that he would keep the Committee updated with progress relating to the review in future meetings.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 5.5  | Biosecurity and Quarantine | <p>A Kachenko provided the Committee with an update on the Australian Quarantine and Inspection Service (AQIS) export reforms through his involvement on the Horticulture Ministerial Task Force (MTF). He indicated that over the past few weeks, discussion with AQIS have deteriorated due to minimal progress in relation to the original objectives and outcomes of the horticulture MTF. Consequently, the horticulture export program has reverted back to the pre reform fees and charges model. That is, the 2009 fees and charges model with the removal of the 40% Government rebate. In addition, the proposed AQIS Authorised Officer (AAO) model has also raised serious doubts among industry in terms of the genuine efficiencies and benefits it will deliver due to the lack of international acceptance of this proposed service delivery model. Notwithstanding this, there has been minimal documentation surrounding how this program will benefit both Industry and Government. A Kachenko also indicated that AQIS are in the middle of developing an online Audit Management System (AMS) that will supposedly provide benefits to both Industry and Government. The AMS is scheduled to be rolled out for plant export operations in November 2011. This is five months after the July 1 2011 deadline for the completion of the reforms and there has been minimal input into the structure and mechanics of how the AMS will operate from Industry. A Kachenko indicated that this would be integrated into the project Progressing BioSecure HACCP project to be discussed under item 6.1.</p> <p>A Kachenko updated the Committee on the recent release of the National Plant Biosecurity Strategy (NPBS). He indicated that this strategy is the culmination of more than three year's work by PHA who formulated the strategy on behalf of its Members and in close consultation with hundreds of expert stakeholders across Australia's plant biosecurity system. A Kachenko indicated that NGIA played a significant role in the development of this strategy to ensure the issues relevant to the nursery industry were addressed. He provided an example whereby the industry accreditation program BioSecure HACCP was explicitly listed as a viable third party process for market access to investigate as part of this strategy. He indicated that this provides the nursery industry with credence and an agenda to pursue this matter further with regulatory agencies in the near future.</p> <p>A Kachenko advised the Committee about the Plant Health Risk Management, Planning and Capacity Building levy funded project to commence July 2011 for four years. He advised that this project is a co-investment between NGI and Department of Employment, Economic Development &amp; Innovation (DEEDI) QLD. It will be the first of its kind delivering dedicated plant diagnostic resources and support to whole of industry. This project will offer many deliverables to industry that are currently being negotiated with DEEDI include:</p> <ul style="list-style-type: none"> <li>• Discounted costs for pathology sampled for NIASA growers.</li> <li>• One pest/disease management workshop per state/territory/annum.</li> <li>• Develop 6 fact sheets and 1 nursery paper annually.</li> <li>• Clearly identify 6 new pesticide registrations or uses of actives in horticulture (national/international) that can be added to the nursery industry Minor Use Program.</li> </ul> |

| ITEM | TOPIC                                                   | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
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|      |                                                         | <ul style="list-style-type: none"> <li>• A desk top audit of biological control agents across Australia and internationally that are available and in use (pest/organism list plus biology of control agent).</li> <li>• Add 10 pests or diseases to the industry electronic identification tool "Insects, Beneficial's, Diseases, Disorders and Weeds of Nursery Production" per annum.</li> <li>• Provide technical support to the Australian Nursery Industry (Entomology, Pathology, etc.) that assists industry meet its obligations under the Emergency Plant Pest Response Deed (EPPRD).</li> <li>• Develop emergency plant pest contingency plans as required by industry with 1 per annum.</li> </ul> <p>A Kachenko updated the committee on the looming changes to Post Entry Quarantine Facilities. He said that progress was slow, with no indication on where the new facilities would be housed, nor the number of facilities. He indicated that AQIS have indicated a 10 year time frame would be likely to see these changes through.</p> <p><b>ACTION:</b> A Kachenko to provide a hardcopy of the NPBS to Committee Members.</p> |
| 5.6  | Nursery Production FMS update                           | <p>A Kachenko indicated that the next NNAC was on 7-8 July 2011 in Cairns. Key areas that will be discussed at the meeting will cover the need of greater consistency in the interpretation and delivery of the program. This will include:</p> <ul style="list-style-type: none"> <li>• Key areas that need to be updated in the NIASA Heads of Agreement.</li> <li>• Proposal for areas within the NIASA checklist that should be 'satisfactory or above' prior to these businesses reaching a level of accreditation (i.e. mandatory requirements)</li> <li>• ICA training of IDOs and ongoing professional development.</li> <li>• Developments in Tasmania regarding BioSecure HACCP being accepted as an instrument for market access.</li> </ul> <p>The Committee asked if they could have data at the next meeting with regards to the number of businesses engaged with each program under the Nursery Production FMS.</p> <p><b>ACTION:</b> A Kachenko to produce data on accredited businesses at the next Environment Committee Meeting.</p>                                                                                           |
| 6    | OPERATIONAL ISSUES                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 6.1  | NY11000 Environment and Technical Project and 10/11 AOP | <p>A Kachenko tabled a summary of the current 11/12 levy funded R&amp;D projects being undertaken by NGIA. He indicated that the project will be contracted in August 2011 for completion in August 2012. The projects that were tabled and discussed included:</p> <ol style="list-style-type: none"> <li>1. <b>IDO Regional Representation.</b> A Kachenko indicated that this followed the same approach as detailed under the 2010/2011 project where meetings reports must follow attendance to events to secure funding. IDOs can attend workshops; forums under this as part of professional development so long as a report detailing outcomes is circulated post the event.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

| ITEM | TOPIC | DETAILS |
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2. **Biosecurity commitments.** A Kachenko indicated that this project is delivered in conjunction with Project 1 above. It recognises the added responsibility that the QLD Industry Development Manager has regarding national biosecurity including Industry's commitment to the Emergency Plant Pest Response Deed
3. **Industry Research Linkages – Support for Honours Research Project. A Kachenko indicated** this project will continue to identify research projects with engaged universities. Projects will be developed in consultation with the NGI and the relevant academic institution and show progress of innovation relevant to industry needs. He indicated that they must address urgency, importance, impact on success in relation to the needs of the NGI.
4. **Progressing BioSecure HACCP.** A Kachenko said that this project funding must be assigned to the development of both the administration and governance protocols that will underpin BioSecure HACCP for it to meet regulatory compliance and competence including updates to the BioSecure HACCP manual and electronic system management. He indicated that specific areas this project will cover include:

BioSecure HACCP Administration & Governance development & documentation:

- Develop clear administration guidelines and processes for managing the BioSecure HACCP program
  - o Terms & Conditions
  - o Heads of Agreement
- Develop governance processes that underpin the program integrity to meet regulatory confidence
  - o Document development of program procedures for governing all aspects
    - Auditor skill sets
    - Alignment to biosecurity agencies (training)
    - On-farm audit process
    - Program third party audit (regulator) process
  - o Regulator access
  - o Data management
  - o Compliance and non-compliance processes and notification

The work will be facilitated by a suitably skilled consultant.

Updating of the BioSecure HACCP Manual

- General content update (e.g. requirement for property plans, etc.)
- On-farm surveillance methodology & procedures
- Development of quarantine pest management templates
- Document management on-farm record/BioSecure HACCP record matrix

Relevant sections will be updated following a review by a suitably skilled consultant.

| ITEM | TOPIC                          | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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|      |                                | <p>Electronic System Management (on-line) development including:</p> <ul style="list-style-type: none"> <li>• BioSecure HACCP audit portal update as per manual update</li> <li>• Develop grower document management system (e.g. electronic certification)</li> <li>• Develop regulator access levels</li> <li>• Develop program procedures and templates storage and retrieval system</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|      |                                | <p>5. <b>NIASA Cost Benefit Analysis.</b> A Kachenko said that this project study into the econometrics of the program was required to assist in quantifying the benefits associated with the program</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|      |                                | <p>6. <b>Nutrient Budgeting Calculators.</b> A Kachenko indicated that this project will develop a web based calculator based off the US GrowCalc software package which includes an alkalinity calculator, a fertilizer calculator, and a plant growth regulator calculator. They would be housed on the water management toolbox developed under the 2010/2011 research and development project.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|      |                                | <p>7. <b>Access to Minor Use Permits.</b> A Kachenko asked that all IDOs need to provide input into the development of future products for minor use application permits.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|      |                                | <p>8. <b>NGIA Environment Committee Expenses</b> including the development of resources such as the Climate Change Policy Position. A workshop will also be funded under this project to look at standardisation of containers and scope out a framework for a tree specification standard.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 6.2  | Biosecurity Policy development | <p>A Kachenko tabled a summary of the six key strategies that would frame the Policy Position. They are:</p> <ol style="list-style-type: none"> <li>1. <b>Leadership in policy development and investment in the area of quarantine and biosecurity</b> – delivering a biosecurity contingency fund and recognition of the impacts of policy decisions and investment on businesses and their customers.</li> <li>2. <b>Harmonised delivery of quarantine and biosecurity arrangements</b> – a National Pest Risk Assessment Framework delivering a world class biosecurity and quarantine to whole of industry.</li> <li>3. <b>Investment in on-farm support to address quarantine and biosecurity</b> – realignment of investment and a commitment by governments to support on-farm practices, innovation and incentives to adapt, manage and respond to biosecurity and quarantine.</li> <li>4. <b>Recognition of established industry best management practice</b> – recognition and support of the Nursery Production Farm Management System as a third market access instrument for the industry and investment in research, development and extension activities.</li> <li>5. <b>Implement a national greenlife producer scheme</b> – securing the reputation of the Australian nursery and garden industry</li> <li>6. <b>Build greater stakeholder engagement, involvement and deliver a national communication network</b> – building industry confidence</li> </ol> |

| ITEM     | TOPIC                                       | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
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|          |                                             | <p>The Committee agreed to these areas, and said that the language in the final version needs to be strong enough to influence those reading the Policy Position. A Kachenko said that a draft would be presented at the next Environment Committee meeting for sign off.</p> <p><b>ACTION:</b> A Kachenko to provide a draft NGIA policy position on Biosecurity for discussion at the next Environment Committee Meeting.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 6.3      | Government enquiries                        | <p>A Kachenko provided an update on the 'Implementation of model schedules for Commonwealth serious drug offences'. The Committee congratulated the authors on the proposal and asked if there has been any progress. A Kachenko informed the Committee that the Attorney Generals Department were still reviewing the submissions they had received and would keep the Committee updated in future meetings.</p> <p>A Kachenko also updated the committee on the Productivity Commission (PC) review on Agricultural Research and Development. He said that the PC outlined a 50% drop in the government contribution to the Research &amp; development levy over 10 years; however Minister Ludwig opposed this for the next financial year. Despite this, A Kachenko indicated that the reality is there are no certainties with the government contribution and industry had to therefore by strategic in future investments. The PC also indicated that changes will occur to the mechanisms behind the Voluntary Contribution funding, however A Kachenko indicated that these should have negligible impact on the NGI.</p> |
| 6.4      | Levy Update                                 | <p>G Fenton provided an update on the levy. He said that things were progressing with levy Revenue Services accepting that the current legislation will allow growing media to be incorporated without significant changes. The next step would invite media manufacturers together to discuss the proposal. The Committee agreed that this model will be useful in minimising risk with more than one collection agency. General discussion followed covering issues relating to bulk and bagged mixes, time lines and detailed modelling to determine the collection capacity of the proposed levy.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>7</b> | <b>RESEARCH PROPOSALS AND OPPORTUNITIES</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 7.1      | Environmental risk matrix – Attachment      | <p>A Kachenko provided the Environment Committee with the Environmental Risk Matrix. It is based on the risks associated with a range of issues that impact on the profitability of Australian nursery and garden industry. The Committee discussed what areas needed updating to reflect the industry position in 2011.</p> <p><b>ACTION:</b> A Kachenko to update the Environmental Risk Matrix for the next Environment Committee meeting in 2011</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

| ITEM                   | TOPIC                                                    | DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------|----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7.2                    | New projects/issues for consideration                    | <p>A Kachenko noted that a timeline for R&amp;D proposal submission had been tabled to the IDO network in December 2010 and would again be tabled at the upcoming NNAC meeting. Proposals were due on 8 August. He noted that it was very important for each state to have the opportunity to provide input into the R&amp;D program.</p> <p>General discussion entailed from the Committee regarding future R&amp;D issues/project areas. These areas included:</p> <ul style="list-style-type: none"> <li>• The need for Industry market data – value of industry, size, scale, markets. Domestic and international movements.</li> <li>• Efficacy of irrigation disinfestation systems based on life stages of pathogens</li> <li>• New Growing Media options – new media markets</li> <li>• Minor Use Program</li> <li>• Greenlife standards for planting (discussed earlier in the Agenda)</li> <li>• Grower Registration</li> <li>• Videos 'how to' on aspects of on-farm biosecurity and supply chain</li> <li>• Benchmarking data – data activity per action to use for an ABC costing calculator</li> <li>• Canopy Cover Benchmark and Local Government Area review to tie in with Plant Life Balance Phase2</li> <li>• Harmonisation and interstate market access using Nursery Production FMS</li> </ul>            |
| 8                      | GENERAL BUSINESS                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 8.1                    | NGI Research and Development Strategic Investment Review | <p>A Kachenko advised that HAL has required all Peak Industry Bodies to undertake a 5 year RD and E investment plan to focus more on industry development and extension activities as a driver of change. He indicated that in the past, the RD and E investment priorities for the industry have been formulated and presented on a yearly basis. He said that this approach has tended to reinforce a pragmatic decision-making approach, rather than a long-term, staged analysis to determine where investment is needed. In addition, short-term plans do not capture the changing trends and refocussing of partners' and other stakeholders' longer-term visions. A Kachenko indicated that this project will be undertaken over the coming 6 months. G Fenton indicated that funding could come from the existing Environment Committee project under the 2011/2012 budget. A Kachenko tabled the 5 year RD and E investment plan from the Apple and Pear Industry. General discussion followed on the quality of the document and the direction the NGIA needed to focus on. The Committee asked for a copy of the Apple and Pear 5 year RD and E investment plan.</p> <p><b>ACTION:</b> A Kachenko to forward a copy of the Apple and Pear 5 year RD and E investment plan to the Environment Committee Members.</p> |
| 9                      | NEXT MEETING - PROPOSED FRIDAY 4 NOVEMBER 2011           | <p>G Fenton thanked the Committee members for the contributions and thanked A Kachenko on behalf of the Committee for his efforts and enthusiasm in his role.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| MEETING CLOSED 2:30 PM |                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

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# Appendix 2



# ENVIRONMENTAL RISK ASSESSMENT FOR NGI

KEY

- Has High Potential to have serious impact on the profitability of the NGI throughout Australia.
- Issue needs to be monitored as it could move to Red classification.
- Issue is being controlled by NGI activities but requires ongoing diligence.

| Aspect                                                                                                                                     | Sector    | Impact                                          | Risk | NGI actions / proposals                                                                                                                                                                     |
|--------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------------------------------------------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| P<br>E<br>S<br>T<br>S<br><br>&<br><br>D<br>I<br>S<br>E<br>A<br>S<br>E<br>S<br>/<br><br>B<br>I<br>O<br>S<br>E<br>C<br>U<br>R<br>I<br>T<br>Y | Industry  | New Incursions                                  |      | Involvement with PHA - EPPRD                                                                                                                                                                |
|                                                                                                                                            |           | Barriers to plant movement                      |      | NIASA/BioSecure HACCP promotion for market access                                                                                                                                           |
|                                                                                                                                            |           | Control methods                                 |      | IPM - Training workshops                                                                                                                                                                    |
|                                                                                                                                            |           | Product choices                                 |      | Need for access to new products/minor use permits<br>Access to new chemistry                                                                                                                |
|                                                                                                                                            |           | Identification and awareness                    |      | Need for crop monitoring training<br>Adoption of BioSecure HACCP<br>IPM workshops                                                                                                           |
|                                                                                                                                            | Community | Control methods                                 |      | Supplier promotion<br>Development of "Greener Options"<br>Nursery Production FMS                                                                                                            |
|                                                                                                                                            |           | Pest & Disease identification                   |      | Lack of resources in jursidictions<br>Need for clear communication strategy                                                                                                                 |
|                                                                                                                                            |           | Legionella - potting mix                        |      | Ongoing education re "safe use"<br>Crisis Managemnt Planning                                                                                                                                |
| C<br>L<br>I<br>M<br>A<br>T<br>E<br><br>C<br>H<br>A<br>N<br>G<br>E<br><br>&<br><br>V<br>A<br>R<br>I<br>A<br>B<br>I<br>L<br>I<br>T<br>Y      | Industry  | Adaption - Weather impacts- temp, rainfall      |      | Need for regional analysis of impacts<br>Best Management Practices/Accreditation Programs<br>Better predict climate events<br>Energy efficiency calculators<br>Managing possible incursions |
|                                                                                                                                            |           | Mitigation - Intensive horticultural production |      | HortCarbon Tool                                                                                                                                                                             |
|                                                                                                                                            |           | Transport component in distribution             |      | Quantify emissions                                                                                                                                                                          |
|                                                                                                                                            |           |                                                 |      |                                                                                                                                                                                             |
|                                                                                                                                            | Community | Green beneficial impact on environment          |      | Quantify benefits associated with green life                                                                                                                                                |
|                                                                                                                                            |           | Communications                                  |      | Need for education of customers re benefits of green life<br>Need for communications for growers                                                                                            |

|                                                                                                                                |           |                                 |   |                                                                                                                                                                        |
|--------------------------------------------------------------------------------------------------------------------------------|-----------|---------------------------------|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I<br>N<br>V<br>A<br>S<br>I<br>V<br>E<br>P<br>L<br>A<br>N<br>T<br>S<br>/<br>B<br>I<br>O<br>S<br>E<br>C<br>U<br>R<br>I<br>T<br>Y | Industry  | Definition of an invasive plant | ● | Review NGI policy<br>Industry recognised Weed Risk Assessment<br>Need for single lists with Industry input/evidence based<br>Adoption of labelling guidelines          |
|                                                                                                                                |           | Barriers to plant movement      | ● | Focus of state organisations<br>Difficulty in identifying key decision makers                                                                                          |
|                                                                                                                                |           | Testing for Invasiveness        | ● | Industry Recognised Weed Risk Assessment                                                                                                                               |
|                                                                                                                                |           | Plant disposal                  | ● | Guidelines to trade<br>Communication with stakeholders                                                                                                                 |
|                                                                                                                                | Community | Labelling of plants             | ● | Clear identification of invasiveness/Adoption of guidelines                                                                                                            |
|                                                                                                                                |           | Community education             | ● | Furthering education - Grow Me Instead<br>Weed awareness/management                                                                                                    |
|                                                                                                                                |           | Opportunity to RetroFit gardens | ● | Promotion of alternative plants<br>Education on plant disposal<br>Furthering education - Grow Me Instead                                                               |
| W<br>A<br>T<br>E<br>R                                                                                                          | Industry  | Restrictions to supply          | ● | Update NGI Policy<br>Murry Darling Basin proposal<br>Lobbying State based water authorities<br>Nursery Production FMS and existing tools/resources                     |
|                                                                                                                                |           | Contamination                   | ● | Nitrate/Phosphate run off minimisation<br>Pesticide levels in run off minimisation<br>Pathogen contamination<br>Training programs - WaterWorks and NIASA Accreditation |
|                                                                                                                                |           | Use of recycled water           | ● | Supply issues-guarantee of supply, source and cost<br>Treatment performance<br>Health impacts<br>Quality of treated water                                              |
|                                                                                                                                |           | Irrigation/application rate     | ● | Upgrade to new technologies<br>Lack of relevant crop data<br>Best management practices - hand watering guidelines/Accreditation                                        |
|                                                                                                                                | Community | Community education             | ● | Need for water to enjoy product<br>Authorities targeting consumers<br>Water efficiencies and savings                                                                   |
| W<br>A<br>S<br>T<br>E                                                                                                          | Industry  | Management of waste streams     | ● | Need for information on contamination treatment<br>Accreditation programs                                                                                              |
|                                                                                                                                |           | Recycled organics               | ● | Need for alignment of industry with organic industry<br>Quantify waste streams on production sites                                                                     |
|                                                                                                                                |           | Plastic containers              | ● | Development of recycled programs<br>Evaluation of alternative containers                                                                                               |
|                                                                                                                                | Community | Plastic containers              | ● | Develope consumer options for recycling<br>AGCAS                                                                                                                       |

# Appendix 3

# MEETING REPORT

|                                       |                     |
|---------------------------------------|---------------------|
| MEETING WITH:                         | NGIA REPRESENTATIVE |
| Plant Health Australia                | John McDonald       |
| CC:                                   | DATE AND LOCATION   |
|                                       | 12/04/11 SYDNEY     |
| SUBJECT:                              |                     |
| National Myrtle Rust Incident Debrief |                     |

On the 12<sup>th</sup> April 2011 NGIA was invited to attend the Plant Health Australia convened National Myrtle Rust Incident Debrief along with representatives of the commonwealth and state/territory governments. NGIA delivered a paper outlining issues related to the response and suggested a number of improvements (**RED**) for inclusion in any future EPP response. Below is a summarised list of outcomes from this meeting:

## ***Short Term Implementation by Plant Health Australia***

- Further teleconference with participants to have final discussions about Surveillance, Domestic Quarantine and other issues
- Encourage the initiation of a Scientific Advisory Panel (SAP) for each incursion with a formal response plan
- Encourage the involvement of environmental state and federal agencies from the first meeting of CCEPP when identified as an Affected Party
- Develop a standard template for;
  - Research and Development contracts
  - **CCEPP Situation updates**
- Develop a Chapter in PLANTPLAN on triggers for review of responses
- Develop Job Cards for;
  - National Management Group
  - Consultative Committee of Emergency Plant Pests
  - Scientific Advisory Panel
  - Categorisation group
  - **Industry Liaison Officer**
  - **Industry Liaison Coordinator**
  - **Industry Body**
- **Develop an EPP web portal that can hold public images (that can be used by stakeholders), facts and information accessible to all stakeholders for generic use in communication**
- **Ensure where possible timings of EPPRD decision making or support bodies meetings (NMG, CCEPP, and SAP) are held sufficiently apart to enable Parties to brief delegates (or attendees if you do not want to as formal).**
- **Provide further information and explanation of 'consensus' in the EPPRD meeting context**
- **Provide further information to Parties about the concept of an 'interim' response plan**
- **Provide further information to Parties about the industry funded Contingency Plans use in Responses**
- **Provide further information and training to Members for Dispute Resolution Processes under the EPPRD**
- **Provide further information and training at a LPCC level on EPPRD functions and processes**
- **Address underlying misconceptions through appropriate training and provision of information**

- Ensure the continuity of information between EPPRD decision making and support body (CCEPP and SAP) meetings

### ***Longer Term Implementation Plans***

- Pre-emptive Domestic movement conditions included in IBP's and endorsement through DQ before incursion
- Ensure that EPPRD signatory organisations have an appropriate number of personnel trained under the National EPP Training program
- Development of a formal communications structure within PLANTPLAN with clearly identified roles within Local and State Centres to run community engagement in all future EPP operations
- Encourage the adoption of social media tools where appropriate
- Consider resource allocation for paid advertising in all EPP responses where media interest is low
- Formalised process to engage industry and stakeholder "multipliers" to improve dissemination of information from the outset.
- Develop a mechanism for nationally coordinated research priorities, milestones and selection process. Ensuring these are realistic, transparent and achievable across the board
- Develop a procedure for the designation of ownership of results, IP from research and development and additionally criteria and process for release of results
- Develop a procedure for the engagement of stakeholders who are not Signatories to the Emergency Plant Pest Response Deed
- Identify and address issues of confidentiality within EPPRD processes
- Development of a 'verbal' situation update template for use with CCEPP
- Encourage the National Emergency Plant Pest Training Program within jurisdictions and industry with a particular focus on Emergency Management
- Continue work with the National Biosecurity Committees Benchmark Working Group for 'Normal Commitments'

### ***For Further Discussion with Parties***

- Investigate Video teleconferencing options for EPPRD decision making or support bodies meetings (NMG, CCEPP, and SAP)
- Develop the idea for a 'fighting fund' from which resources could be drawn immediately in a response
- In future responses Market Access conditions should be aligned between jurisdictions and within the Lead Agency State. This concept will need further development external to PHA - DQMAWG
- Develop guidance document for when CCEPP members should participate in field visits for appropriate EPP's. This is especially important when there is consideration for funding approval of an eradication Response Plan
- Develop a process for an EPP which is deemed 'non-eradicable' but management is preferable – concept of 'transition to management'

If the above are embraced by all stakeholders it will go a long way to improving the effectiveness of the EPPRD.

# Appendix 4



## POTENTIAL INDUSTRY DEVELOPMENT ACTIVITY SCHEDULE

---

| PROJECT DETAILS | NEEDS ASSESSMENT TEAM RANKING |                |                 |                  | ADDITIONAL COMMENTS |
|-----------------|-------------------------------|----------------|-----------------|------------------|---------------------|
| Description     | Urgency<br>(1-3)              | Imp.<br>(1-3)) | Impact<br>(1-3) | Success<br>(1-3) |                     |
|                 |                               |                |                 |                  |                     |
|                 |                               |                |                 |                  |                     |
|                 |                               |                |                 |                  |                     |
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|                 |                               |                |                 |                  |                     |
|                 |                               |                |                 |                  |                     |
|                 |                               |                |                 |                  |                     |

| PRIORITISATION RANKING GUIDE                                              |                                                                                                                                                                                                                                                                                                                                                                                            |  |  |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| <b>Urgency</b><br>(in the context of the industry's national interest)    | <b>Ranked 1 to 3 with:</b><br><div> <b>1. Very Urgent</b><br/> Must be continued (existing projects) or addressed immediately </div> <div> <b>2. Urgent</b><br/> Must be continued (existing projects) or addressed within the next three years </div> <div> <b>3. Not so Urgent</b><br/> Must be continued (existing projects) or addressed within the next five years </div>             |  |  |
| <b>Importance</b><br>(in the context of the industry's national interest) | <b>Ranked 1 to 3 with:</b><br><div> <b>1. Very Important</b><br/> Critical to the survival of the industry </div> <div> <b>2. Important</b><br/> Important for the industry's development and growth </div> <div> <b>3. Not so Important</b><br/> Would be valuable to do, funds permitting </div>                                                                                         |  |  |
| <b>Impact</b><br>(in the context of the industry's national interest)     | <b>Ranked 1 to 3 with:</b><br><div> <b>1. Greatest Impact</b><br/> Very significant impact on the overall industry's profitability and or future viability </div> <div> <b>2. High Impact</b><br/> Considerable beneficial impact, though not of the highest level </div> <div> <b>3. Moderate Impact</b><br/> Impact is limited or restricted to a certain sector, region or group </div> |  |  |
| <b>Success</b><br>(in the context of the industry's national interest)    | <b>Ranked 1 to 3 with:</b><br><div> <b>1. High</b><br/> Very likely to achieve the outcomes </div> <div> <b>2. Moderate</b><br/> Reasonably likely to achieve the outcomes </div> <div> <b>3. Limited</b><br/> Only a limited chance of achieving the outcomes </div>                                                                                                                      |  |  |



# Appendix 5



**Nursery & Garden Industry**

**Australian**  
**Nursery Industry**  
**Myrtle Rust**  
*(Uredo rangelii)*  
**Management Plan**  
**2011**

**Developed for the**  
**Australian Nursery Industry**

**Production**  
**Wholesale**  
**Retail**

## Acknowledgements

This Myrtle Rust Management Plan has been developed by the Nursery & Garden Industry Queensland (John McDonald - Nursery Industry Development Manager) for the Australian Nursery Industry.

Version 01 February 2011

Photographs sourced from I&I NSW and Queensland DEEDI.

Various sources have contributed to the content of this plan including:

- Nursery Industry Accreditation Scheme Australia (NIASA)
- BioSecure HACCP
- Nursery Industry Guava Rust Plant Pest Contingency Plan
- DEEDI Queensland Myrtle Rust Fact Sheets
- I&I NSW Myrtle Rust Fact Sheets and Updates

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While every effort has been made to ensure the accuracy of contents, Nursery & Garden Industry Queensland accepts no liability for the information.

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## 1. Managing Myrtle Rust in the Australian Nursery Industry

Myrtle rust (*Uredo rangelii*) has the potential to infect all myrtaceous plants in both our built (gardens & landscape) and natural environments plus a range of industries (nursery production, timber, cut flower, etc) along the coastline of Australia. Under threat from this disease, if it becomes widely established, are a number of identified threatened native plant species across Australia plus a number of endangered wildlife habitat(s) that could have a major impact on our natural biodiversity.

In April 2010 Myrtle rust was detected in Australia in the Central Coast area of New South Wales (NSW). A national response was agreed to and a comprehensive surveillance and management program was initiated across NSW. By November 2010 more than 140 infected premises had been identified across NSW culminating in the disease being detected in Queensland in on the 27<sup>th</sup> December 2010.

On December 22<sup>nd</sup> 2010 the Myrtle Rust National Management Group agreed the disease was not technically feasible to eradicate. Due to the impact the disease could have across Australia it was further agreed to implement a structured management plan to limit the establishment of the pathogen within industries and the natural environment.

The development of this industry specific Myrtle Rust Management Plan, by the Australian Nursery Industry, is in direct response to the agreed national position in which the industry participated in developing. As a professional and responsible industry it is appropriate that all growers, wholesalers and retailers apply the relevant strategies to manage Myrtle rust as described in this plan.

Myrtle rust is a notifiable disease in all Australian jurisdictions requiring any detection of the disease be reported to the relevant state or territory biosecurity agency within 24 – 48 hours.

**Exotic Plant Pest Hotline: 1800 084 881**

This **Myrtle Rust Management Plan** has been developed for use by production nurseries and retailers of greenlife including garden centres, greenlife markets (wholesalers), big box hardware, supermarkets, chain stores, etc. The plan provides a detailed framework for growers and retailers to apply on-site in the management of Myrtle rust on plants from the Myrtaceae family. It is recommended that the industry apply this plan to all plants from the Myrtaceae family not only those that have been currently identified as hosts.

For further information on whole of property biosecurity in the nursery industry including on-farm programs such as BioSecure HACCP and the industry Biosecurity Manual go to [www.ngia.com.au](http://www.ngia.com.au) and follow the links.

**Note: State/territory laws and requirements including interstate movement protocols over-ride this Industry Myrtle Rust Management Plan.**

## 2. Myrtaceae Family – Genera

It is possible that all Genera listed may be susceptible to Myrtle rust under optimum conditions.

- |                           |                                     |                         |                         |
|---------------------------|-------------------------------------|-------------------------|-------------------------|
| • <u>Accara</u>           | • <u>Choricarpia</u>                | • <u>Luma</u>           | • <u>Plinia</u>         |
| • <u>Acmena</u>           | • <u>Cleistocalyx</u>               | • <u>Lysicarpus</u>     | • <u>Pseudanmomis</u>   |
| • <u>Acmenosperma</u>     | • <u>Cloezia</u>                    | • <u>Mallostemon</u>    | • <u>Psidium</u>        |
| • <u>Actinodium</u>       | • <u>Conothamnus</u>                | • <u>Marlierea</u>      | • <u>Purpureostemon</u> |
| • <u>Agonis</u>           | • <u>Corymbia</u>                   | • <u>Melaleuca</u>      | • <u>Regelia</u>        |
| • <u>Algrizea</u>         | • <u>Corynanthera</u>               | • <u>Meteoromyrtus</u>  | • <u>Rhodamnia</u>      |
| • <u>Allosyncarpia</u>    | • <u>Cupheanthus</u>                | • <u>Metrosideros</u>   | • <u>Rhodomyrtus</u>    |
| • <u>Amomyrtella</u>      | • <u>Curitiba</u>                   | • <u>Micromyrtus</u>    | • <u>Rinzia</u>         |
| • <u>Amomyrtus</u>        | • <u>Darwinia</u>                   | • <u>Mitrantes</u>      | • <u>Ristantia</u>      |
| • <u>Anqasomyrtus</u>     | • <u>Decaspermum</u>                | • <u>Mitrantia</u>      | • <u>Sannantha</u>      |
| • <u>Anqophora</u>        | • <u>Eremaea</u>                    | • <u>Monimiastrum</u>   | • <u>Scholtzia</u>      |
| • <u>Archirhodomyrtus</u> | • <u>Eucalyptopsis</u>              | • <u>Mosiera</u>        | • <u>Seorsus</u>        |
| • <u>Arillastrum</u>      | • <u>Eucalyptus</u>                 | • <u>Myrceugenia</u>    | • <u>Siphoneugena</u>   |
| • <u>Astartea</u>         | • <u>Eugenia</u>                    | • <u>Myrcia</u>         | • <u>Sphaerantia</u>    |
| • <u>Asteromyrtus</u>     | • <u>Feijoa</u> (syn. <u>Acca</u> ) | • <u>Myrcianthes</u>    | • <u>Stereocaryum</u>   |
| • <u>Austromyrtus</u>     | • <u>Gomidesia</u>                  | • <u>Myrciaria</u>      | • <u>Stockwellia</u>    |
| • <u>Backhousia</u>       | • <u>Gossia</u>                     | • <u>Myrrhinium</u>     | • <u>Syncarpia</u>      |
| • <u>Baeckea</u>          | • <u>Hexachlamys</u>                | • <u>Myrtastrum</u>     | • <u>Syzygium</u>       |
| • <u>Balaustion</u>       | • <u>Homalocalyx</u>                | • <u>Myrtella</u>       | • <u>Taxandria</u>      |
| • <u>Barongia</u>         | • <u>Homalospermum</u>              | • <u>Myrteola</u>       | • <u>Tepualia</u>       |
| • <u>Basisperma</u>       | • <u>Homoranthus</u>                | • <u>Myrtus</u>         | • <u>Thaleropia</u>     |
| • <u>Beaufortia</u>       | • <u>Hottea</u>                     | • <u>Neofabricia</u>    | • <u>Thryptomene</u>    |
| • <u>Blepharocalyx</u>    | • <u>Hypocalymma</u>                | • <u>Neomitranthes</u>  | • <u>Tristania</u>      |
| • <u>Callistemon</u>      | • <u>Kanakomyrtus</u>               | • <u>Neomyrtus</u>      | • <u>Tristaniopsis</u>  |
| • <u>Calothamnus</u>      | • <u>Kania</u>                      | • <u>Ochrosperma</u>    | • <u>Ugni</u>           |
| • <u>Calycolpus</u>       | • <u>Kjellbergiodendron</u>         | • <u>Octamyrtus</u>     | • <u>Uromyrtus</u>      |
| • <u>Calycorectes</u>     | • <u>Kunzea</u>                     | • <u>Osbornia</u>       | • <u>Verticordia</u>    |
| • <u>Calypttranthes</u>   | • <u>Lamarchea</u>                  | • <u>Paramyrciaria</u>  | • <u>Waterhousea</u>    |
| • <u>Calyptrogenia</u>    | • <u>Legrandia</u>                  | • <u>Pericalymma</u>    | • <u>Welchiodendron</u> |
| • <u>Calythropsis</u>     | • <u>Lenwebbia</u>                  | • <u>Phymatocarpus</u>  | • <u>Whiteodendron</u>  |
| • <u>Calytrix</u>         | • <u>Leptospermum</u>               | • <u>Pileanthus</u>     | • <u>Xanthomyrtus</u>   |
| • <u>Campomanesia</u>     | • <u>Lindsayomyrtus</u>             | • <u>Pilidiostigma</u>  | • <u>Xanthostemon</u>   |
| • <u>Carpolepis</u>       | • <u>Lithomyrtus</u>                | • <u>Piliocalyx</u>     |                         |
| • <u>Chamelaucium</u>     | • <u>Lophomyrtus</u>                | • <u>Pimenta</u>        |                         |
| • <u>Chamquava</u>        | • <u>Lophostemon</u>                | • <u>Pleurocalyptus</u> |                         |

**NOTE:** The genera highlighted in yellow have had species, within these genera, return positive detections in Australia based on natural infection up to February 2011.

### 3. Myrtle Rust (*Uredo rangelii*)

Myrtle rust (*Uredo rangelii*), a plant fungal disease native to South America, is a member of the fungal complex known as the Guava rust (*Puccinia psidii*) group and, based on information from Florida, Hawaii and Brazil, Myrtle rust has a limited host range compared to that of Guava rust. The disease infects young, actively growing, emerging leaves, buds, flowers, fruit and shoots of plants within the Myrtaceae family. In Australia to date the most severe infections of the disease have been recorded on *Agonis*, *Tristania*, *Syzygium Jambos* and *Austromyrtus* species.

Myrtle rust may infect plants under a wide range of environmental conditions, however infection rates may be heightened when the following conditions are present:

- Soft new growth/tissue
- High humidity
- Free water on plant surfaces for 6 hours or more
- Night temperatures within 15 - 25°C
- Low light conditions including darkness (minimum of 8 hours) after spore contact can increase germination success
- Life cycle can be as short as 10 – 14 days (spore to spore)

Myrtle rust has the ability to complete its entire lifecycle on a single host plant. This pathogen will infect the plant and, over time as the disease spreads killing the leaves, in heavy infections will eventually kill the plant. As the plant drops dead leaves the pathogen will reinfect new growth limiting the plants ability to recover.

It is possible that as this disease establishes in Australia the host range may grow to include many of the internationally recorded plant species infected by Guava rust. The nursery industry **must** consider **all** myrtaceous species as potential hosts of Myrtle rust.

**Note:** Guava rust (*Puccinia psidii*) is also known as **Eucalyptus rust** and has caused heavy crop losses in the Brazilian hardwood industry through the decimation of planted Eucalyptus seedlings in the field. For identification purposes Myrtle rust and Guava rust are visually and symptomatically identical therefore identification tools are interchangeable.

**The general symptoms of Myrtle rust/Guava rust include:**

**(Myrtle rust generally attacks soft new growth including leaf surfaces, shoots, buds, flowers and fruit)**

- **Small purple flecks with a faint chlorotic (yellow) halo on leaf surfaces**
- **Large purple lesions as a result of flecks coalescing**
- **Purple lesions and bright yellow rust pustules (spores)**
- **Bright yellow rust pustules (spores) on underside of the leaf (young infection)**
- **Bright yellow rust pustules (spores) on both sides of the leaf (mature infection)**
- **Small and large purple lesions and leaf distortion (twisting)**
- **Older lesions can contain brown/grey rust pustules (older spores) on the lesions**

See photographs on pages 16, 17 and 18 of this plan.

(Photographs sourced from I&I NSW and DEEDI Queensland)

**Note:** Myrtle rust spores are believed to remain viable (under optimal conditions) for between 3 – 6 months.

#### 4. Known hosts of Myrtle Rust in Australia (as of February 2011)

| Botanical Name                                        | Common Name                                                        |
|-------------------------------------------------------|--------------------------------------------------------------------|
| <i>Acmena sp.</i>                                     | Lilly pilly                                                        |
| <i>Agonis flexuosa</i>                                | Willow myrtle 'Afterdark' , 'Burgundy', 'Jeddas Dream'             |
| <i>Austromyrtus inophloia</i>                         | see <i>Gossia inophloia</i>                                        |
| <i>Backhousia citriodora</i>                          | Lemon-scented myrtle                                               |
| <i>Backhousia myrtifolia</i>                          | Grey myrtle                                                        |
| <i>Callistemon viminalis</i> (now <i>Melaleuca</i> )  | Weeping bottlebrush                                                |
| <i>Callistemon salignus</i> (now <i>Melaleuca</i> )   | Willow bottlebrush                                                 |
| <i>Callistemon</i> (now <i>Melaleuca</i> )            | 'St Mary MacKillop'                                                |
| <i>Chamelaucium uncinatum</i>                         | Geraldton wax                                                      |
| <i>Choricarpia leptopetala</i>                        | Brown myrtle or Rusty turpentine                                   |
| <i>Eucalyptus agglomerata</i>                         | Blue-leaved stringybark                                            |
| <i>Eucalyptus deanei</i>                              | Mountain blue gum or Deane's gum                                   |
| <i>Eucalyptus pilularis</i>                           | Blackbutt                                                          |
| <i>Eugenia reinwardiana</i>                           | Beach cherry                                                       |
| <i>Gossia gonoclada</i> (syn <i>Austromyrtus</i> )    | Angle-stemmed myrtle                                               |
| <i>Gossia inophloia</i> (syn <i>Austromyrtus</i> )    | 'Aurora' & 'Blushing Beauty' (syn. <i>Austromyrtus inophloia</i> ) |
| <i>Lenwebbia prominens</i>                            | Southern velvet myrtle                                             |
| <i>Leptospermum rotundifolium</i>                     | Round-leaved tea tree                                              |
| <i>Lophomyrtus bullata</i>                            | 'Rainbow's End'                                                    |
| <i>Lophomyrtus x ralphii</i>                          | 'Red Dragon', 'Black Stallion', 'Krinkly'                          |
| <i>Melaleuca alternifolia</i>                         | Tea tree                                                           |
| <i>Melaleuca quinquenervia</i>                        | Broad-leaved paperbark                                             |
| <i>Melaleuca linariifolia</i>                         | 'Claret tops'                                                      |
| <i>Metrosideros collina</i>                           | 'Tahiti' and 'Fiji'                                                |
| <i>Rhodamnia maideniana</i>                           | Smooth scrub turpentine                                            |
| <i>Rhodamnia rubescens</i>                            | Scrub turpentine                                                   |
| <i>Rhodamnia whiteana</i>                             | White malletwood                                                   |
| <i>Rhodomyrtus psidioides</i>                         | Native guava                                                       |
| <i>Syncarpia glomulifera</i>                          | Turpentine                                                         |
| <i>Syzygium anisatum</i>                              | Aniseed myrtle                                                     |
| <i>Syzygium apodophyllum</i>                          | Rex satinash                                                       |
| <i>Syzygium australe</i>                              | 'Meridian Midget'                                                  |
| <i>Syzygium jambos</i>                                | Rose apple                                                         |
| <i>Syzygium luehmannii</i>                            | Small-leaved lilly pilly, riberry                                  |
| <i>Syzygium luehmannii</i> x <i>Syzygium wilsonii</i> | 'Cascade' (lilly pilly)                                            |
| <i>Tristania neriifolia</i>                           | Water gum                                                          |
| <i>Uromyrtus lamingtonensis</i>                       |                                                                    |
| <i>Xanthostemon chrysanthus</i>                       | Golden penda                                                       |



## 5. Fungicide Treatment

For the treatment of plants (Myrtaceae family) the industry has access to an Emergency Permit (**PER12156**) that allows a range of fungicides to be applied for the management of Myrtle rust. Therefore if you intend to treat plants with a fungicide you must have a copy of this permit on-site and you must use the application rates as outlined in the permit. You can download the permit by going to the APVMA website ([www.apvma.gov.au](http://www.apvma.gov.au)) and click on 'Permits' and follow the prompts.

The table below identify's the various fungicides on the permit plus others with existing registrations and lists the '**Fungicide activity**' that will assist in selecting the appropriate product. The '**Chemical group**' is to ensure that an effective rotation program (see 5.2 below) can be applied on-farm if a business intends to have a standard fungicide strategy for the management of Myrtle rust.

### 5.1 Fungicide Table:

| Fungicide trade name                         | Active constituent | Fungicide activity                             | Chemical group (Mode of Action) | Minimum re-treatment interval between consecutive applications |
|----------------------------------------------|--------------------|------------------------------------------------|---------------------------------|----------------------------------------------------------------|
| BAYFIDAN 250 EC FUNGICIDE (PER12156)         | TRIADIMENOL        | Systemic, curative and protectant              | 3                               | 14-21 days                                                     |
| SAPROL FUNGICIDE (PER12156)                  | TRIFORINE          | Systemic, slightly curative and protectant     | 3                               | 7 days                                                         |
| IMTRADE MANCOZEB 750 DF FUNGICIDE (PER12156) | MANCOZEB           | Non-systemic protectant                        | M3                              | 7 days                                                         |
| AMISTAR 250 SC FUNGICIDE (PER12156)          | AZOXYSTROBIN       | Systemic, slightly curative and protectant     | 11                              | 14-21 days                                                     |
| COPPER OXYCHLORIDE (PER12156)                | COPPER OXYCHLORIDE | Non-systemic protectant                        | M1                              | 7-14 days                                                      |
| PLANTVAX 750 WP FUNGICIDE (PER12156)         | OXYCARBOXIN        | Systemic, curative and protectant              | 7                               | 14 days                                                        |
| TILT 250 EC FUNGICIDE (PER12156)             | PROPICONAZOLE      | Systemic, curative and protectant              | 3                               | 7 days                                                         |
| BRAVO (Registered)                           | CHLOROTHALONIL     | Non-systemic, slightly curative and protectant | M5                              | 7 – 14 days                                                    |

### 5.2 Myrtle Rust Fungicide Treatment Rotation Program (Production/Propagation)

| Crop Situation | Fungicide (Fortnight 1) | Fungicide (Fortnight 2)       | Fungicide (Fortnight 3) |
|----------------|-------------------------|-------------------------------|-------------------------|
| Stock receival | Bayfidan                | Plantvax                      | Bayfidan                |
| Propagation    | Bayfidan/Tilt           | Mancozeb/Copper/Bravo/Amistar | Plantvax                |

|                                   |                              |                               |              |
|-----------------------------------|------------------------------|-------------------------------|--------------|
| Growing on<br>(Low level risk)    | Bayfidan/Tilt or<br>Plantvax | Mancozeb/Bravo                | Copper/Bravo |
| Growing on<br>(Medium level risk) | Bayfidan/Tilt or<br>Saprol   | Mancozeb/Copper/Bravo/Amistar | Plantvax     |
| Growing on<br>(High level risk)   | Bayfidan                     | Mancozeb/Copper/Bravo/Amistar | Plantvax     |

**NOTE:** Test fungicide(s) on a sample of the crop to ensure the product is not phytotoxic to your plant species before batch treatment.

### 5.3 Fungicide Application

Applying fungicides to manage Myrtle rust will require the appropriate application equipment is available to ensure the chemical is delivered to the target crop within the acceptable parameters as defined by industry best management practice. The aim of using fungicides to manage Myrtle rust is to ensure the necessary coverage is achieved that allows the fungicide to do its job. Generally a systemic fungicide has some room for error due to the ability of the plant to take the fungicide up and hold it in plant tissue and translocate it throughout the vegetative material. Protectants such as Bravo, copper and mancozeb provide a “protective” film covering the plant surface which requires greater precision in the delivery technique particularly in achieving contact with the underside of vegetative material.

The following list identifies the key aspects that are critical for successful fungicide treatment:

- Personnel applying fungicides appropriately trained (e.g. ChemCert Certified)
- APVMA Permit (**PER12156**) available on-site (defines fungicide rate)
- Fungicide(s) to be applied within “best before” or “use by date”
- Appropriate Personal Protective Equipment available
- Signage advising staff not to re-enter treated areas before designated re-entry period
- Re-entry period guidelines (if not on Label) are: minimum 24hr’s, if possible 48 hr’s
- Ensure overhead irrigation is withheld for approximately 6 - 12 hours after treatment
- Application equipment is appropriate for the development of droplets that are within 150 – 250 microns such as:
  - Hydraulic handguns/booms fitted with either solid or hollow cone nozzles
  - Hydraulic application equipment rated at 600kpa or higher
  - Three point linkage/knapsack misters are operated at correct speeds
  - All equipment regularly calibrated
- Use a chemical surfactant (wetter/sticker) if recommended on the product label
- Test fungicide(s) on a sample of the crop to ensure the product is not phytotoxic to your plant species before batch treatment.

## 6. On-site Biosecurity Actions

Currently (February 2011) Myrtle rust is confined to New South Wales and Queensland and as such it is important that businesses in **all** states and territories, retail, wholesale and production, maintain the highest plant health standards to ensure this disease is either suppressed or not introduced. Any business purchasing, or has sourced, Myrtle rust host plant material from an

outside source **must** survey their stock to ensure freedom from the disease. Other businesses with host plants are advised to maintain a structured monitoring program (weekly) to ensure they remain free of the disease.

**Myrtle rust can move across the landscape and within a production system by:**

- **Vegetative material (alive or dead)**
- **Air movement of spores**
- **Human assisted movement (spores on clothing/vehicles/containers/etc)**
- **Water splash from rain and irrigation**
- **Animals both native and domestic**

The following simple strategies should be applied (where possible) across all businesses growing/selling Myrtle rust host material (myrtaceous species). It is further recommended to consider this program for all plants within the Myrtaceae family:

**6.1 Production Nursery (including propagation)**

- Ensure a high standard of awareness of the disease at all staff levels
- Advise staff to avoid any plant contact prior to arriving at work
- Have on-site disease (Myrtle rust/Guava rust) identification information for all staff
- Train staff on disease identification & good hygiene practices (see State biosecurity websites and Nursery Paper December 2004 Issue No: 11 at [www.ngia.com.au](http://www.ngia.com.au))
- Disinfest all equipment/vehicles that move off-site and return to operate within the production area
- Limit the access of people (visitors & staff) to your production areas
- Implement a hygiene protocol for essential visitors (contractors, etc) to production areas including awareness of previous work sites, inspection of clothing/tools, etc and if required provide disposable overalls while on-site
- Restrict all non-business vehicles from entry to production areas, disinfest if required on-site
- Remove myrtaceous plants from driveways and carparks or prune to avoid possible visitor contact
- Consolidate all myrtaceous plant species within a defined area on-site away from native or landscape planted myrtaceous plant species and avoid direct exposure (buffer) to the prevailing winds of the season
- Allocate specific staff to manage all myrtaceous species
- Source myrtaceous plant material from known professional growers (e.g. NIASA Accredited)
- Request **all** suppliers of myrtaceous plant material provide evidence that they are adhering to this **Myrtle Rust Management Plan** (see attached declaration page 15)
- Inspect and treat (curative fungicide) imported myrtaceous species prior to incorporating into growing areas (7 days and re-inspect). It is recommend this be applied irrespective of the source (**see Sampling Protocol below**)
- **Inspect all myrtaceous species prior to despatch (see Sampling Protocol below)**
- Monitor all myrtaceous plant species weekly across growing areas for disease symptoms (particularly inspect areas of crop that have high humidity e.g. centre of batch and on the side exposed to prevailing winds) (**see Monitoring Protocol below**)
- Ensure growing areas remain free of all waste vegetative material

- Periodically (monthly) survey myrtaceous species growing on-site or along property boundaries/roads/etc. Pay particular attention to plants located upwind based on the most common prevailing wind direction of the season
- **Implement a fortnightly fungicide treatment program across all myrtaceous plants (see recommended program(s) Section 5.2)**
- Treat with a disinfectant (e.g. copper) the growing area upon the completion of the crop growing cycle before placing a new crop down on the production bed
- Dispose of all extraneous vegetative plant material from crop management such as pruning, detailing or from natural desiccation via bulk waste, composting or deep burial
- Assess irrigation system and timing to ensure plant surfaces are dry within a short period (less than 6 hours) after irrigation. Avoid irrigating late afternoon which allows water to sit on surfaces for periods of 6 hours or more during the night. Consider installing drip/capillary or other under canopy irrigation system to myrtaceous plant species
- Access industry guidelines such as NIASA and **BioSecure HACCP** for guidance in developing monitoring/surveillance/inspection programs and recording templates.

## 6.2 Propagation (specifics)

### As above plus:

- Maintain high health practices in propagation (surface/implements/equipment disinfestation, staff hygiene, etc)
- Staff to wash hands before commencing work in propagation area (start of day/after breaks/etc) using a recognised hand sanitation product
- Propagation staff to undertake any field activities at end of day and not to re-enter propagation area.
- If possible provide staff with clothing or coveralls (e.g. disposable overalls) for moving outside propagation into production areas if required
- Avoid using adsorbent surfaces such as timber, cement board, fibro, etc as propagation work surfaces unless covered with 200 micron thick black plastic (replace when cut/punctured/damaged)
- Regularly disinfest propagation surfaces throughout the day at various points such as upon returning from a break, a change of species or batch
- Disinfest all items including surfaces using a recognised industry disinfectant such as:
  - Quaternary ammonium (e.g. PathX, Sporekil, etc)
  - Combination of 70% Methylated Spirits and 30% water
- **Avoid sourcing vegetative propagation material from myrtaceous plant species off-site**
- Ensure **off-site** motherstock for **non-myrtaceous** plant species are inspected and not located within 10m of myrtaceous plants
- Prior to taking vegetative propagation material from **off-site** motherstock survey the area and inspect all myrtaceous plants for signs of Myrtle rust
- Motherstock must be monitored and inspected at weekly intervals
- **Implement a fortnightly fungicide treatment program across all myrtaceous motherstock (see recommended program(s) Section 5.2)**
- All myrtaceous vegetative cuttings should be dipped in a bath containing a recognised disinfectant prior to sticking such as diluted chlorine, a specific quaternary ammonium (PathX/Sporekil/etc) that has low phytotoxicity or an approved fungicide. **NOTE:** Test on a sample to ensure the product is not phytotoxic to your plant species
- Consolidate all myrtaceous plant species within propagation houses (dedicated house) and hardening off/growing areas
- Monitor and inspect struck cuttings on a weekly cycle (see Monitoring Process below)

- **Implement a fortnightly fungicide treatment program across all myrtaceous plant species in propagation houses and hardening off/growing areas (see recommended program(s) Section 5.2)**
- Treat with a disinfectant (e.g. copper) the growing area upon the completion of the crop growing cycle before placing a new crop down on the propagation bed/bench and production bed

### 6.3 Greenlife Markets/Retailers

- Ensure a high standard of awareness of the disease at all staff levels
- Advise staff to avoid any plant contact prior to arriving at work
- Have on-site disease (Myrtle rust/Guava rust) identification information for all staff
- Train staff on disease identification & good hygiene practices (see State biosecurity websites and Nursery Paper December 2004 Issue No: 11 at [www.ngia.com.au](http://www.ngia.com.au))
- Restrict all non-business vehicles from entry to greenlife stocking areas
- If possible remove/prune myrtaceous plant species from carparks, driveways, etc that could come into contact with staff and customers or could overhang greenlife stock
- If possible allocate specific staff to manage all myrtaceous species
- Request all suppliers of myrtaceous plant species to certify the plant material is grown under this industry **Myrtle Rust Management Plan (see declaration template page 15)**
- **Inspect all plant material at receival point with a close inspection of all myrtaceous plant species (see Sampling Protocol below)**
- Consolidate all myrtaceous plant species within a defined area on-site away from native or landscape planted myrtaceous plant species and avoid direct exposure (buffer) to the prevailing winds of the season
- Keep all areas stocking myrtaceous plant species free of waste vegetative material such as leaves/flowers/fruit etc dropped by plants
- Periodically, if possible, apply a recognised disinfectant treatment at monthly intervals over holding area(s) where myrtaceous plant species are stocked/placed/held
- Conduct weekly monitoring inspections of all myrtaceous plant species **(see Monitoring Protocol below)**
- Periodically (monthly) survey myrtaceous species growing on-site or along property boundaries/roads/driveways, etc. Pay particular attention to plants located upwind based on the most common prevailing wind direction of the season
- Dispose of all extraneous vegetative plant material from crop management such as pruning, detailing or from natural desiccation via bulk waste, composting or deep burial
- Have staff inspect all myrtaceous plant species at paypoint(s)
- Assess irrigation system and timing to ensure leaf surfaces are dry within short period after irrigation. Avoid irrigating late afternoon which allows water to sit on surfaces for periods of 6 hours or more during the night. Consider installing drip/capillary or other under canopy irrigation system to myrtaceous plant species
- Access industry guidelines such as NIASA and **BioSecure HACCP** for guidance in developing monitoring/surveillance/inspection programs and recording templates

## 7. Monitoring and Inspection Sampling Protocol

### 7.1 Monitoring Process

The following table provides growers with the number of plants required to complete an appropriate crop monitoring plan. All aerial parts of the selected plant must be inspected

including upper and lower surfaces of leaves with a keen focus on young growth, buds, flowers, etc.

### Crop Monitoring Process

|                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Enter each block or bench of plant material looking for abnormal plant symptoms                                                                                                   |
| Walk at random through the area in a zigzag pattern                                                                                                                               |
| Take at least 10 minutes to inspect 10 to 20 plants or tube/plug trays per 100m <sup>2</sup> of production area                                                                   |
| Inspect the tops and bottoms of leaves/stems/buds/fruit looking for any direct evidence of the disease                                                                            |
| Inspect the entire plant if it has six or fewer leaves                                                                                                                            |
| With larger plants, select six leaves from all parts of the plant (upper, middle, lower) and examine them individually.                                                           |
| Inspect the length of all stems and branches for insects, mites, and disease symptoms                                                                                             |
| During individual plant inspection, strike the foliage over a white sheet of paper or a paper plate to dislodge spores for easier viewing                                         |
| If a suspect infection is identified either leave it in-situ or place the plant in a plastic bag (if at dispatch) and contact the relevant state/territory biosecurity agency.    |
| Record on the 'Crop Monitoring Record' sheet (see BioSecure HACCP) relevant monitoring information                                                                                |
| Record the minimum and maximum temperatures and reset the thermometer                                                                                                             |
| Observe any situational problems such as malfunctioning sprinkler heads                                                                                                           |
| Using an identification guide, identify any symptoms observed.                                                                                                                    |
| Routinely inspect growing areas and remove alternate hosts and reservoirs of disease and insect vectors, including weeds, crop residue, and old plants that will not be marketed. |

### 7.2 Sampling Process

The following tables provide growers with the number of plants required to complete an appropriate sample size for in-field and consignment inspections. All aerial parts of the selected plant must be inspected including upper and lower surfaces of leaves with a keen focus on young growth.

#### Sampling Methodology

|                                                                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The plants, cartons, trays or containers forming a consignment should be inspected as close as practicable and not more than 48 hours prior to the time of dispatch |
| Before undertaking the inspection the Nursery Manager will determine the sampling to be applied to the consignment as per below methodology.                        |
| Depending on the size of the consignment one of the two sampling methods (below) may be used                                                                        |
| The number of plants/ cartons/trays/containers selected for inspection must be chosen at random.                                                                    |

#### Sampling method

| Number of Plants in Consignment | Number of Plants to be inspected/sampled |
|---------------------------------|------------------------------------------|
| 1 to 20                         | All plants                               |

|             |                                             |
|-------------|---------------------------------------------|
| 21 to 200   | A minimum of 20 plants                      |
| 200 or more | 20 plants plus 2 plants of each 100 thereof |

**OR**

| CONSIGNMENT                                                | SAMPLE SIZE                                                |
|------------------------------------------------------------|------------------------------------------------------------|
| Number of cartons/trays/containers forming the consignment | Number of cartons/trays/containers to be inspected/sampled |
| 2 - 15                                                     | 2                                                          |
| 16 – 50                                                    | 3                                                          |
| 51 – 150                                                   | 5                                                          |
| 151 – 500                                                  | 5                                                          |
| 501 – 3200                                                 | 8                                                          |
| 3201 AND OVER                                              | 13                                                         |

**NOTE:** The Australian Nursery Industry has a complete guide for on-farm biosecurity protocols and procedures (BioSecure HACCP) available from state associations. Information on sterilisation, disinfestation, sanitation, quarantine, monitoring and inspecting, etc is available in this concise manual.

## 8. Interstate Movement Controls

Since early May 2010 there have been various movement controls put in place by a number of state and territory plant health agencies to manage the real or perceived risks associated with the movement of host plant material. The following table summarises the status of current Myrtle rust movement controls by jurisdiction as at February 2011:

### Movement Controls February 2011

| Jurisdiction       | Myrtle Rust Movement Controls                                              |
|--------------------|----------------------------------------------------------------------------|
| Queensland         | Restrictions on Myrtaceous plants from an infected jurisdiction            |
| New South Wales    | Pest Quarantine Area (Gosford/Wyong)                                       |
| Victoria           | Restrictions on Myrtaceous plants from an infected jurisdiction            |
| South Australia    | Restrictions on Myrtaceous plants from an infected jurisdiction            |
| Northern Territory | Restrictions on Myrtaceous plants from an infected jurisdiction            |
| Western Australia  | Restrictions on Myrtaceous plants from <b>all Australian</b> jurisdictions |
| Tasmania           | Restrictions on Myrtaceous plants from <b>all Australian</b> jurisdictions |

**Note:** WA and TAS will not accept plants of the Myrtaceae family irrespective of treatment.

### State/Territory Biosecurity Agency Contact Numbers:

Queensland – 07 3239 3980

Western Australia - (08) 9334 1800

South Australia - 1300 666 010

Victoria - 13 61 86

Tasmania - (03) 6233 3352

Northern Territory - (08) 8999 2118

New South Wales - 1800 084 881

**NOTE:** Any business despatching Myrtle rust host material interstate must follow the import or movement controls of the receiving jurisdiction.

# Myrtle Rust Management Plan Declaration

**Business Name:**.....

**Address:**.....

**Telephone:**..... **Email:**.....

**Invoice Number:**..... **Date:**.....

I the undersigned declare that ..... has implemented the Australian Nursery Industry **Myrtle Rust Management Plan** (the plan) and is applying all relevant aspects of the plan to all Myrtaceous plant species grown on-site. All myrtaceous plants in this consignment (as per Invoice) have been treated under the plan.

..... has applied the following protocols of the plan to ensure the risk of receiving/introducing and/or distributing Myrtle rust is reduced and managed to the best of our ability.

**Note:** (Insert business name in the above blank fields)

| PROTOCOL IMPLEMENTED                                                                                                           | N/A | Y/N | PROTOCOL IMPLEMENTED                                                                                  | N/A | Y/N |
|--------------------------------------------------------------------------------------------------------------------------------|-----|-----|-------------------------------------------------------------------------------------------------------|-----|-----|
| Myrtaceous plant material is imported onto this site(s)                                                                        |     |     | Myrtaceous plant material propagated is sourced on-site                                               |     |     |
| All myrtaceous plant material is propagated and grown on-site(s) (no imported material)                                        |     |     | Myrtaceous plant material propagated is sourced off-site                                              |     |     |
| All myrtaceous plant material imported is accompanied by this Declaration from suppliers                                       |     |     | All myrtaceous plant material propagated comes from Motherstock inspected and treated as per the plan |     |     |
| All myrtaceous plant material imported is inspected upon receipt by trained personnel                                          |     |     | A sound hygiene system has been implemented across all aspects of myrtaceous plant production         |     |     |
| All myrtaceous plant material imported is treated with a curative fungicide upon receipt                                       |     |     | A sound waste disposal system for greenlife residue is in place                                       |     |     |
| All myrtaceous plant material grown is monitored & inspected at weekly intervals                                               |     |     | Visitor vehicles are denied access to production area                                                 |     |     |
| All myrtaceous plant material grown is treated at fortnightly intervals as recommended under the fungicide program in the plan |     |     | A hygiene system is in place for essential visitors to the production area                            |     |     |

.....

**Name**

.....

**Signature**





Photographs sourced from I&I NSW and Qld DEEDI









# Appendix 6

INDUSTRY BIOSECURITY PLAN  
FOR THE NURSERY & GARDEN INDUSTRY

## Threat Specific Contingency Plan

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### Aphid transmitted viruses

Specific examples detailed in this plan:

*Plum pox potyvirus*

*Tobacco etch virus*

Plant Health Australia

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# 1 Purpose and background of this contingency plan

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This contingency plan provides background information on the pest biology and available control measures to assist with preparedness for an incursion into Australia of a range of viruses that are transmitted by aphids. In this contingency plan viruses have been used as examples of those considered to be of greatest economic impact and risk to the Nursery and Garden Industry. It should be noted that some aphid transmitted viruses with a high economic impact are already present in Australia.

The contingency plan provides guidelines and options for steps to be undertaken and considered when developing a Response Plan for incursion of the virus pests. 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.

This contingency plan was developed for the Nursery and Industry Australia (NGIA), and therefore is focused on production nurseries covered by this association. In the event of an incursion, operations that are not covered by the NGIA or another Emergency Plant Pest Response Deed (EPPRD) signatory (e.g. retail nurseries), will not be represented or have a decision making say in any arrangements for emergency response.

The information for this plan has been primarily obtained from documents as cited in the reference section. For each virus, information on background, life cycle, host range, distribution, symptoms and management/control is given.

## 2 Australian nursery industry

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The Australian nursery industry is a significant horticultural sector with a combined supply chain (production to retail/grower) valued at more than \$6 billion dollars annually. The industry employs approximately 45,000 people spread over more than 20,000 small to medium sized businesses including production nurseries and retail outlets. The industry is located predominantly along the Australian coastline and in major inland regions servicing urban and production horticulture.

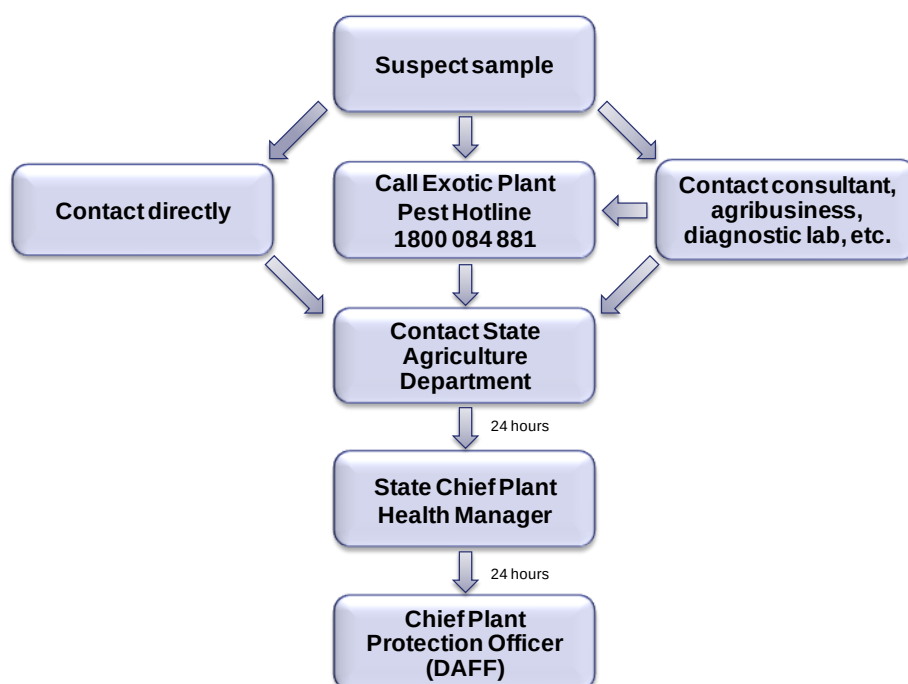
Nursery production is a highly diverse primary industry servicing the broader \$14 billion horticultural sector within Australia (Table 1). A pest incursion is likely to impact market access (see Section 11.7 Appendix 7).

**Table 1.** Nursery production supply sectors within Australian horticulture

| Production Nursery                    | Horticultural markets            | Economic value           |
|---------------------------------------|----------------------------------|--------------------------|
| Container stock <sup>1</sup>          | Ornamental/urban horticulture    | \$2 billion retail value |
| Foliage plants <sup>1</sup>           | Interior-scapes                  | \$87 million industry    |
| Seedling stock <sup>2</sup>           | Vegetable growers                | \$3.3 billion industry   |
| Forestry stock <sup>3</sup>           | Plantation timber                | \$1.7 billion industry   |
| Fruit and nut tree stock <sup>2</sup> | Orchardists (citrus, mango, etc) | \$5.2 billion industry   |
| Landscape stock <sup>1</sup>          | Domestic & commercial projects   | \$2 billion industry     |
| Plug and tube stock <sup>4</sup>      | Cut flower                       | \$319 million industry   |
| Revegetation stock <sup>1</sup>       | Farmers, government, landcare    | \$109 million industry   |
| Mine revegetation                     | Mine site rehabilitation         | Value unknown            |
| Total horticultural market value      |                                  | \$14.5 billion           |

## 2.1 Notification process for the reporting of suspect pests

Early detection and reporting may prevent or minimise the long-term impact of an incursion into Australia of aphid transmitted viruses.

**Figure 1.** Notification process for the reporting of suspect pests

<sup>1</sup> Data sourced from Market Monitor

<sup>2</sup> Data sourced from Horticultural Handbook 2004

<sup>3</sup> Data sourced from ABARE 2005

<sup>4</sup> Data sourced from industry

### 3 Eradication or containment decision matrix

The decision to eradicate should be based on the potential economic impact of host damage resulting from aphid transmitted virus infection, the cost of eradication and on technical feasibility. Eradication costs must factor in long term surveys to prove the success of the eradication program. A minimum of two years with no detections of the virus may be necessary to confirm that no aphid transmitted virus infections remain before pest free status can be declared. The timeframe needs to be considered on a case by case basis, based both on the size of the infection, the degree and distribution of the pest with the final decision determined by the National Management Group.

No specific eradication matrix has been determined for aphid transmitted viruses; however, the general decision process as outlined in Figure 2 and Table 2 should be followed in determining if an incursion of this pest will be eradicated or managed/contained. The final decision between eradication and management will be made through the National Management Group.

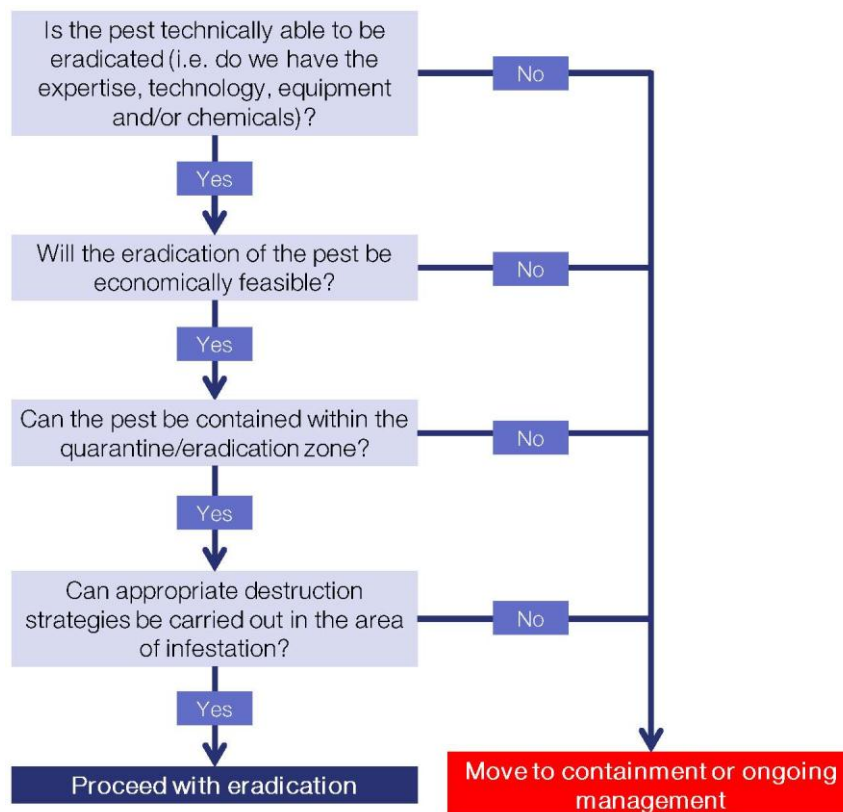


**Figure 2.** Decision outline for the response to an exotic pest incursion

**Table 2.** Factors considered in determining whether eradication or alternative action will be taken for an EPP Incident (taken from Appendix 12 of PLANTPLAN)

| Factors favouring eradication                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Factors favouring alternative action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Cost/benefit analysis shows significant economic or amenity loss to industry or the community if the organism establishes.</li> <li>• Physical barriers and/or discontinuity of hosts between production districts.</li> <li>• Cost effective control difficult to achieve (e.g. limited availability of protectant or curative treatments).</li> <li>• The generation time, population dynamics and dispersal of the organism favour more restricted spread and distribution.</li> <li>• Pest biocontrol agents not known or recorded in Australia.</li> <li>• Vectors discontinuous and can be effectively controlled.</li> <li>• Outbreak(s) few and confined.</li> <li>• Trace back information indicates few opportunities for secondary spread.</li> <li>• Weather records show unfavourable conditions for pest development.</li> <li>• Ease of access to outbreak site and location of alternate hosts.</li> </ul> | <ul style="list-style-type: none"> <li>• Cost/benefit analysis shows relatively low economic or environmental impact if the organism establishes.</li> <li>• Major areas of continuous production of host plants.</li> <li>• Cost effective control strategies available.</li> <li>• Short generation times, potential for rapid population growth and long distance dispersal lead to rapid establishment and spread.</li> <li>• Widespread populations of known pest biocontrol agents present in Australia.</li> <li>• Vectors unknown, continuous or difficult to control.</li> <li>• Outbreaks numerous and widely dispersed.</li> <li>• Trace back information indicates extensive opportunities for secondary spread.</li> <li>• Weather records show optimum conditions for pest development.</li> <li>• Terrain difficult and/or problems accessing and locating host plants.</li> </ul> |

## 4 Pest information/status

### 4.1 Pest details - viruses

A large number of viruses are spread, at least to a degree, by aphids, including viruses from the families Bromoviridae, Caulimoviridae, Comoviridae, Closteroviridae, Luteoviridae, Potyviridae, Sequiviridae and some Nanoviruses and Sobemoviruses from unassigned families (Ng and Perry 2004). Of these families, the family Potyviridae contains the majority of aphid transmitted viruses, predominantly in the genus *Potyvirus*, which is the focus of this Contingency Plan. Brault *et al.* (2010) reported that according to the International Committee of Taxonomy of Viruses the *Potyvirus* genus contains 125 definitive species and a further 88 tentative species. Many of these viruses are present and impact on crops in Australia, including *Bean common mosaic virus*, *Bean yellow mosaic virus*, *Celery mosaic virus*, *Johnson grass mosaic virus*, *Papaya ringspot virus*, *Pea seed-borne mosaic virus*, *Peanut mottle virus*, *Sugarcane mosaic virus*, *Sweet potato feathery mottle virus*, *Sweet potato virus Y*, *Turnip mosaic virus* and *Watermelon mosaic virus* (Gibbs *et al.* 2008). A list of definitive *Potyvirus* species that are exotic to Australia are listed in Table 3. Around 100 viruses tentatively classified as belonging to the genus *Potyvirus* also exist.

The *Potyvirus* group is named after the type species, *Potato virus Y*, and all viruses in this group can be transmitted by aphids (Danci *et al.* 2009). Several aphid species may transmit each *Potyvirus* and some are also transmitted in seeds (Gibbs *et al.* 2008). The viruses are transmitted mechanically by the mouthparts of aphids and are non-persistent and non-circulative (Danci *et al.* 2009). Non-circulative refers to the relatively short retention time of the virus by the vector (Brault *et al.* 2010),

meaning that the vectors only remain viruliferous for a period of minutes to hours (Ng and Perry 2004). Non-persistent transmission is characterised by short acquisition periods (seconds) and inoculation periods (minutes), where semi-persistent transmission refers to acquisition over minutes to hours, and retention of the virus by the vector for hours (Brault *et al.* 2010). For this reason, aphids can normally only carry the virus short distances; however, if strong winds are present then aphids can move large distances more quickly.

In this contingency plan specific pest information and status will be given for the aphid vector, as well as *Plum pox virus (Potyvirus)*, a virus of high risk to plum and summerfruit species, and *Tobacco etch virus (Potyvirus)*, a virus of risk to the Solanaceae family. These viruses have been chosen because of their economic importance and potential relevance to the Australian nursery industry. It should be noted however that for each virus in this family, specific information would be required on symptoms, host range, diagnosis, geographic distribution as well as risk ratings for entry, establishment, spread and economic impact.

**Table 3.** Exotic aphid transmitted definitive Potyviruses and their perceived importance to Australian plant industries (virus data modified from Danci *et al.* 2009).

| Virus                                            | Acronym | Industry High Priority Pest | Industry Threat Summary Tables |
|--------------------------------------------------|---------|-----------------------------|--------------------------------|
| <i>Alstroemeria mosaic virus</i> <sup>5</sup>    | AIMV    |                             |                                |
| <i>Amaranthus leaf mottle virus</i>              | AmLMV   |                             |                                |
| <i>Araujia mosaic virus</i>                      | ArjMV   |                             |                                |
| <i>Artichoke latent virus</i>                    | ALV     |                             |                                |
| <i>Asparagus virus 1</i>                         | AV-1    |                             | Nursery & Garden               |
| <i>Azuki bean mosaic virus</i>                   |         |                             |                                |
| <i>Bean common mosaic necrosis virus</i>         | BCMNV   |                             |                                |
| <i>Beet mosaic virus</i>                         | BtMV    |                             |                                |
| <i>Bidens mottle virus</i>                       | BiMoV   |                             |                                |
| <i>Blackeye cowpea mosaic virus</i> <sup>6</sup> |         |                             |                                |
| <i>Calanthe mild mosaic virus</i>                | CalMMV  |                             |                                |
| <i>Cardamom mosaic virus</i>                     | CdMV    |                             |                                |
| <i>Carnation vein mottle virus</i>               | CVMoV   |                             |                                |
| <i>Carrot thin leaf virus</i>                    | CTLV    |                             | Vegetables                     |
| <i>Chilli veinal mottle virus</i>                | ChiVMV  |                             |                                |
| <i>Cocksfoot streak virus</i>                    | CSV     |                             |                                |
| <i>Commelina mosaic virus</i>                    | ComMV   |                             |                                |
| <i>Crocus tomasinianus virus</i>                 |         |                             |                                |

<sup>5</sup> One report in Vic in APPD

<sup>6</sup> One report in Qld in APD

| Virus                                      | Acronym | Industry High Priority Pest | Industry Threat Summary Tables |
|--------------------------------------------|---------|-----------------------------|--------------------------------|
| <i>Cowpea green vein banding virus</i>     | CGVBV   |                             |                                |
| <i>Dendrobium mosaic virus</i>             |         |                             |                                |
| <i>Dasheen mosaic virus</i>                | DsMV    |                             |                                |
| <i>Datura shoestring virus</i>             | DSTV    |                             |                                |
| <i>Dioscorea green banding virus</i>       |         |                             |                                |
| <i>Endive necrotic mosaic virus</i>        | ENMV    |                             |                                |
| <i>Freesia mosaic virus</i>                | FreMV   |                             |                                |
| <i>Garlic potyvirus</i>                    |         |                             |                                |
| <i>Garlic virus</i>                        |         |                             |                                |
| <i>Gloriosa stripe mosaic virus</i>        | GSMV    |                             |                                |
| <i>Groundnut eyespot virus</i>             | GEV     |                             |                                |
| <i>Guar green sterile virus</i>            |         |                             |                                |
| <i>Guinea grass mosaic virus</i>           | GGMV    |                             | Grains                         |
| <i>Helenium virus Y</i>                    | HVY     |                             |                                |
| <i>Henbane mosaic virus</i>                | HMV     |                             |                                |
| <i>Hippeastrum mosaic virus</i>            | HiMV    |                             |                                |
| <i>Hyacinth mosaic virus</i>               | HyaMV   |                             |                                |
| <i>Iris fulva mosaic virus</i>             | IFMV    |                             |                                |
| <i>Iris mild mosaic virus</i> <sup>7</sup> | IMMV    |                             |                                |
| <i>Iris severe mosaic virus</i>            | ISMV    |                             |                                |
| <i>Jonquil mild mosaic virus</i>           |         |                             |                                |
| <i>Kalanchoe mosaic virus</i>              | KMV     |                             |                                |
| <i>Konjak mosaic virus</i>                 | KonMV   |                             |                                |
| <i>Lily mottle virus</i>                   | LiMoV   |                             |                                |
| <i>Maize dwarf mosaic virus</i>            | MDMV    | Grains                      | Grains                         |
| <i>Moroccan watermelon mosaic virus</i>    | WMMV    |                             |                                |
| <i>Narcissus degeneration virus</i>        | NDV     |                             |                                |
| <i>Narcissus yellow stripe virus</i>       | NYSV    |                             |                                |
| <i>Nerine yellow stripe virus</i>          | NeYSV   |                             |                                |

<sup>7</sup> One report in Vic in APPD

| Virus                                     | Acronym | Industry High Priority Pest | Industry Threat Summary Tables                 |
|-------------------------------------------|---------|-----------------------------|------------------------------------------------|
| <i>Nothoscordum mosaic virus</i>          | NoMV    |                             |                                                |
| <i>Onion yellow dwarf</i>                 | OYDV    |                             |                                                |
| <i>Ornithogalum mosaic virus</i>          | OrMV    |                             |                                                |
| <i>Parsnip mosaic virus</i>               | ParMV   |                             |                                                |
| <i>Pea mosaic virus</i>                   |         |                             |                                                |
| <i>Pea necrosis virus</i>                 |         |                             |                                                |
| <i>Pea seed-borne mosaic virus</i>        | PSbMV   |                             |                                                |
| <i>Peanut chlorotic ring mottle virus</i> |         |                             |                                                |
| <i>Peanut mild mottle virus</i>           |         |                             |                                                |
| <i>Peanut stripe virus</i>                |         |                             | Grains                                         |
| <i>Pepper mottle virus</i>                | PepMoV  |                             |                                                |
| <i>Pepper severe mosaic virus</i>         | PeSMV   |                             |                                                |
| <i>Pepper vein banding mosaic virus</i>   |         |                             |                                                |
| <i>Pepper veinal mottle virus</i>         | PVMV    |                             |                                                |
| <i>Peru tomato virus</i>                  | PTV     |                             |                                                |
| <i>Petunia flower mottle virus</i>        | PfMoV   |                             |                                                |
| <i>Plum pox virus</i>                     | PPV     | Cherry, Summerfruit         | Cherry, Nursery & Garden, Almonds, Summerfruit |
| <i>Pokeweed mosaic virus</i>              | PkMV    |                             |                                                |
| <i>Potato virus A</i>                     | PVA     |                             | Potatoes                                       |
| <i>Potato virus V</i>                     | PVV     |                             | Potatoes                                       |
| <i>Rembrandt tulip breaking virus</i>     | RTBV    |                             |                                                |
| <i>Sesame mosaic virus</i>                | SeMV    |                             |                                                |
| <i>Shallot yellow stripe virus</i>        | SYSV    |                             |                                                |
| <i>Sorghum mosaic virus</i>               | SrMV    | Sugarcane                   | Sugarcane, grains                              |
| <i>South African passiflora virus</i>     |         |                             |                                                |
| <i>Statice virus Y</i>                    |         |                             |                                                |
| <i>Sweet potato A</i>                     |         |                             |                                                |
| <i>Sweet potato chlorotic leaf spot</i>   |         |                             |                                                |
| <i>Sweet potato internal cork</i>         |         |                             |                                                |
| <i>Sweet potato latent virus</i>          | SwPLV   |                             |                                                |



| Virus                                    | Acronym | Industry High Priority Pest | Industry Threat Summary Tables |
|------------------------------------------|---------|-----------------------------|--------------------------------|
| <i>Sweet potato russet crack</i>         |         |                             |                                |
| <i>Tamarillo mosaic virus</i>            | TamMV   |                             |                                |
| <i>Telfairia mosaic virus</i>            | TeMV    |                             |                                |
| <i>Tobacco etch virus</i>                | TEV     |                             |                                |
| <i>Tobacco vein banding mosaic virus</i> | TVBMV   |                             |                                |
| <i>Tobacco vein mottling virus</i>       | TVMV    |                             |                                |
| <i>Tulip breaking virus</i> <sup>8</sup> | TBV     |                             |                                |
| <i>Tulip chlorotic blotch virus</i>      |         |                             |                                |
| <i>Tulip top breaking virus</i>          |         |                             |                                |
| <i>Vanilla necrosis virus</i>            |         |                             |                                |
| <i>Wakegi yellow dwarf virus</i>         | WYDV    |                             |                                |
| <i>Welsh onion yellow stripe virus</i>   |         |                             | Onion                          |
| <i>White lupin mosaic virus</i>          |         |                             |                                |
| <i>Wisteria vein mosaic virus</i>        | WVMV    |                             |                                |
| <i>Yam mild mosaic virus</i>             | YMMV    |                             |                                |
| <i>Yam mosaic virus</i>                  | YMV     |                             |                                |
| <i>Zucchini yellow fleck virus</i>       | ZYFV    |                             |                                |

## 5 Pest information/status – aphid vectors

### 5.1 Pest details – aphid vectors

**Taxonomic position:** Kingdom, Animalia; Phylum, Arthropoda; Class, Insecta; Order, Hemiptera; Suborder, Sternorrhyncha; Family, Aphididae.

Over 200 aphid species act as vectors for plant viruses, accounting for around 50% of insect-vectorized viruses (Nault 1997). Most aphid vectors are from the subfamily Aphidinae with a small proportion of vectors from nine other subfamilies (Ng and Perry 2004). Aphids are ideal vectors of viruses because many have wide plant host ranges, they have piercing-sucking mouthparts to facilitate the delivery of viruses into plant cells and they have high rates of reproduction, allowing disease epidemics to develop (Ng and Perry 2004).

The major aphid vectors of Plum Pox Virus (PPV) are *Aphis spiraecola* and *Myzus persicae*, and these two vector species are also two of the twelve known vectors of Tobacco etch virus (TEV). Thus,

<sup>8</sup> Two records of this in Vic in APPD, one was at Knoxfield.

this contingency plan will focus on these two vectors (both of which are present in Australia) as examples of aphid vectors of viruses (Table 4).

**Table 4.** Examples of aphid vectors of exotic virus threats to the Nursery & Garden Industry

| Scientific name         | Synonyms                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Common names                       |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| <i>Aphis spiraecola</i> | <i>Anuraphis erratica</i> del Guercio, 1917, <i>Aphis bidentis</i> Theobald, 1929, <i>Aphis citricola</i> van der Goot, 1912, <i>Aphis croomiae</i> Shinji, 1922, <i>Aphis deutziae</i> Shinji, 1922, <i>Aphis malvoides</i> van der Goot, 1917, <i>Aphis mitsubae</i> Shinji, 1922, <i>Aphis nigricauda</i> van der Goot, 1917, <i>Aphis pirifoliae</i> Shinji, 1922, <i>Aphis pseudopomi</i> Blanchard, 1939, <i>Aphis pseudopomi</i> Bertels, 1973, <i>Aphis virburnicolens</i> Swain, 1919                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Green citrus aphid<br>Spirea aphid |
| <i>Myzus persicae</i>   | <i>Aphis convolvuli</i> Kaltenbach, 1843, <i>Aphis cynoglossi</i> Walker, 1848, <i>Aphis derelicta</i> Walker, 1849, <i>Aphis dianthi</i> Schrank, 1801, <i>Aphis dubia</i> Curtis, 1842, <i>Aphis egressa</i> Walker, 1849, <i>Aphis malvae</i> Mosl., 1841, <i>Aphis persicae</i> Sulzer, 1776, <i>Aphis persiciphila</i> , <i>Aphis persola</i> Walker, 1848, <i>Aphis rapae</i> Curtis, 1842, <i>Aphis redundans</i> Walker, 1849 sec. Laing, 1925, <i>Aphis suffragans</i> Walker, 1848, <i>Aphis tuberoscellae</i> , <i>Aphis vastator</i> , <i>Aphis vulgaris</i> Kyber, 1815 (sec. Walker), <i>Aulacorthum convolvuli</i> , <i>Myzodes persicae</i> (Sulzer), <i>Myzodes tabaci</i> Mordvilko, 1914, <i>Myzoides persicae</i> , <i>Myzus dianthi</i> (Schrank), <i>Myzus malvae</i> Oestl., 1886 (sec. Theob.), <i>Myzus nicotianae</i> Blackman, <i>Myzus pergandei</i> Sanders, 1901 sec. Patch, <i>Myzus persicae</i> var. <i>cerastii</i> Theobald, <i>Myzus persicae</i> var. <i>sanguisorbella</i> Theobald, 1926, <i>Nectarosiphon persicae</i> (Sulzer), <i>Phorodon cynoglossi</i> Williams, 1891 sec. Davis, 1911, <i>Phorodon persicae</i> (Sulzer), <i>Rhopalosiphum betae</i> Theobald, 1913, <i>Rhopalosiphum calthae</i> Koch, 1854, <i>Rhopalosiphum dianthi</i> , <i>Rhopalosiphum lactucellum</i> , <i>Rhopalosiphum lactucellum</i> Theobald, 1915, <i>Rhopalosiphum persicae</i> , <i>Rhopalosiphum solani</i> Theobald, 1912 nonKalt, 1843, <i>Rhopalosiphum tuberosellae</i> Theobald, 1922, <i>Rhopalosiphum tulipae</i> Thos., 1879 sec. Davis, 1911, <i>Siphonophora achyranthes</i> Mon., 1879, <i>Siphonophora nasturtii</i> Koch, 1855 | Green peach aphid                  |

### 5.1.1 Background

Both *Myzus persicae* and *Aphis spiraecola* are widespread in Australia and are pests of many agriculturally important crops. They cause damage to plants directly as their piercing-sucking mouthparts are inserted into the plant tissue to feed on leaves, green shoots and flowers. Leaves may curl as a result of feeding damage, and the large quantities of honeydew produced may result in blackening of leaves and fruit due to sooty mould.

### 5.1.2 Life cycle

Aphids can propagate parthenogenically, that is, females do not need to mate to produce young and no eggs are laid. Sexual and parthenogenic reproduction alternate in the life cycle, with sexual forms typically appearing in autumn to oviposit overwintering eggs on the primary host (Komazaki 1993). Eggs hatch in spring, and each hatched larva develops into a mother which reproduces parthenogenically (Komazaki 1993). Adult females can be wingless or winged, with the presence of wings indicating a decline in food quality or overcrowding (Broughton 2007).

Development of *M. persicae* can be rapid, often 10 to 12 days for a complete generation though in cooler temperatures the life cycle may last up to 50 days (Toba 1964). Fertility drops rapidly at temperatures over 30°C, but on average each female gives rise to 50-80 nymphs (wingless forms lay more eggs than winged forms). Over 20 annual generations have been reported in mild climates.

Further, longevity of *M. persicae* may be affected by temperature, type of life cycle (egg laying or live births), and plant host (Mau and Kessing 1991). In warmer climates, reproduction does not involve mating and egg laying i.e. the entire life cycle is parthenogenic (Mau and Kessing 1991). As a consequence of this type of reproduction, populations are composed solely of females. In colder climates where suitable host plants cannot persist, aphids overwinter in the egg stage on *Prunus* spp.

For *A. spiraecola*, an entire generation can develop within a week and there can be up to 25 generations per year, with females producing 60 young each (Broughton 2007). Up to 40 generations per year have been reported in Italy. Wang and Tsai (2000) reported that the mean generation time of *A. spiraecola* ranged from 35.1 days at 10°C to 10.7 days at 32°C and the optimal range of temperature for population growth was 20-30°C.

Where sexual reproduction is apparent in *A. spiraecola*, the primary hosts are *Spiraea* or *Citrus*. However, over the majority of its geographical range its reproduction is entirely parthenogenic (CABI 2011).

### 5.1.3 Dispersal

Both *A. spiraecola* and *M. persicae* can be transported long distances by wind and storms, and as such are found throughout the world and in all parts of Australia.

## 5.2 Affected hosts

### 5.2.1 Host range

*M. persicae* is polyphagous with host plants in over 40 families. *A. spiraecola* also has a wide host range across multiple families. Lists compiled in the cabicompndium (CABI 2011) for hosts of *M. persicae* and *A. spiraecola* are presented in Sections 11.1 and 11.2, respectively.

### 5.2.2 Current geographic distribution

Both *M. persicae* and *A. spiraecola* have a worldwide distribution, including having a widespread distribution in Australia.

### 5.2.3 Symptoms

Both species have toxic saliva and can cause direct damage to plants. Symptoms can include dwarfing, wilting or curling of leaves, while high aphid densities can lead to water stress, reduced growth and ultimately to decreased yield.

## 5.3 Diagnostic information

### 5.3.1 *M. persicae*

The wingless adult aphids vary in colour from green to pale yellow, or pink, red or black, and are 1.5 to 2 mm long (Mau and Kessing 1991). Winged adults have green abdomens with black or dark brown markings, a black thorax and translucent wings (Figure 3).

Nymphs are pale yellowish-green in colour with three dark lines on the back of the abdomen. Nymphal development is completed in 6 to 11 days in warmer climates (Toba 1964). In cooler regions, aphids overwinter during the egg stage. The eggs are shiny black and are often laid on the bark of fruit trees.



**Figure 3.** *Myzus persicae* winged adult. Image courtesy Scott Bauer, USDA Agricultural Research Service, Bugwood.org.

### 5.3.2 *A. spiraecola*

Adults are apple green with brown heads, mainly pale legs and antennae, 2 mm in length and can be winged or wingless. Nymphs are pear shaped, apple green to bright yellow in colour (Broughton 2007) (Figure 4).



**Figure 4.** *Aphis spiraecola*. Image courtesy Andrew Jensen

## 5.4 Pathogen risk ratings and potential impacts

Both *M. persicae* and *A. spiraecola* are widespread within Australia, and cause damage to crops directly as well as act as vectors for the spread of viruses.

# 6 Pest information/status – aphid transmitted viruses

## 6.1 Pest details – example: Plum pox virus

|                     |                                                                   |
|---------------------|-------------------------------------------------------------------|
| Common name:        | Plum pox virus (PPV)                                              |
| Scientific name:    | <i>Plum pox virus (Potyvirus)</i>                                 |
| Synonyms:           | Peach sharka, Pox disease of plum, Sharka, Sharka disease of plum |
| Taxonomic position: | Family, Potyviridae; Genus, Potyvirus                             |

The information from this plan has been primarily obtained from documents as cited in the reference section as well as material sourced from the 'Diagnostic Protocol for *Plum pox virus* (PPV)' (SPHDS, 2010).

### 6.1.1 Background

Plum pox virus (PPV) has been chosen as an example in this contingency plan as it is one of the most destructive diseases of stone fruits and has a very wide host range among *Prunus* species. It is

not present in Australia but has been introduced to many other countries from its origin in eastern Europe (Bulgaria). It has been eradicated, or is currently under eradication or containment, from several countries.

PPV is a filamentous virus with particles 750 nm long and 15 nm in diameter. The virus has a single-stranded RNA genome with a molecular weight of  $3.5 \times 10^6$  Da. Protein inclusions of the pinwheel type are present in the cytoplasm of infected host cells (Salvador *et al.* 2006).

Currently, PPV can be divided into six strains: PPV-D, PPV-M, PPV-El Amar, PPV-C, PPV-W, and PPV-Rec (Candresse and Cambra 2006; James and Glasa 2006). Strains of PPV were originally distinguished on the basis of symptoms induced in herbaceous indicator plants. Kerlan and Dunez (1979) then serologically differentiated Dideron (PPV-D) and Markus (PPV-M) strains, the former on apricot (*Prunus armeniaca*) in France and the latter originally on peach (*Prunus persica*) in Greece. Within these strains, individual isolates can vary in the severity of symptoms they induce.

PPV-D is the most common strain in Western Europe and is the only strain currently found in the US and Canada (Levy *et al.* 2000).

PPV-M is considered to be a more aggressive, epidemic form and is the most common strain in Southern, Eastern and Central Europe. Peach is most susceptible to PPV-M. An isolate of the PPV-M strain which is very aggressive and necrogenic on peach was reported in France in the 1980s (Candresse *et al.* 1993). This necrogenic strain has since been referred to as PPV-SP.

The El Amar strain (PPV-El Amar) is distinct from the D and M strains on the basis of divergences in RNA sequence (Wetzel *et al.* 1991a) and has only been isolated in the North Africa region.

The cherry strain (PPV-C) has been found to infect sweet (*Prunus avium*) and sour (*Prunus cerasus*) cherry trees and is found in Eastern and Central Europe (Kalashyan *et al.* 1994; Kölber *et al.* 1997). It differs significantly from other strains of PPV in biological, serological and molecular properties.

PPV-Rec is a stable recombinant strain consisting of D and M strain recombinants with a common phylogenetic link (Glasa *et al.* 2004). It has been reported in several European countries, often having been incorrectly identified as PPV-M.

A sixth strain of PPV, termed PPV-W has been identified in Canada (James *et al.* 2003; James and Varga 2005).

### 6.1.2 Life cycle

Aphid vectors probe or feed on infected trees, then fly to other trees where they again probe or feed. The aphids can acquire the virus from infected leaves, flowers, or fruits in seconds to minutes and can transmit it to new plants within, again, only a few minutes. There is no latent period in the insect.

After inoculation, an incubation period occurs and infected plants may not show symptoms for several months. Symptoms are often transient and may easily be mistaken for those of other diseases allowing the virus to become established before the disease is recognised as PPV. Systemic spread of the virus within woody hosts may take several years (OEPP/EPPO 1983). The virus may be distributed very irregularly throughout the tree further confounding detection.

Infection begins to spread from the first infected trees after 2-3 years (Llácer *et al.* 1986).

### 6.1.3 Dispersal

PPV is transmitted in a non-persistent manner by two main winged aphid vectors, *Aphis spiraecola* and *Myzus persicae*, both of which are widespread throughout Australia. Other aphids that can transmit PPV, but less efficiently, include *A. craccivora*, *A. fabae*, *A. gossypii*, *A. hederae*, *Brachycaudus cardui*, *B. helvichrysi*, *B. persicae*, *Hyalopterus pruni*, *M. varians*, *Phorodon humuli*, and *Rhopalosiphum padi* (Avinent *et al.* 1994; Kunze and Krczal 1971; Labonne *et al.* 1994; Leclant 1973). *Metopolophium dirhodum* and *Toxoptera citricida* have been shown to be vectors of PPV under experimental conditions (Gildow *et al.* 2004).

The number of trees becoming infected in an orchard is directly related, in a given season, to numbers of these aphid vectors. Aphids spread the disease to trees several spaces away rather than to immediately adjacent trees (Gottwald *et al.* 1995).

Grafting can also contribute significantly to the spread of PPV in infected areas if certified virus-free material is not used. Dissemination of the virus nationally and internationally is most often through transport of uncertified plants or plant parts (Diekmann and Putter 1996).

Although spread is difficult to control within a localised area as aphid vectors have been shown to carry the virus for several kilometres if starved (Levy *et al.* 2000). Long distance spread can be controlled through the use of certified virus-free nursery stock and strict quarantine regulations.

### 6.1.4 Host range

The major hosts of PPV are fruit-producing species of the *Prunus* genus and Levy *et al.* 2000 reports the following as having been shown to be natural hosts:

- *P. armeniaca* - Apricot
- *P. persica* - Peach
- *P. persica* var. *nectarina* - Nectarine
- *P. domestica* - Garden plum (prune)
- *P. salicina* - Japanese plum
- *P. insititia* - Damson plum
- *P. cerasifera* - Myrobalan plum
- *P. glandulosa* - Dwarf flowering almond, Cherry almond
- *P. avium* - Sweet cherry
- *P. cerasus* - Sour (tart) cherry
- *P. dulcis* - Almond

While almond (*P. dulcis*) can be infected with PPV, it expresses few, if any, symptoms (Llácer and Cambra 2006).

It is also thought that many other cultivated or weedy annual plant species can potentially carry PPV and Section 11.3 Appendix 3 provides a list of PPV's host species (CABI 2011). An asterisk (\*) indicates those species that are often grown in domestic gardens or used as street trees in Australia. These species would need to be considered in the event of an incursion of PPV (Diagnostic protocol for *Plum pox virus*).



### 6.1.5 Current geographic distribution

PPV is widespread throughout Europe and is found in Albania (restricted distribution), Austria (restricted distribution), Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus (restricted distribution), the Czech Republic, France (restricted distribution), Germany, Greece, Hungary, Italy (restricted distribution), Latvia (under eradication), Lithuania, Luxembourg, Moldova (restricted distribution), Montenegro, the Netherlands, Norway (restricted distribution), Poland, Portugal (restricted distribution), Romania, Russia (restricted distribution), Serbia, Slovakia, Slovenia (restricted distribution), Spain (restricted distribution), Switzerland, Syria, Turkey (restricted distribution), Ukraine (restricted distribution), and the United Kingdom (restricted distribution) (CABI 2007). PPV is also present in Argentina, Canada (restricted distribution), Chile, China, Egypt, India (restricted distribution), Iran, Jordan, Kazakhstan, Pakistan, Tunisia, the United States of America (restricted distribution) (CABI 2011).

The virus was present in but has since been eradicated from Belgium, Denmark, Estonia, and Georgia (CABI 2011).

### 6.1.6 Symptoms

Symptoms of PPV depend very much on the strain of the virus; the host species, cultivar and plant tissue infected; as well as locality and season (Dosba *et al.* 1986; Kegler and Hartmann 1998).

Symptoms may appear on leaves, flowers, fruit, or seeds. Diseased apricots and plums are deformed with a misshapen, bumpy appearance. Apricots show internal browning of the flesh with stones displaying pale spots or rings. Infected fruit may drop prematurely (Dunez 1987) (Figure 5).

Symptoms are particularly conspicuous on leaves of all *Prunus* in spring and include vein clearing or chlorotic bands, spots, or rings (Figure 6). Infected fruit show spots or rings that can be lighter or darker in colour than the surrounding skin.

In peaches, leaf deformation resembling insect damage can sometimes be observed. An early symptom of PPV infection in peaches is the appearance of dark pink streaks on flower petals and this is the most reliable symptom to look for in this host. Necrotic areas can also be seen on peach leaves.

Cherry leaves show mottling and necrotic spots.

In the case of plums, leaf spots or rings can be large or small and speckle-like with some necrotic areas on leaves that often fall out giving a shot-hole appearance. The fruit can show large or small and speckle-like spots or rings on the surrounding skin that may also develop sunken lesions (Figure 7).





**Figure 5.** Symptoms of PPV infection on apricots (*P. armeniaca*) fruit and stones. Image courtesy of Ministry of Agriculture and Regional Development Archive, Ministry of Agriculture and Regional Development, Bugwood.org.

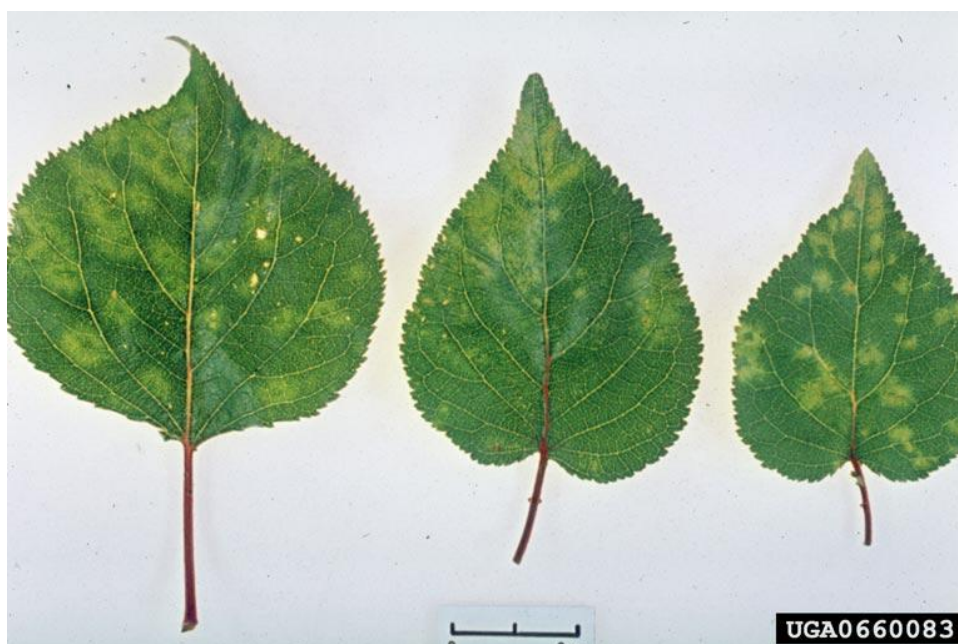


**Figure 6.** Symptoms of PPV infection on apricot (*P. armeniaca*) leaves. Image courtesy of Biologische Bundesanstalt für Land- und Forstwirtschaft Archive, Biologische Bundesanstalt für Land- und Forstwirtschaft, Bugwood.org



**Figure 7.** Symptoms of PPV infection on plum (*P. domestica*) fruit. Image courtesy of Biologische Bundesanstalt für Land- und Forstwirtschaft Archive, Biologische Bundesanstalt für Land- und Forstwirtschaft, Bugwood.org.

### 6.1.7 Diagnostic information

An endorsed National Diagnostic Protocol (NDP2) for Plum pox virus (PPV) has been prepared (SPHDS 2010). This protocol describes three methods for the positive identification of PPV including electron microscopy, ELISA, and RT-PCR and a short summary of each method is outlined below. For further information on standard diagnostic protocols see Section 11.4 Appendix 4. For a full list of diagnostic facilities and advisory services that can be utilised in the event of an incursion see Section 11.5 Appendix 5.

#### 6.1.7.1 ELECTRON MICROSCOPY

Transmission electron microscope (TEM) examination of grids prepared from small sections of homogenised leaf tissue negatively stained with 1% uranyl acetate (UA) can be used to rapidly detect PPV. The grids are examined at 40,000 x magnification for flexuous filamentous *Potyvirus* particles 660-770nm in length. Immunosorbent electron microscopy (ISEM) can be used when the concentration of virus particles in the crude sap preparation is low. Two detailed protocols for crude sap preparation, one of which being specific to ISEM, are described in the National Diagnostic Protocol for *Plum pox virus* (PPV).

Diagnosis using electron microscopy requires validation by ELISA and/or RT-PCR.

#### 6.1.7.2 ELISA

The National Diagnostic Protocol for *Plum pox virus* (PPV) describes a protocol for double antibody sandwich enzyme linked immunosorbent assay (DAS-ELISA) which enables the serological detection and quantification of PPV capsid protein using both monoclonal and polyclonal antibodies. The

antibodies selected for use allow for the detection of PPV-D, PPV-M, PPV-EI Amar, PPV-C, and PPV-W strains of the virus.

Due to its specificity and high throughput, DAS-ELISA can be used to specifically target PPV during surveys in production areas, commercial nurseries, or for production purposes.

#### 6.1.7.3 RT-PCR

The reverse transcription polymerase chain reaction (RT-PCR) is a rapid, specific, and sensitive test that can be used to detect and diagnose PPV from extracted nucleic acids. The National Diagnostic Protocol for *Plum pox virus* (PPV) describes a two-step RT-PCR reaction which allows the cDNA template obtained to be stored for future RT-PCR testing and subsequent cloning. Standard primers designed for the detection of all strains of PPV (Wetzel *et al.* 1991b) are used. A restriction digestion test can then be used to differentiate between the strains.

While more expensive than ELISA and less suitable as a high throughput method, RT-PCR is very specific and sensitive and allows for the detection of minimal amounts of target RNA. As such, RT-PCR can be used to validate the results from electron microscopy and ELISA. These results can be further validated by sequencing the DNA amplicon and using the Basic Local Alignment Search Tool (BLAST) to align the sequence obtained with sequences held in the NCBI-GenBank database.

#### 6.1.7.4 INDICATOR SPECIES FOR PPV

The following are important herbaceous indicator or propagation hosts of Plum pox virus (taken from Levy *et al.* 2000):

- *Chenopodium foetidum*
- *Nicotiana benthamina*
- *N. bigelowii*
- *N. clelandii*
- *N. occidentalis* #37 B
- *N. edwardsonii*
- *N. megalosiphon*
- *N. tabacum*
- *N. physalodes*
- *Pisum sativum* cv. Colmo

## 6.1.8 Risk assessments for pathways and potential impacts – Plum pox virus

### 6.1.8.1 ENTRY POTENTIAL

#### Rating: Low

Australia has been importing apricots, peaches and nectarines, plums, and cherries from New Zealand since 1986 and cherries from the USA since 1996, and in 2010 Biosecurity Australia gave approval for the import of peaches and nectarines and plums. As PPV is not present in New Zealand or in the areas of production in the USA (California, Idaho, Oregon, and Washington), it is unlikely that PPV would be introduced to Australia via these pathways. While Chile, China, Japan, Mexico, and South Africa have requested market access and PPV is present in both Chile and China, it should be noted that introduction of PPV on fruit is considered to be very low.

The most likely pathway by which PPV could be introduced to Australia is through the importation of infected but symptomless budwood for grafting. The risk of entry of PPV into Australia is therefore **Low**.

### 6.1.8.2 ESTABLISHMENT POTENTIAL

#### Rating: High

Due to the fact that symptoms do not appear for several months, establishment of PPV can occur prior to detection. The virus multiplies in growing host plants. Almond, apricot, nectarine, peach and plum are common trees in Australia and aphid species are present in Australia that can spread PPV. As such, the likelihood of PPV establishing is considered to be **High**.

### 6.1.8.3 SPREAD POTENTIAL

#### Rating: High

Due to the wide host range available in Australia, the presence of aphid vectors, and lack of a latent period within the aphid vectors, the potential for spread of PPV following establishment is **High**. Aphids have been shown to carry the virus for several kilometres if starved (Levy *et al.* 2000). In addition, the climate, vector and host numbers in temperate areas of Australia would be similar to those in areas where the virus is prevalent and would therefore be suitable for the spread of PPV.

### 6.1.8.4 ECONOMIC IMPACT

#### Rating: High

PPV can significantly reduce fruit yield and quality, rendering fruit unpalatable and unmarketable. As such, the virus has a major economic impact on stonefruit production and international trading worldwide. The global cost associated with the management of PPV worldwide, excluding indirect trade costs, has been estimated to be 10 billion euros (Cambra *et al.* 2006). The economic impact of PPV in Australia could be **High**.

#### 6.1.8.5 ENVIRONMENTAL IMPACT

##### Rating: Negligible

Infected fruit does not pose a health problem for humans or animals, and native plants are not known to be hosts of PPV so the environmental impact is considered to be **Negligible**.

#### 6.1.8.6 OVERALL RISK

##### Rating: High

Based on the individual ratings above, the combined overall risk is considered to be **High**.

## 6.2 Pest details – example: Tobacco etch virus

|                     |                                       |
|---------------------|---------------------------------------|
| Common name:        | Tobacco etch virus (TEV)              |
| Scientific name:    | <i>Tobacco etch virus (Potyvirus)</i> |
| Taxonomic position: | Family, Potyviridae; Genus, Potyvirus |

### 6.2.1 Background

Tobacco etch virus (TEV) is a disease of Solanaceous species including tomatoes and capsicums. TEV has been chosen as an example virus in this contingency plan as these Solanaceous species make up a significant component of seedling production in nurseries and this virus would be expected to have a high economic impact on these crops should it enter Australia.

TEV is a flexuous filamentous virus with particles 730-750 nm long and 12-13 nm in diameter and a single-stranded RNA genome (Purcifull and Hiebert 1982). It induces the formation of crystalline nuclear inclusions and cytoplasmic, cylindrical (pinwheel) inclusions in host cells.

The virus is transmitted in a non-persistent manner by the aphid vector, *Myzus persicae*, which is widespread throughout Australia. It can also be transmitted by several other aphid species (AVRDC 2004; 2005). The virus is also readily transmitted mechanically and by grafting using infected plant material.

### 6.2.2 Life cycle

Aphid vectors feed on infected plants then fly to other plants where they again probe or feed. The aphids can acquire the virus from feeding on an infected plant for less than a minute and can transmit it to a new plant just as quickly (AVRDC 2005). The aphids will retain the virus for a day or longer if the aphid does not feed after acquisition of the virus.

TEV overwinters in perennial Solanaceous weeds and is transmitted to tobacco, tomato, and pepper plants by migrating aphids.

TEV often occurs in combination with other aphid-borne viruses.

### 6.2.3 Dispersal

TEV is not reported to be seedborne in any plant species (Purcifull and Hiebert 1982). Its principal mode of transmission is by *M. persicae* and several other aphid species in a non-persistent manner (AVRDC 2004; 2005). The virus is also readily transmitted mechanically and by grafting.

Although spread is difficult to control within a localised area due to aphid vectors, long distance spread can be controlled through the use of certified virus-free nursery stock and strict quarantine regulations.

### 6.2.4 Host range

The major hosts of TEV are species of the Solanaceae family and include Tobacco (*Nicotiana tabacum*), Tomato (*Solanum lycopersicum*), and Bell and Tabasco peppers (*Capsicum annuum*, *C. frutescens*). Various weeds are also affected (AVRDC 2004; 2005). A detailed list of host plants is given in Table 5.

**Table 5.** Hosts of TEV as listed on the CAB Compendium (CAB International 2011)

| Scientific name              | Common name          |
|------------------------------|----------------------|
| <i>Capsicum annuum</i>       | Bell pepper          |
| <i>Capsicum frutescens</i>   | Tabasco pepper       |
| <i>Chenopodium album</i>     | Fat hen              |
| <i>Cirsium vulgare</i>       | Spear thistle        |
| <i>Datura stramonium</i>     | Jimson weed          |
| <i>Linaria canadensis</i>    | Blue toadflax        |
| <i>Nicotiana tabacum</i>     | Tobacco              |
| <i>Physalis heterophylla</i> | Clammy ground cherry |
| <i>Senna obtusifolia</i>     | Sicklepod            |
| <i>Solanum carolinense</i>   | Carolina horsenettle |
| <i>Solanum lycopersicum</i>  | Tomato               |
| <i>Solanum seaforthianum</i> | Star potato-vine     |
| <i>Solanum viarum</i>        | Tropical soda apple  |

### 6.2.5 Current geographic distribution

TEV is found primarily in the Western Hemisphere, especially in North and South America (CABI 2011). The virus has been reported in Canada, Mexico, Puerto Rico, the USA including Hawaii, and Venezuela (CABI 2011).



## 6.2.6 Symptoms

The severity of symptoms in cultivated plants depends greatly on the host species and cultivar, virus strain, and time of infection (AVRDC 2004).

In tobacco, affected plants are stunted. The leaves are narrowed and show vein-clearing, mottling and a characteristic etching pattern which may become necrotic (Johnson 1930; Shepherd and Purcifull 1971) (Figure 8). Symptoms and effects on yield can be more severe in Burley (air-cured) tobaccos than flue-cured types (Stover 1951).

All stages of growth are affected in infected pepper plants. Symptoms on leaves include vein-clearing and vein-banding, mosaic patterns which fade to mottling as the leaf ages, and narrowing and distortion of leaves (Johnson 1930; McLean 1962; Zitter 1971, Figure 9 and Figure 10). Plants infected early have shortened internodes and can be severely stunted (AVRDC 2004). Fruit from such plants is small, misshapen, and displays severe mosaic symptoms. TEV can cause root necrosis, wilting, and death in Tabasco pepper plants (Greenleaf, 1953). The symptoms of TEV on pepper plants may be confused with those of other viruses such as Pepper mottle virus (PMV) or Potato virus Y (PVY) (AVRDC 2004). It should be noted that cultivars of pepper species with resistance to TEV have been developed (Cook *et al.* 1976).

As with pepper, all stages of growth in infected tomato plants may be affected. Leaves may show mild vein-clearing and mottling, a reduction in size, and distortion such as crinkling and pronounced downward curling (McLean, 1962; AVRDC 2005). Plants infected early have shortened internodes and can be severely stunted (Debrot 1976; Zitter and Tsai 1981). Fruit from such plants is mottled and does not reach full size (Figure 11). The symptoms of TEV on tomato plants may be confused with those of other viruses such as Tomato mosaic virus (ToMV) or Potato virus Y (PVY) (AVRDC 2005). However, due to the fact that several varieties of tomato carry partial resistance to ToMV while none have been bred for resistance to TEV or PVY, mottling tends to indicate infection with either TEV or PVY. Symptoms of TEV are usually more severe than those of PVY which usually consist of only faint mottling and slight distortion of leaves.



**Figure 8.** Symptoms of TEV on tobacco (*N. tabacum*). Image courtesy of R.J. Reynolds Tobacco Company Slide Set, R.J. Reynolds Tobacco Company, Bugwood.org.



**Figure 9.** Symptoms of TEV on bell pepper (*C. annuum*). Image courtesy of Florida Division of Plant Industry Archive, Florida Department of Agriculture and Consume Services, Bugwood.org.



**Figure 10.** Symptoms on *Capsicum annuum* leaves showing dark green mosaic areas associated with veins. Image courtesy of Thomas A. Zitter, Cornell University.





**Figure 11.** Symptoms on tomato showing mottling fruit caused by infection with TEV. Courtesy of Thomas A. Zitter, Cornell University.

### 6.2.7 Diagnostic information

No National Diagnostic Protocol has been developed or endorsed for TEV.

#### 6.2.7.1 ELISA

Agdia markets a double antibody sandwich enzyme linked immunosorbent assay (DAS-ELISA) kit which enables the serological detection and quantification of TEV using polyclonal antibodies. A detailed protocol is available from the Agdia website (<http://www.agdia.com/>).

#### 6.2.7.2 RT-PCR

The reverse transcription polymerase chain reaction (RT-PCR) is a rapid, specific, and sensitive test that can be used to detect and diagnose TEV from extracted nucleic acids. Carrasco *et al.* (2007) describes a set of primers used in real-time RT-PCR assays to quantify the fitness of TEV. Alternatively, Sangrok Biolab markets an immunocapture RT-PCR kit which includes pre-coated PCR tubes for capturing virus particles which can then be directly amplified by RT-PCR. A detailed protocol is available from the Sangrok Biolab website (<http://www.srbiolab.com/>).

RT-PCR can be used to validate the results from ELISA. These results can be further validated by sequencing the DNA amplicon and using the Basic Local Alignment Search Tool (BLAST) to align the sequence obtained with sequences held in the NCBI-GenBank database.

## 6.2.8 Risk assessments for pathways and potential impacts - TEV

### 6.2.8.1 ENTRY POTENTIAL

#### Rating: Low

Australia imports tomato and bell pepper seeds but, as TEV is not seed borne, it is unlikely that TEV would be introduced to Australia via this pathway. It is more likely that TEV could be introduced via an aphid vector entering the country with a cold-stored shipment of an alternate host of the vector. The risk of entry of TEV into Australia is considered to be **Low**.

### 6.2.8.2 ESTABLISHMENT POTENTIAL

#### Rating: High

TEV host plants and vectors are widespread in Australia, and the ability of the virus to become established is expected to be **High**.

### 6.2.8.3 SPREAD POTENTIAL

#### Rating: High

Due to the wide host range available in Australia including weeds, the presence of aphid vectors, and the fact that the virus is also transmitted mechanically, the potential for spread of TEV following establishment is considered to be **High**.

### 6.2.8.4 ECONOMIC IMPACT

#### Rating: High

TEV is responsible for heavy losses in both tomato (Zitter and Tsai 1981) and pepper (Zitter and Ozaki 1973) crops. A 25% reduction in yield has been reported for tomatoes in Venezuela (Debrot 1976). The economic impact of TEV in Australia in tobacco, tomato and capsicum and through nursery production that supplies seedlings to these industries is expected to be **High**.

### 6.2.8.5 ENVIRONMENTAL IMPACT

#### Rating: Negligible

There is no known potential to degrade the environment or otherwise alter the ecosystem by affecting species composition or reducing the longevity or competitiveness of wild hosts.

### 6.2.8.6 OVERALL RISK

#### Rating: Medium

Based on the individual ratings above, the combined overall risk is considered to be **Medium**.

## 7 Pest management

### 7.1 Response checklist

The following checklist (Table 6) provides a summary of generic requirements to be identified and implemented within a Response Plan for an incursion of a new aphid transmitted virus into Australia.

**Table 6.** Checklist of requirements to be identified in a Response Plan

| Checklist item                                                    | Further information  |
|-------------------------------------------------------------------|----------------------|
| Destruction methods for plant material, soil and disposable items | Section 8.1.1, 8.1.2 |
| Disposal procedures                                               | Section 8.1.5        |
| Quarantine restrictions and movement controls                     | Section 8.3          |
| Decontamination and property cleanup procedures                   | Section 8.5          |
| Diagnostic protocols and laboratories                             | Section 5.3          |
| Trace back and trace forward procedures                           | Section 8.6          |
| Protocols for delimiting, intensive and ongoing surveillance      | Section 7.2          |
| Zoning                                                            | Section 8.4          |
| Reporting and communication strategy                              | Section 11.6         |

A range of specifically designed procedures for the emergency response to a pest incursion and a general communication strategy refer to PLANTPLAN (Plant Health Australia 2010). Additional information is provided by Merriman and McKirdy (2005)<sup>9</sup> in the Technical Guidelines for Development of Pest Specific Response Plans.

### 7.2 Surveys and epidemiology studies

Information provided in Sections 7.2.1 to 7.2.3 provides a framework for the development of early detection and delimiting surveys for aphid transmitted viruses.

Where aphids are found in a production nursery that is in close proximity to potential host plants, periodically inspect nearby hosts for signs of virus symptoms by examining stems, leaves and fruit. Some hosts may be asymptomatic and leaf samples may be required from all known hosts as part of a targeted survey.

Infested sources within the production nursery may provide an opportunity for aphids to spread to trees and shrubs outside the production nursery. Personnel should avoid moving plant material between production nurseries to limit movement of both the vector and virus infected material. Shoes, tools and vehicle tyres should be thoroughly washed of soil and then sanitised with a registered disinfectant. Extra precaution should be taken when working in areas known to be infested, including disposable overboots that may be used and disposed of on-site.

<sup>9</sup> Available on the PHA website ([www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information](http://www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information))

### 7.2.1 Technical information for planning surveys

When developing surveys for presence and/or distribution of the virus (and potentially for the virus vectors), the following characteristics provide the basic biological knowledge that informs the survey strategy:

- Virus infected plant material may be asymptomatic
- Host species in Australia are likely to be numerous and widely dispersed and may be present within relevant industries, nurseries as well as home gardens, landscape plantings and weeds
- Numerous aphid vectors are already present and widespread in Australia and many aphids (including *M. persicae* and *A. spiraecola*) have wide host ranges and share many of the same hosts with that of the virus
- The risk of aphid movement on nursery stock machinery, equipment and personal effects is high
- Winged forms of adult aphids can travel large distances on winds
- Virus transmission can often also occur through mechanical transmission involved with plant propagation or management
- Production nursery greenhouses and significant proportions of Australia have favourable climatic conditions for both virus development and aphid spread and establishment

### 7.2.2 Surveys for early detection of an incursion in a production nursery

Points to consider in effectively monitoring aphid populations in commercial production nurseries are:

- Initial surveys using yellow sticky card traps or water pan traps to determine the species of aphid present. Yellow sticky card traps will determine the presence of aphids and other insect species such as thrips and aphids. It is recommended that traps be placed at a density of 1 trap per 300 to 400 plants positioning the trap bottom at canopy height. The traps should remain in place for one week
- The position of aphids on leaves depends on the aphid species and the crop. For example, Green peach aphids may uniformly scatter on the leaf, yet in lettuce populations start on the lower leaves and move up the plant, and in other crops may be found on the underside of the leaf. Because of their size, detection may be dependent on careful visual inspection, preferably supplemented by use of a hand lens magnifier
- Water pan traps are frequently used for monitoring aphid populations
- If aphids are detected, leaves infested with aphids (as many life stages as possible) should be collected for identification of the species

Points to consider in monitoring virus infected material in commercial production nurseries are:

- The host range of the potential virus incursion must be determined and hosts grouped into risk categories for transmission and expression of the disease (high, medium and low)
- Conditions under which transmission, amplification and expression of the disease must be determined to assess the likelihood of detection and reporting through general surveillance and to assist develop protocols for targeted surveillance
- Potential pathways for distribution of virus-infected material must be determined
- Depending on the virus, distribution of the virus in the plant may be irregular and plant material with most likely infection should be determined
- Depending on the virus incursion, host species in Australia are likely to be numerous and widely dispersed and may be present within relevant industries, nurseries as well as home gardens, landscape plantings and weeds
- Virologist expertise will be needed to determine diagnostic protocols and sampling requirements including the age of plant material to be sampled, time of year and the potential to bulk samples from plant species or cultivars

Important points to consider when developing early detection surveys are:

- Awareness information should be targeted at people who are in regular close contact with potential hosts in high risk areas or movement vectors (e.g. production nursery operators)
- Systematic and careful inspection of nursery crops and propagative plant material is essential to prevent introduction of an aphid transmitted virus and limit its spread within and from contaminated nurseries. Where possible, early detection of disease symptoms while at low levels, will provide the best chance of eradication
- An inspector must be trained to recognise a particular aphid vector and the virus symptoms and other similar disorders for comparison (see Section 5.2.3). A nursery layout map that includes approximate locations of target species will be required to develop a strategy for surveys. A survey map should include species and cultivar names, locations, approximate quantity and sources of targeted plants within the area. During the survey walkthrough, record the date, observations, and sampling information directly onto the survey map. The recorded information should be reviewed and used to develop an efficient survey strategy each time the nursery is inspected.

### 7.2.3 Delimiting surveys in the event of an incursion

- In the event of an incursion, delimiting surveys are essential to inform the decision-making process
- The size of the survey area will depend on the size of the infected area and the severity of the infection, as well as distribution pathways for plant material and potentially weather patterns during the period prior to detection (Figure 12). Other considerations are for example, movement of people or plant material equipment as a result of trace-forward and trace-backs
- Aphids can fly and can readily spread long distances by winds or can be transported on infested plants. New introductions can pose serious threats and complicate identification of naturalised populations

- All potential host species (refer to Section 5.2) should be surveyed, with particular attention paid to the species in which the virus was initially detected
- In addition to inspection of possible host plants, material should be collected for diagnostic purposes (refer to Section 7.2.4)
- If the incursion is in a populated area, publication and distribution of information sheets and appeals for public assistance may be helpful

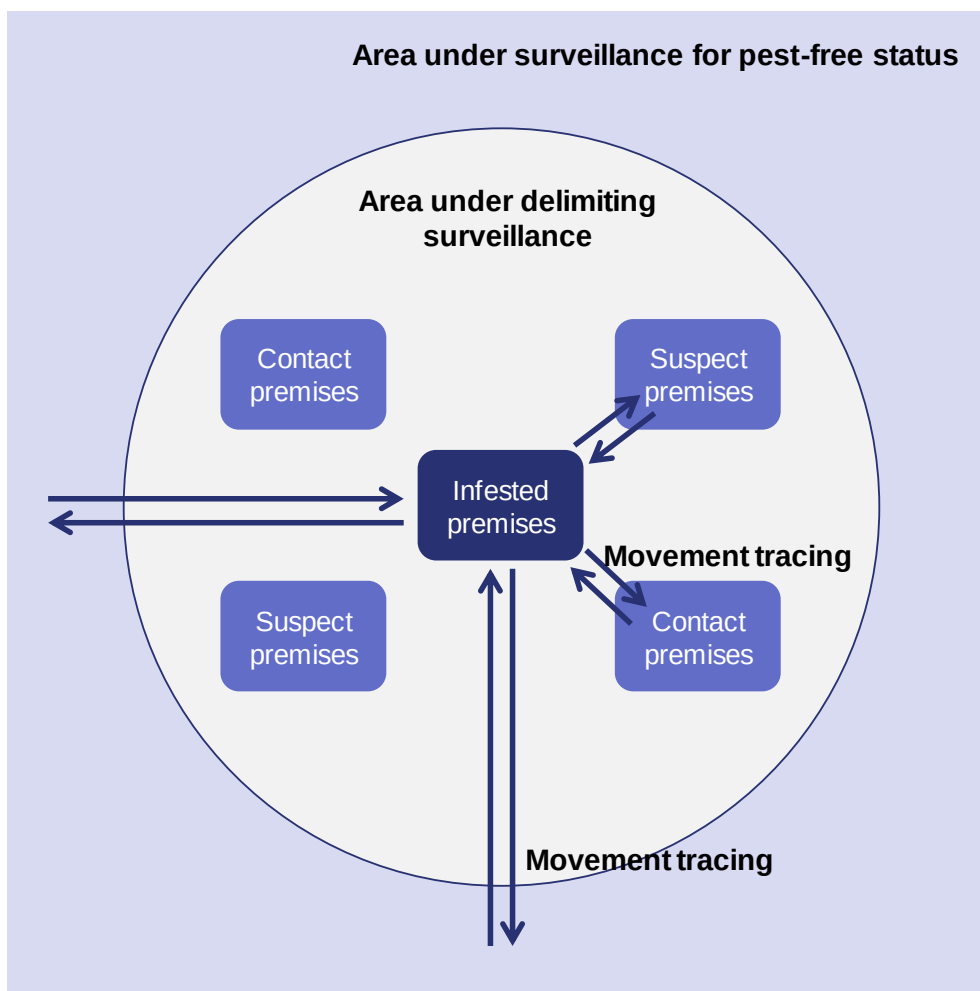


**Figure 12.** Diagram of a delimiting survey showing surveillance activities from the infected premises

#### 7.2.4 Collection and treatment of aphid samples

Protocols for the collection, transport and diagnosis of suspect Emergency Plant Pests (EPPs) must follow PLANTPLAN (Plant Health Australia 2010). Any personnel collecting samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (Plant Health Australia 2010). Containers should be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of affected

plant species/parts, location of nursery and affected plant within the nursery (preferably with a GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650.

#### **7.2.4.1 COLLECTION OF SPECIMENS**

##### ***Sampling procedures***

Samples can be collected on leaf samples, yellow sticky traps, suction traps or water pan traps.

##### ***Number of specimens to be collected***

Where possible, collect multiple specimens representative of all life stages of the population available. Hollingsworth and Gatsonis (1990) reported that a minimum of 10 and maximum of 50 leaf samples should be taken to monitor levels of *M. persicae* in field-grown potato.

Record the identity of the host plant where the aphids were collected. Record the location, preferably as GPS co-ordinates, or alternatively, a map reference or distance and direction from a suitable landmark. If the land is privately owned, record the owner's details including contact telephone numbers.

##### ***How to collect and send plant samples with eggs, larvae or pupae***

Leaf samples containing nymphs and if possible adults are to be placed in a specimen container and placed in a portable fridge or insulated container with cool packs to prevent the insect and leaf samples from drying out.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (Plant Health Australia 2010; Appendix 3). Containers should then be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of plant species/parts affected, location of affected plant (where available include GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650.

##### ***Precaution***

Overheating or desiccation of samples prior to despatch should be prevented. Samples may be stored in a fridge (4-10°C) for a few days if necessary.

##### ***Receipt***

On receipt of the samples the diagnostic laboratory should follow strict quarantine and processing guidelines. In keeping with ISO 17025 refer to PLANTPLAN (Plant Health Australia 2010).



### 7.2.5 Collection and treatment of virus samples

In general, plants showing virus like symptoms or suspected symptoms should be sampled. For PPV, when sampling leaf material, leaves from the middle of the branch should be sampled from various points around the tree. Optimal tissue for peach samples is petals if possible (National Diagnostic Protocol for Plum pox virus [PPV]). Any personnel collecting samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis. General protocols for collecting and dispatching samples are available within Appendix 3 PLANTPLAN (Plant Health Australia 2010).

#### *Number of specimens to be collected*

In general, 5-10 samples of symptomatic plants should be collected for initial identification. If a survey to determine the incidence of disease within a crop or geographic area is required, then a more formalised, statistical-based sampling strategy should be employed.

For PPV, sampling protocols are listed in the National Diagnostic Protocol for Plum pox virus (PPV) and state that leaves of four trees will constitute a field sample, and 12-16 leaves will be collected per tree. Within the diagnostic test, a bulk sample of no more than 8 leaves will be tested.

It is important to record the precise location of all samples collected, preferably using GPS, or if this is not available, map references including longitude and latitude and road names should be recorded. Property and owners names should also be included where possible.

#### *How to collect plant samples*

Samples should be treated in a manner that allows them to arrive at the laboratory in a fresh, well-preserved state. An esky with ice packs or portable fridge should be carried when sampling crops.

The samples should be kept cool, out of direct sunlight and clearly labelled. Aim to keep the tissue at less than 10°C. For appropriate labelling and packaging procedures for suspect emergency plant pests consult PLANTPLAN (Plant Health Australia 2010).

Sampling and collection of plant material will depend on the host and virus. Technical advice on sampling will be required for each virus if an incursion is suspected.

In general, infected plant material should be collected using scissors, with sterilisation to occur between each collection.

For PPV, leaves should be collected into zip-lock plastic bags, with air removed and without paper towelling, or any material that will keep the plant leaves wet (National Diagnostic Protocol for Plum pox virus [PPV])

#### *How to preserve plant samples*

Collected material can be stored at 2-5°C. Do not expose plant samples to direct sunlight. It is important to keep the sampled plant tissue below 10°C where possible.

#### *How to transport plant samples*

Plant material should be mailed as a flat package. The samples should be either sent by a courier or by Express Post if overnight delivery to the diagnostic laboratory is guaranteed. Each laboratory has different labelling protocols and the receiving laboratory must be contacted before sending samples to



ensure that these protocols are followed and that someone will be present to receive the samples. Email is not sufficient as a sole method of contact.

### 7.2.6 Epidemiological study

The extent of infestation in a production nursery, on a property or within a region will depend on the initial population size of the virus introduction and also on populations of the aphid vector and whether conditions have been favourable for the pest to spread from the initial location. Sampling should be based upon the origins of the initial suspect sample(s). Factors to consider will be:

- The proximity of other susceptible plants to the initial infestation source, including both current and previous crops. This will include crops in the production nursery or on the property with the initial detection and those on neighbouring properties
- Machinery or vehicles that have been into the infested area or in close proximity to the infestation source
- The extent of human movements into and around the infested area. A possible link to the recent importation of plant material from other regions should also be considered
- The source of any production nursery stock propagation material
- If any other crops have been propagated from the same source and/or distributed from the affected production nurseries
- Depending on the temperature and environmental conditions aphids can have up to 20 generations per year
- Many vector- transmitted viruses can easily be spread by mechanical transmission in sap on contaminated machinery and equipment and also potentially by contact between plants

### 7.2.7 Models of spread potential

No models of spread potential have been developed for aphid transmitted viruses.

### 7.2.8 Pest Free Area guidelines

Determination of Pest Free Areas (PFAs) should be completed in accordance with the International Standards for Phytosanitary Measures (ISPMs) 8 and 10 (IPPC 1998a, 1999).

In the event of an incursion, specific guidelines for surveys and monitoring will be provided by the Consultative Committee on Emergency Plant Pests (CCEPP). General points to consider are:

- Design of a statistical delimiting survey for symptoms on host plants (see Section 7.2 for points to consider in the design)
- Plant sampling should be completed as described in the BioSecure HACCP manual (Nursery and Garden Industry Australia 2008), including monitoring processes (summarised in Table 7 and Table 8), indicator plants and weed monitoring
- Surveys should also consider alternative hosts (see Section 5.2.1) and not be limited to the primary infected host
- Information (including absence of the pest) should be recorded

**Table 7.** Summary of monitoring processes for protected production areas as described in BioSecure HACCP Guidelines. Further specific guidelines may be provided by a CCEPP

|                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wear protective clothing when handling suspect samples                                                                                                                          |
| Walk at random through the area in a zigzag pattern                                                                                                                             |
| Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m <sup>2</sup> of production area                                                                        |
| Inspect the tops and bottoms of leaves, looking for any direct evidence of insects                                                                                              |
| Inspect the entire plant if it has less than 6 leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually |
| Inspect the length of all stems and branches for insects and symptoms                                                                                                           |
| During individual plant inspection, examine the underside of the foliage for the presence of whiteflies                                                                         |
| If any plants show suspect symptoms or evidence of eggs or larvae (refer to Symptoms Section 5.2.3) take a sample (refer to Section 9.2.4) to be formally diagnosed             |
| Check for a problem that has occurred regularly in the past, until you are certain it is not present                                                                            |
| Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest                                                                                                |
| Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed                  |

Additional information is provided by the IPPC (1995) in Requirements for the Establishment of Pest Free Areas. This standard describes the requirements for the establishment and use of pest free areas as a risk management option for phytosanitary certification of plants and plant products. Establishment and maintenance of a PFA can vary according to the biology of the pest, pest survival potential, means of dispersal, availability of host plants, restrictions on movement of produce, as well as PFA characteristics (size, degree of isolation and ecological conditions).

**Table 8.** Summary of monitoring processes for field production areas as described in BioSecure HACCP Guidelines. Further specific guidelines may be provided by a CCEPP.

|                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wear protective clothing when handling suspect samples                                                                                                                          |
| Pay particular attention to areas on the windward side, the sides bordering ditches, canals or other uncultivated areas and growing block centres                               |
| Place a flag or other marker at the entrance to the block or sampling area at the beginning of each inspection                                                                  |
| Vary the entrance point in the sampling area (1 m to 3 m) for each subsequent sampling so that the same plants are not inspected each time                                      |
| Walk at random through the area in a zigzag pattern                                                                                                                             |
| The scout should follow the same general pattern at each sampling                                                                                                               |
| Make an effort to select those plants that appear less healthy for visual inspection                                                                                            |
| Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m <sup>2</sup> of production area                                                                        |
| Inspect the tops and bottoms or leaves, looking for any direct evidence of insects                                                                                              |
| Inspect the entire plant if it has less than 6 leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually |
| Inspect the length of all stems and branches for insects and symptoms                                                                                                           |
| During individual plant inspection, strike the foliage over a white sheet of paper, or a plastic or paper plate to dislodge small insects for easier viewing                    |
| If any plants show suspect symptoms or evidence of eggs or larvae (refer to Symptoms Section 5.2.3) take a sample (refer to Section 7.2.4) to be formally diagnosed             |
| Check for a problem that has occurred regularly in the past, until you are certain it is not present                                                                            |
| Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest                                                                                                |
| Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed                  |

## 7.3 Availability of control methods

### 7.3.1 General procedures for control

Control of aphid transmitted viruses is likely to be largely reliant on control measures for the aphid vectors. However, measures can also be taken to minimise the spread of virus-infected nursery stock. Specific control measures will be determined by a CCEPP, however, general procedures include:

- Keep traffic out of affected areas and minimise movement in adjacent areas
- Adopt best-practice property hygiene procedures to retard the spread of the pest between fields and adjacent properties
- After surveys are completed, and permission has been obtained from the Chief Plant Health Manager or the CCEPP, destruction of the infested plant material is an effective control
- On-going surveillance of infected areas to ensure the pest is eradicated
- Do not use any material from infected plants for propagation

For general management (i.e. not eradication), controlling aphid populations before they reach large numbers in crops is very important and requires close monitoring of aphid populations early in the

season. If the adults occur in large numbers it becomes difficult to control the nymphal stages. Adults move between successive crops, so management approaches must be employed in all crops within the area.

To reduce early season populations, best management practices require consideration of several management approaches including the use of pest-free seedlings, weed management, chemical control and cleaning up of crop residue. Winged Green peach aphids generally begin migrating from weeds to initiate colonies on crop seedlings in autumn in Australia, and populations peak in late winter and early spring.

It should be recognised that it will be extremely difficult for effective eradication of aphid populations and this will in turn limit the ability to eliminate all transmission of an aphid transmitted virus.

### **7.3.2 Pest free (clean) seedlings**

Seedlings are potentially a major means of spreading aphids and aphid transmitted viruses into new plantings. Young plants are more susceptible to damage from aphids, so early infestations need to be avoided. Clean seedlings/nursery stock can be the first line of protection against the development of damaging populations.

Growers should check their suppliers to determine how the seedlings or nursery stock are grown and what measures are being used to protect against aphid infestation and virus infection. Inspect transplants carefully for signs of aphids or virus expression.

### **7.3.3 Weed management**

Minimising aphid host plants is important in reducing the base aphid population at the start of the season, which will delay the time it takes for aphid numbers to reach significant levels, reducing the number of sprays needed for control. However, Green peach aphid (a major vector for TEV and PPV) feeds on hundreds of host plants in over 40 plant families, so controlling all host plants may not be an option.

Potviruses are typically non-persistent in the aphid vectors, so host plants of the vector that do not host the virus are not as great a concern as they are with persistent viruses. In the case of TEV for example, controlling host plants of the virus (such as tomato, capsicum, tobacco and solanaceous weeds) will limit the spread and survival of the virus.

### **7.3.4 Chemical control**

Chemical control of viruses is not an option, but chemicals may be effective in trying to eliminate aphid vectors in an eradication campaign, or in the management of the aphid vectors should eradication be deemed unfeasible. In the event of an incursion of an aphid thrips transmitted virus, several chemicals, as listed on infopest, are currently registered for the control of aphids in Australia (Table 9).

**Table 9.** Registered chemicals and chemical use permits for the control of aphids in crops (from Infopest 2011)

| Chemical group | Active ingredient                        | APVMA Permit                    | State                          | Use                                                                                    |
|----------------|------------------------------------------|---------------------------------|--------------------------------|----------------------------------------------------------------------------------------|
|                | aldicarb 150 g kg <sup>-1</sup>          | 11105                           | NT                             | Aphid control in garlic seed production                                                |
|                | diafenthuron 500 g kg <sup>-1</sup>      | 11971                           | Qld, NT, Vic, WA, SA, Tas, NSW | Aphid control in nursery stock (non-food) and fruit trees (non-food)                   |
|                | diazinon 800 g L <sup>-1</sup>           | 12187                           | Tas                            | Black cherry aphid control on sweet cherries                                           |
|                | imidacloprid 200 g L <sup>-1</sup>       | 10497                           | Qld, NT, WA, SA, Tas, NSW      | Aphid control in <i>Brassica</i> leafy vegetables                                      |
|                |                                          | 9894                            | Qld, NT, WA, SA, Tas, NSW      | Aphid control in rhubarb crops                                                         |
|                |                                          | Registered: Agspray aphid guard | Qld, NT, Vic, WA, SA, Tas, NSW | Aphid control in certain vegetables and turf                                           |
|                | lambda-cyhalothrin 250 g L <sup>-1</sup> | 11801                           | NT                             | Aphid control in garlic                                                                |
|                | pirimicarb 500 g kg <sup>-1</sup>        | 11941                           | Qld, NT, WA, SA, Tas, NSW      | Aphid control in eggplants and almonds                                                 |
|                |                                          | 11800                           | NT                             | Aphid control in garlic                                                                |
|                |                                          | 11763                           | Qld, NT, WA, SA, Tas, NSW      | Aphid control in spring onions                                                         |
|                |                                          | 11439                           | Qld, NT, WA, SA, Tas, NSW      | Aphid control in sweet potato, <i>Brassica</i> leafy vegetables, chicory and coriander |
|                |                                          | 10433                           | Qld, NT, WA, SA, Tas, NSW      | Aphid control in sweet corn                                                            |
|                |                                          | 8613                            | Qld, NT, WA, SA, Tas, NSW      | Aphid control in leafy and woody herbs as specified when grown as annuals              |
|                |                                          | Registered: Farmoz aphidex      | Qld, NT, Vic, WA, SA, Tas, NSW | Control of certain aphids on crops and pastures                                        |

| Chemical group | Active ingredient                                                    | APVMA Permit | State                          | Use                                                                             |
|----------------|----------------------------------------------------------------------|--------------|--------------------------------|---------------------------------------------------------------------------------|
|                | pirimicarb 500 g kg <sup>-1</sup> + pyrethrins 75 g kg <sup>-1</sup> | 11292        | Tas                            | Aphid control in pyrethrum (restricted to approved persons)                     |
|                | pirimicarb 500 g L <sup>-1</sup>                                     | 11194        | Qld, NT                        | Control of Cowpea aphid and Soybean aphid in adzuki bean, mung bean and soybean |
|                | Pymetrozine 500 g kg <sup>-1</sup>                                   | 11988        | Qld, NT, WA, SA, Tas, NSW      | Control of Lettuce aphid in specified vegetable crops                           |
|                |                                                                      | 11973        | Qld, NT, Vic, WA, SA, Tas, NSW | Aphid control in nursery plants (non-food), seedlings and plugs                 |
|                |                                                                      | 10005        | Qld, NT, WA, SA, Tas, NSW      | Control of Green peach aphid in almonds                                         |
|                |                                                                      | 9317         | Qld, NT, WA, SA, Tas, NSW      | Aphid control in snow peas and sugar snap peas                                  |
|                | Spirotetramat 240 g L <sup>-1</sup>                                  | 11839        | Qld, NT                        | Control of Green peach aphid in seed crops of maize and sorghum                 |
|                |                                                                      | 11775        | Qld, NT, WA                    | Aphid control in seed crops of maize, sorghum and sunflower                     |

### 7.3.5 Clean-up crop residues

For control of aphids, movement of adults from older crops and crop residues is the main source of local infestation for younger crops. Post-harvest destruction of heavily infested crops often causes mass migration of aphids into adjacent crops. Therefore it is important to control aphids before they move into young crops.

Clean-up strategies for aphid infested crops/crop residues:

- For moderate aphid infestations, use an insecticide effective against adults
- Use high spray volumes for better coverage as defined on the label
- Re-entry/withholding periods still apply. Entry into crops should be avoided and produce should not be taken from the fields for consumption. Crop residues should not be fed to livestock
- Residues should be deep-buried or contained (sealed plastic bags) and disposed of via incineration

Clean up of virus-infected plant material could include:

- Spraying of host material (including newly emerging plants) with herbicide to kill the plants *in situ*, followed by disposal of plant material by deep burial
- Break down of larger volumes of plant material under black plastic prior to deep burial, (methodology to be confirmed by CCEPP)
- Burning of plant material providing
  - Material is sufficiently dry to burn
  - Aphid populations have been controlled/eliminated to ensure they are not distributed in rising thermals or surrounding areas by burning
- Decontamination of all items in contact with decomposing plant material with a 1% a.i. sodium hypochlorite solution or by deep burial
- Keeping infested area free of hosts for a minimum of 12 months (or a period to be determined by a CCEPP)

### 7.3.6 Cultural Control

The use of sawdust, woodchips or mulches (organic or aluminium) can reduce aphid visits to plants and thus reduce spread of some viruses (e.g. TEV, AVRDC 2004). Aphid trap crops (such as beans) surrounding field plantings of capsicums can be effective in reducing TEV spread provided that aphids are chemically controlled within the trap crop (Sherf and MacNab 1986).

The use of aphid-proof glasshouses or greenhouses for raising seedlings will strongly reduce the chance of virus infection.

### 7.3.7 Host-Plant Resistance

For TEV, resistant capsicum/pepper varieties are available but there are no resistant tomato varieties at present.

For PPV, the natural hosts are restricted to *Prunus* and it should be noted that not all PPV isolates infect all *Prunus* species. Despite significant efforts to identify resistance to PPV, few reliable sources of high level resistance have been found. Resistance to PPV has been identified in the model plant species *Arabidopsis thaliana* (Decroocq *et al.* 2006). High levels of resistance have also been produced to the D and M strains using genetic engineering in the transgenic C5 plum (Levy *et al.* 2000). In addition, multigenic sources of resistance have been shown to provide moderate levels of resistance or tolerance to some strains of PPV (Kegler *et al.* 1998) however incorporation of multiple genes, especially in combination with quality, yield and agronomic traits makes breeding difficult.

### 7.3.8 Insect Pest Management

The use of mineral oil sprays can delay virus spread by interfering with aphid transmission of viruses (AVRDC 2004).

There are many natural enemies of *M. persicae*, some of which are specific and others that are general to all aphids. These include syphid maggots, *Allograpta* sp., lady beetles and parasitic wasps. Another effective parasite is *Diaretus chenopodiaphidis* Ashmead. Parasites of *A. spiraecola* include wasps of the genera *Aphidius* and *Aphelinus*, and predators including hoverfly larvae, lacewing larvae and ladybird beetles (Broughton 2007).

### 7.3.9 Managing viruses

The two key points in managing the spread of TEV and PPV virus are to:

- Prevent the movement of infected host plants, seedlings and aphid-infected plants
- Control aphids on-farm, in surrounding vegetation and in seedling nurseries using good farm management and farm hygiene practices
- Minimise handling during the growing season to reduce the mechanical spread of TEV (AVRDC 2005)
- Use virus free nursery stock

## 7.4 Phytosanitary Measures

There are no known phytosanitary measures for *S. persicae* or *A. spiraecola* because they already have a worldwide distribution.

Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where aphid-transmitted viruses are present.

Of the list provided in Table 3, EPPO lists Plum pox virus as an A2 quarantine pest (i.e. present in Europe but with limited distribution).



## 8 Course of action

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Additional information is provided by the IPPC (1998b) in Guidelines for Pest Eradication Programmes. This standard describes the components of a pest eradication programme which can lead to the establishment or re-establishment of pest absence in an area. A pest eradication programme may be developed as an emergency measure to prevent establishment and/or spread of a pest following its recent entry (re-establish a pest free area) or a measure to eliminate an established pest (establish a pest free area). The eradication process involves three main activities: surveillance, containment, and treatment and/or control measures.

### 8.1 Destruction strategy

#### 8.1.1 Destruction protocols

- General protocols:
  - No plant material should be removed from the infested area unless part of the disposal procedure
  - Disposable equipment, infested plant material or growing media/soil should be disposed of by autoclaving, high temperature incineration or deep burial
  - Any equipment removed from the site for disposal should be double-bagged
  - Machinery used in destruction processes need to be thoroughly washed, preferably using a detergent or farm degreaser

#### 8.1.2 Decontamination protocols

Machinery, equipment and vehicles in contact with infested plant material or growing media/soil, or present within the Quarantine Area, should be washed to remove plant material and growing media/soil using high pressure water or scrubbing with products such as a degreaser or a bleach solution (1% available chlorine) in a designated wash down area. When using high pressure water, care should be taken not to spread plant material. High pressure water should be used in wash down areas which meet the following guidelines:

- Located away from crops or sensitive vegetation
- Readily accessible with clear signage
- Access to fresh water and power
- Mud free, including entry and exit points (e.g. gravel, concrete or rubber matting)
- Gently sloped to drain effluent away
- Effluent must not enter water courses or water bodies
- Allow adequate space to move larger vehicles
- Away from hazards such as power lines
- Waste water, growing media/soil or plant residues should be contained (see Appendix 18 of PLANTPLAN [Plant Health Australia 2010])

- Disposable overalls and rubber boots should be worn when handling infested plant material or growing media/soil in the field. Boots, clothes and shoes in contact with infested plant material or growing media/soil should be disinfected at the site or double-bagged to remove for cleaning
- Skin and hair in contact with infested plant material or growing media/soil should be washed

Procedures for the sterilisation of plant containers and growing media are provided within the BioSecure *HACCP* Guidelines, however, in the event of an aphid transmitted virus incursion, additional or modified procedures may be required for the destruction of the pest. Any sterilisation procedure must be approved for use in the endorsed Response Plan.

### 8.1.3 Priorities

- Confirm the presence of the pest
- Limit movement of people and prevent movement of vehicles and equipment through affected areas
- Stop the movement of any plant material that may be infested with the pest
- Determine the strategy for the eradication/decontamination of the pest and infested host material
- Determine the extent of infestation through survey and plant material trace back and trace forward which would be assessed on a case by case basis and included within the response plan

### 8.1.4 Plants, by-products and waste processing

- Any growing media/soil or infected plant material removed from the infected site should be destroyed by (enclosed) high temperature incineration, autoclaving or deep burial
- As aphid transmitted viruses are easily spread, plant debris from the destruction zone must be carefully handled and transported
- Infested areas or production nursery property should remain free of susceptible host plants until the area has been shown to be free from the pathogen

### 8.1.5 Disposal issues

- Particular care must be taken to minimise the transfer of infected plant material from the area
- Host material including leaf litter should be collected and incinerated or double bagged and deep buried in an approved site

## 8.2 Containment strategies

For some exotic pest incursions where eradication is considered impractical, containment of the pest may be attempted to prevent or slow its spread and to limit its impact on other parts of the state or country. Containment is currently being considered for inclusion within the Emergency Plant Pest

Response Deed (EPPRD). The decision on whether to eradicate or contain the pest will be made by the National Management Group, based on scientific and economic advice. Emergency interim containment measures are possible under EPPRD arrangements to gather information to determine if eradication is technically feasible.

## 8.3 Quarantine and movement controls

Consult PLANTPLAN (Plant Health Australia 2010) for administrative details and procedures.

### 8.3.1 Quarantine priorities

- Plant material and growing media/soil at the site of infestation to be subject to movement restrictions
- Machinery, equipment, vehicles and disposable equipment in contact with infested plant material or growing media/soil, or present in close proximity to the site of infestation to be subject to movement restrictions

### 8.3.2 Movement controls

Movement controls need to be put in place to minimise the potential for transport of the pest, and this will apply to all plant material, growing media and other items within the quarantined area.

Movement of people, vehicles, equipment and plant material, from and to affected properties or areas, must be controlled to ensure that the pest is not moved off-property. Movement controls can be achieved through the following, however specific measures must be endorsed in the Response Plan:

- Signage to indicate quarantine area and restricted movement into and within these zones
- Fenced, barricaded or locked entry to quarantine areas
- Movement of equipment, machinery, plant material or growing media/soil by permit only. Therefore, all non-essential operations in the area or on the property should cease
- Where no dwellings are located within these areas, strong movement controls should be enforced
- Where dwellings and places of business are included within the Restricted and Control Areas movement restrictions are more difficult to enforce, however limitation of contact with infested plants should be enforced
- If a production nursery is situated within the Restricted Area, all trading in host and non-host material must cease and no material should be removed from the site without permission, due to the high likelihood of pest spread. Movement restrictions would be imposed on both host and non-host material
- Residents should be advised on measures to minimise the inadvertent transport of aphids from the infested area to unaffected areas
- Clothing and footwear worn at the infested site should either be double-bagged prior to removal for decontamination or should not leave the site until thoroughly disinfected, washed and cleaned

- Plant material or plant products must not be removed from the site unless part of an approved disposal procedure.
- All machinery and equipment should be thoroughly cleaned down with a high pressure cleaner (see Section 8.1.2) or scrubbing with products such as a farm degreaser or a 1% bleach (available chlorine) solution, prior to leaving the affected area. Machinery should be inspected for the presence of insects and if found, treatment with insecticide may be required. The clean down procedure should be carried out on a hard surface, preferably a designated wash-down area, to avoid mud being re-collected from the affected site onto the machine. When using high pressure water, care should be taken to contain all plant material and mud dislodged during the cleaning process

## 8.4 Zoning

The size of each quarantine area will be determined by a number of factors, including the location of the incursion, biology of the pest, climatic conditions and the proximity of the infested property to other infested properties. This will be determined by the National Management Group during the production of the Response Plan. Further information on quarantine zones in an Emergency Plant Pest (EPP) incursion can be found in Appendix 10 of PLANTPLAN (Plant Health Australia 2010). These zones are outlined below and in Figure 13.

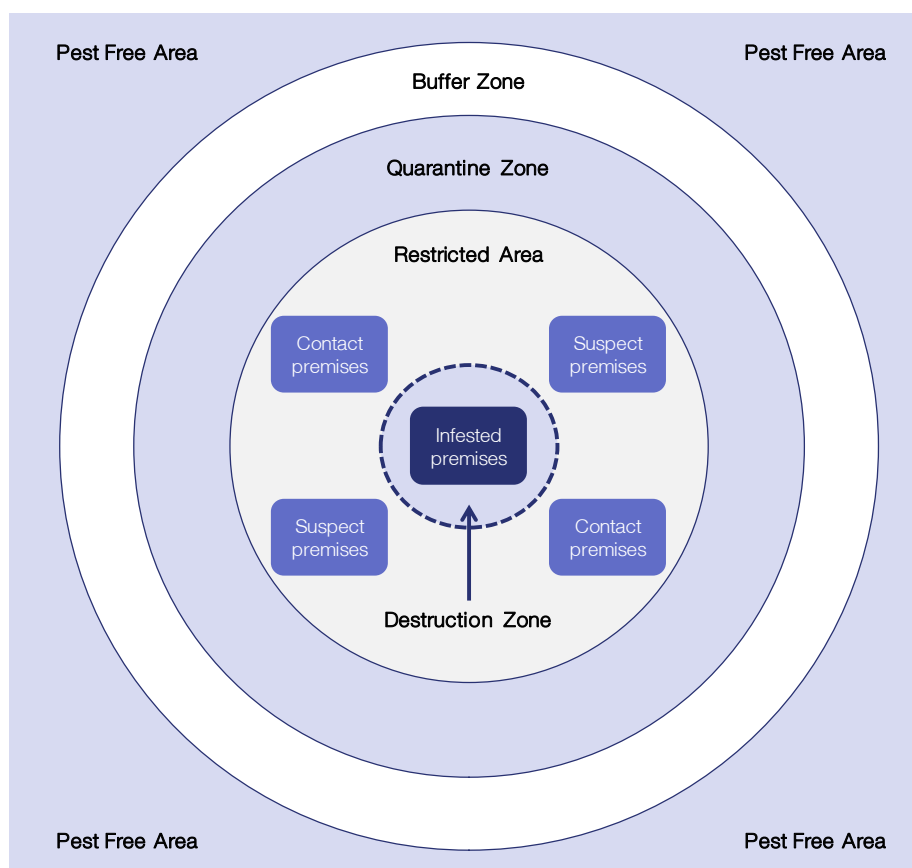


**Figure 13.** Schematic diagram of quarantine zones used during an EPP incursion (not drawn to scale)

### 8.4.1 Destruction Zone

The size of the destruction zone (i.e. zone in which the pest and all host material is destroyed) will depend on the ability of the pest to spread, distribution of the pest (as determined by delimiting surveys), time of season (and part of the pest life cycle being targeted) and factors which may contribute to the pest spreading.

All host plants should be destroyed after the level of infestation has been established. The delimiting survey will determine whether or not neighbouring plants are infested and need to be destroyed. Non-host plant material within this zone may be destroyed, based on recommendations in the Response Plan. The Destruction Zone may be defined as contiguous areas associated with the same management practices as, or in contact with, the infested area (i.e. the entire production nursery, property or area if spread could have occurred prior to the infection being identified). It should also consider the predicted range associated with movement of the vector.

Particular care needs to be taken to ensure that plant material (including non-hosts) is not moved into surrounding areas.

### 8.4.2 Quarantine Zone

The Quarantine Zone is defined as the area where voluntary or compulsory restraints are in place for the affected property or properties. These restraints may include restrictions or movement control for removal of plants, people, growing media/soil or contaminated equipment from an infected property.

### 8.4.3 Buffer Zone

A Buffer Zone may or may not be required depending on the incident. It is defined as the area in which the pest does not occur but where movement controls or restrictions for removal of plants, people, soil or equipment from this area are still deemed necessary. The Buffer Zone may enclose an infested area (and is therefore part of the Control Area) or may be adjacent to an infested area.

### 8.4.4 Restricted Area

The Restricted Area is defined as the zone immediately around the infected premises and suspected infected premises. The Restricted Area is established following initial surveys that confirm the presence of the pest. The Restricted Area will be subject to intense surveillance and movement control with movement out of the Restricted Area to be prohibited and movement into the Restricted Area to occur by permit only. Multiple Restricted Areas may be required within a Control Area.

### 8.4.5 Control Area

The Control Area is defined as all areas affected within the incursion. The Control Area comprises the Restricted Area, all infected premises and all suspected infected premises and will be defined as the minimum area necessary to prevent spread of the pest from the Quarantine Zone. The Control Area will also be used to regulate movement of all susceptible plant species to allow trace back, trace forward and epidemiological studies to be completed.

## 8.5 Decontamination and farm clean up

Decontaminant practices are aimed at eliminating the pathogen thus preventing its spread to other areas.

### 8.5.1 Decontamination procedures

General guidelines for decontamination and clean up:

- Refer to PLANTPLAN (Plant Health Australia 2010) for further information
- Keep traffic out of affected area and minimise it in adjacent areas
- Adopt best-practice property hygiene procedures to retard the spread of the pest between growing areas/fields and adjacent properties
- Machinery, equipment, vehicles in contact with infested or infected plant material or growing media/soil present within the Quarantine Zone, should be washed to remove growing media/soil and plant material using high pressure water or scrubbing with products such as a degreaser or a bleach solution in a designated wash down area as described in Section 8.1.2
- Only recommended materials are to be used when conducting decontamination procedures, and should be applied according to the product label
- Infested plant material should be disposed of by autoclaving, high temperature (enclosed) incineration or deep burial

### 8.5.2 General safety precautions

For any chemicals used in the decontamination, follow all safety procedures listed within each MSDS.

## 8.6 Surveillance and tracing

### 8.6.1 Surveillance

Detection and delimiting surveys are required to delimit the extent of the outbreak, ensuring areas free of the pest retain market access and appropriate quarantine zones are established.

Initial surveillance priorities include the following:

- Surveying all host growing properties and businesses in the pest quarantine area
- Surveying all properties and businesses identified in trace-forward or trace-back analysis as being at risk
- Surveying all host growing properties and businesses that are reliant on trade with interstate or international markets which may be sensitive to pathogen presence
- Surveying production nurseries selling at risk host plants
- Surveying other host growing properties and backyards

## 8.6.2 Survey regions

Establish survey regions around the surveillance priorities identified above. These regions will be generated based on the zoning requirements (see Section 8.4), and prioritised based on their potential likelihood to currently have or receive an incursion of this pest. Surveillance activities within these regions will either allow for the area to be declared pest free and maintain market access requirements or establish the impact and spread of the incursion to allow for effective control and containment measures to be carried out. Detailed information regarding surveys for aphid and virus infected plant material have been outlined elsewhere in this plan (refer to Section 7.2).

Steps outlined in Table 10 form a basis for a survey plan. Although categorised in stages, some stages may be undertaken concurrently based on available skill sets, resources and priorities.

**Table 10.** *Phases to be covered in a survey plan*

|                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Phase 1</b> | Identify properties that fall within the buffer zone around the infested premise<br>Complete preliminary surveillance to determine ownership, property details, production dynamics and tracings information (this may be an ongoing action)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Phase 2</b> | Preliminary survey of host crops in properties in buffer zone establishing points of pest detection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Phase 3</b> | Surveillance of an intensive nature, to support control and containment activities around points of pest detection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Phase 4</b> | Surveillance of contact premises. A contact premise is a property containing susceptible host plants, which are known to have been in direct or indirect contact with an infested premises or infected plants. Contact premises may be determined through tracking movement of materials from the property that may provide a viable pathway for spread of the disease. Pathways to be considered are: <ul style="list-style-type: none"> <li>• Movement of plant material and growing media/soil from controlled and restricted areas</li> <li>• Items of equipment and machinery which have been shared between properties including bins, containers, irrigation lines, vehicles and equipment</li> <li>• The producer and retailer of infected material if this is suspected to be the source of the outbreak</li> <li>• Labour and other personnel that have moved from infected, contact and suspect premises to unaffected properties (other growers, tradesmen, visitors, salesmen, crop scouts, harvesters and possibly beekeepers)</li> <li>• Storm and rain events and the direction of prevailing winds that result in air-borne dispersal of the pathogen during these weather events</li> </ul> |
| <b>Phase 5</b> | Surveillance of production and greenlife retailers, including garden centres, hardware outlets and supermarkets, as well as gardens and public land where plants known to be hosts of pathogen are being grown                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Phase 6</b> | Agreed area freedom maintenance, post control and containment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

## 8.6.3 Post-eradication surveillance

The period of pest freedom sufficient to indicate that eradication of the pest has been achieved will be determined by a number of factors, including growth conditions, the previous level of infection, the control measures applied and the pest biology.

Specific methods to confirm eradication of aphid transmitted viruses may include:

- Monitoring of sentinel plants

- Sentinel plants are to be grown in containers or small plots at the affected site. Plants are to be grown *in situ* under quarantine conditions and monitored for symptoms of infection
- If symptoms or virus are detected, samples are to be collected and stored and plants destroyed
- Surveys comprising host plant sampling for the virus should be undertaken for a minimum of three years after eradication has been achieved (or as endorsed by a CCEPP)

## 9 Technical debrief and analysis for stand down

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Refer to PLANTPLAN (Plant Health Australia 2010) for further details

The emergency response is considered to be ended when either:

- Eradication has been deemed successful by the lead agency, with agreement by the Consultative Committee on Emergency Plant Pests and the Domestic Quarantine and Market Access Working Group
- Eradication has been deemed impractical and procedures for long-term management of the disease risk have been implemented

A final report should be completed by the lead agency and the handling of the incident reviewed.

Eradication will be deemed impractical if, at any stage, the results of the delimiting surveys lead to a decision to move to containment/control.

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## 11 Appendices

### 11.1 Appendix 1: Hosts of Green peach aphid (*Myzus persicae*) as listed on the CAB Compendium (CAB International 2011)

| Species                                                        | Species                                            |
|----------------------------------------------------------------|----------------------------------------------------|
| <i>Abelmoschus esculentus</i> (okra)                           | <i>Hordeum vulgare</i> (barley)                    |
| <i>Aleurites</i>                                               | <i>Humulus lupulus</i> (hop)                       |
| <i>Aloe</i> (grey alder)                                       | <i>Impatiens</i> (balsam)                          |
| <i>Anchusa</i> (Bugloss)                                       | <i>Indigofera</i> (indigo)                         |
| <i>Anethum graveolens</i> (dill)                               | <i>Ipomoea batatas</i> (sweet potato)              |
| <i>Anthriscus</i> (chervil)                                    | <i>Iris</i> (irises)                               |
| <i>Antirrhinum</i> (snapdragon)                                | <i>Lactuca sativa</i> (lettuce)                    |
| <i>Apium graveolens</i> (celery)                               | <i>Lavandula angustifolia</i> (lavender)           |
| <i>Araceae</i>                                                 | <i>Lepidium sativum</i> (garden cress)             |
| <i>Arachis hypogaea</i> (groundnut)                            | <i>Lepidium virginicum</i> (Virginian peppergrass) |
| <i>Armoracia rusticana</i> (horseradish)                       | <i>Lilium</i> (lily)                               |
| <i>Artemisia</i> (wormwoods)                                   | <i>Lolium</i> (ryegrasses)                         |
| <i>Asparagus officinalis</i> (asparagus)                       | <i>Lolium multiflorum</i> (Italian ryegrass)       |
| <i>Beta vulgaris</i> var. <i>saccharifera</i> (sugarbeet)      | <i>Lupinus</i> (lupins)                            |
| <i>Brassica</i>                                                | <i>Malus domestica</i> (apple)                     |
| <i>Brassica oleracea</i> (cabbages, cauliflowers)              | <i>Malva</i> (mallow)                              |
| <i>Brassica rapa</i> cultivar group Caixin                     | <i>Matthiola</i>                                   |
| <i>Brassica rapa</i> subsp. <i>chinensis</i> (Chinese cabbage) | <i>Medicago sativa</i> (lucerne)                   |
| <i>Cajanus cajan</i> (pigeon pea)                              | <i>Mentha</i> (mints)                              |
| <i>Capsella bursa-pastoris</i> (shepherd's purse)              | <i>Narcissus</i> (daffodil)                        |
| <i>Capsicum</i> (peppers)                                      | <i>Papaver somniferum</i> (Opium poppy)            |
| <i>Capsicum annuum</i> (bell pepper)                           | <i>Pastinaca sativa</i> (parsnip)                  |
| <i>Carica papaya</i> (papaw)                                   | <i>Persea americana</i> (avocado)                  |
| <i>Carthamus tinctorius</i> (safflower)                        | <i>Petroselinum</i> (parsley)                      |
| <i>Chenopodium</i> (Goosefoot)                                 | <i>Phaseolus</i> (beans)                           |
| <i>Chenopodium quinoa</i> (quinoa)                             | <i>Pisum sativum</i> (pea)                         |
| <i>Chrysanthemum</i> (daisy)                                   | <i>Poa</i> (meadow grass)                          |
| <i>Chrysanthemum indicum</i> (chrysanthemum)                   | <i>Prunus</i> (stone fruit)                        |
| <i>Cichorium intybus</i> (chicory)                             | <i>Prunus amygdalus</i>                            |
| <i>Citrullus lanatus</i> (watermelon)                          | <i>Prunus armeniaca</i> (apricot)                  |

|                                                                  |                                                            |
|------------------------------------------------------------------|------------------------------------------------------------|
| <i>Citrus</i>                                                    | <i>Prunus mume</i> (Japanese apricot tree)                 |
| <i>Colocasia esculenta</i> (taro)                                | <i>Prunus nana</i>                                         |
| <i>Convallaria majalis</i> (lily of the valley)                  | <i>Prunus nigra</i> (Canada plumtree)                      |
| <i>Convolvulus</i> (morning glory)                               | <i>Prunus persica</i> (peach)                              |
| <i>Coriandrum sativum</i> (coriander)                            | <i>Prunus serotina</i> (black cherry)                      |
| <i>Crocus sativus</i> (saffron)                                  | <i>Psidium guajava</i> (guava)                             |
| <i>Cucumis</i> (melons, cucumbers, gherkins)                     | <i>Punica granatum</i> (pomegranate)                       |
| <i>Cucurbita</i> (pumpkin)                                       | <i>Raphanus sativus</i> (radish)                           |
| <i>Cucurbita moschata</i> (pumpkin)                              | <i>Rhus</i> (Sumach)                                       |
| <i>Cucurbita pepo</i> (ornamental gourd)                         | <i>Rosa</i> (roses)                                        |
| <i>Cuminum cyminum</i> (cumin)                                   | <i>Rumex acetosa</i> var. <i>hortensis</i> (garden sorrel) |
| <i>Cydonia oblonga</i> (quince)                                  | <i>Saccharum officinarum</i> (sugarcane)                   |
| <i>Cynara cardunculus</i> var. <i>scolymus</i> (globe artichoke) | <i>Secale cereale</i> (rye)                                |
| <i>Cyphomandra betacea</i> (tree tomato)                         | <i>Senecio</i> (Groundsel)                                 |
| <i>Dahlia</i>                                                    | <i>Senecio vulgaris</i>                                    |
| <i>Daucus carota</i> (carrot)                                    | <i>Sesamum indicum</i> (sesame)                            |
| <i>Dianthus</i> (carnation)                                      | <i>Solanum lycopersicum</i> (tomato)                       |
| <i>Dianthus caryophyllus</i> (carnation)                         | <i>Solanum melongena</i> (aubergine)                       |
| <i>Euphorbia</i> (spurges)                                       | <i>Solanum nigrum</i> (black nightshade)                   |
| <i>Foeniculum vulgare</i> (fennel)                               | <i>Solanum tuberosum</i> (potato)                          |
| <i>Fragaria chiloensis</i> (Chilean strawberry)                  | <i>Spinacia oleracea</i> (spinach)                         |
| <i>Gladiolus hybrids</i> (sword lily)                            | <i>Trifolium</i> (clovers)                                 |
| <i>Glycine max</i> (soyabean)                                    | <i>Triticum</i> (wheat)                                    |
| <i>Gossypium</i> (cotton)                                        | <i>Tulipa</i> (tulip)                                      |
| <i>Hemerocallis</i> (daylilies)                                  | <i>Vicia</i> (vetch)                                       |
| <i>Nasturtium officinale</i> (watercress)                        | <i>Vigna unguiculata</i> (cowpea)                          |
| <i>Nicotiana tabacum</i> (tobacco)                               | <i>Zea mays</i> (maize)                                    |
| <i>Origanum majorana</i> (sweet marjoram)                        |                                                            |

## 11.2 Appendix 2: Hosts of Green citrus aphid (*Aphis spiraecola*) as listed on the CAB Compendium (CAB International 2011)

| Species                                          | Species                                          |
|--------------------------------------------------|--------------------------------------------------|
| <i>Abelia grandiflora</i> (Glossy abelia)        | <i>Malus domestica</i> (apple)                   |
| <i>Annona</i>                                    | <i>Nicotiana</i>                                 |
| <i>Apium graveolens</i> (celery)                 | <i>Passiflora edulis</i> (passionfruit)          |
| <i>Astragalus sinicus</i> (chinese clover)       | <i>Persea americana</i> (avocado)                |
| <i>Capsicum annuum</i> (bell pepper)             | <i>Phaseolus vulgaris</i> (common bean)          |
| <i>Carica papaya</i> (papaw)                     | <i>Pittosporum tobira</i> (Japanese pittosporum) |
| <i>Citrus</i>                                    | <i>Prunus</i> (stone fruit)                      |
| <i>Citrus deliciosa</i> (Mediterranean mandarin) | <i>Prunus armeniaca</i> (apricot)                |
| <i>Citrus limon</i> (lemon)                      | <i>Prunus persica</i> (peach)                    |
| <i>Citrus reticulata</i> (mandarin)              | <i>Prunus salicina</i> (Japanese plum)           |
| <i>Citrus sinensis</i> (navel orange)            | <i>Pyrus communis</i> (European pear)            |
| <i>Coriandrum sativum</i> (coriander)            | <i>Saccharum officinarum</i> (sugarcane)         |
| <i>Cotoneaster</i>                               | <i>Solanum melongena</i> (aubergine)             |
| <i>Crataegus</i> (hawthorns)                     | <i>Solanum nigrum</i> (black nightshade)         |
| <i>Cucumis sativus</i> (cucumber)                | <i>Solanum tuberosum</i> (potato)                |
| <i>Cucurbita</i> (pumpkin)                       | <i>Sorghum bicolor</i> (sorghum)                 |
| <i>Cydonia oblonga</i> (quince)                  | <i>Spiraea</i>                                   |
| <i>Cynodon dactylon</i> (Bermuda grass)          | <i>Spiraea thunbergii</i> (Thunberg's spiraea)   |
| <i>Cyphomandra betacea</i> (tree tomato)         | <i>Spiraea vanhouttei</i> (Bridal wreath)        |
| <i>Daucus carota</i> (carrot)                    | <i>Theobroma cacao</i> (cocoa)                   |
| <i>Eriobotrya japonica</i> (loquat)              | <i>Viburnum</i>                                  |
| <i>Glycine max</i> (soyabean)                    | <i>Viburnum odoratissimum</i>                    |
| <i>Juglans regia</i> (walnut)                    | <i>Vigna unguiculata</i> (cowpea)                |
| <i>Lactuca sativa</i> (lettuce)                  | <i>Vitis vinifera</i> (grapevine)                |
| <i>Macadamia ternifolia</i> (Queensland nut)     | <i>Zea mays</i> (maize)                          |
| <i>Malus</i> (ornamental species apple)          |                                                  |

### 11.3 Appendix 3: Hosts of Plum pox virus (*potyvirus*) as listed on the CAB Compendium (CAB International 2011)

| Scientific name             | Common name                           |
|-----------------------------|---------------------------------------|
| <i>Cichorium</i> sp.        | Chicory                               |
| <i>Cirsium arvense</i>      | Creeping thistle                      |
| <i>Clematis</i> sp.         |                                       |
| <i>Convolvulus arvensis</i> | Bindweed                              |
| <i>Euonymus europaeus</i>   |                                       |
| <i>Juglans regia</i>        | Carpathian walnut                     |
| <i>Ligustrum vulgare</i>    | Privet                                |
| <i>Prunus americana</i>     | American plum                         |
| <i>Prunus angustifolia</i>  | Mountain cherry tree                  |
| <i>Prunus armeniaca</i>     | Apricot                               |
| <i>Prunus avium</i>         | Sweet cherry                          |
| <i>Prunus besseyi</i>       | Bessey cherry                         |
| <i>Prunus cerasifera</i> *  | Cherry plum, Myrobalan plum           |
| <i>Prunus cerasus</i>       | Sour cherry                           |
| <i>Prunus cistena</i>       |                                       |
| <i>Prunus davidiana</i>     |                                       |
| <i>Prunus domestica</i>     | Plum                                  |
| <i>Prunus dulcis</i>        | Almond                                |
| <i>Prunus emarginata</i>    | Bitter cherry tree                    |
| <i>Prunus fruticosa</i>     | Dwarf cherry                          |
| <i>Prunus glandulosa</i> *  | Almond cherry, Dwarf flowering almond |
| <i>Prunus hortulana</i>     |                                       |
| <i>Prunus humilis</i>       |                                       |
| <i>Prunus ilicifolia</i>    | Holly-leaved cherry                   |
| <i>Prunus insititia</i> *   | Damson plum                           |
| <i>Prunus japonica</i> *    | Japanese single bush cherry           |
| <i>Prunus maackii</i>       |                                       |
| <i>Prunus mahaleb</i> *     | Mahaleb cherry, St. Lucie cherry      |
| <i>Prunus maritima</i> *    | Beach plum                            |
| <i>Prunus mexicana</i>      |                                       |
| <i>Prunus nigra</i>         | Canada plumbtree                      |
| <i>Prunus padus</i>         | Bird cherry                           |
| <i>Prunus pensylvanica</i>  | Pin cherry                            |



| Scientific name                              | Common name               |
|----------------------------------------------|---------------------------|
| <i>Prunus persica</i>                        | Peach                     |
| <i>Prunus pumila</i> var. <i>besseyi</i>     |                           |
| <i>Prunus pumila</i> var. <i>depressa</i>    |                           |
| <i>Prunus salicina</i> *                     | Japanese plum             |
| <i>Prunus sargentii</i>                      | Sargent's cherry          |
| <i>Prunus serotina</i>                       | Black cherry              |
| <i>Prunus serrulata</i>                      | Japanese flowering cherry |
| <i>Prunus sibirica</i> *                     | Siberian apricot          |
| <i>Prunus spinosa</i> *                      | Blackthorn, Sloe          |
| <i>Prunus subhirtella</i>                    | Weeping Japanese cherry   |
| <i>Prunus tenella</i>                        |                           |
| <i>Prunus tomentosa</i> *                    | Nanking cherry            |
| <i>Prunus triloba</i>                        | Rose tree of China        |
| <i>Prunus virginiana</i>                     | Chokecherry tree          |
| <i>Prunus virginiana</i> var. <i>demissa</i> |                           |
| <i>Prunus yedoensis</i>                      |                           |
| <i>Rorippa sylvestris</i>                    | Creeping yellowcress      |
| <i>Solanum nigrum</i>                        | Black nightshade          |
| <i>Sonchus</i> sp.                           | Sowthistle                |
| <i>Taraxacum officinale</i> complex          | Dandelion                 |
| <i>Trifolium</i> sp.                         | Clovers                   |

An asterisk (\*) indicates those species that are often grown in domestic gardens or used as street trees in Australia. These species would need to be considered in the event of an incursion of PPV (Diagnostic protocol for *Plum pox virus*).

## 11.4 Appendix 4: Standard diagnostic protocols

For a range of specifically designed procedures for the emergency response to a pest incursion refer to Plant Health Australia's PLANTPLAN ([www.planthealthaustralia.com.au/plantplan](http://www.planthealthaustralia.com.au/plantplan)).

## 11.5 Appendix 5: Resources and facilities

Table 11 provides a list of diagnostic facilities for use in professional diagnosis and advisory services in the case of an incursion.

**Table 11.** *Diagnostic service facilities in Australia*

| Facility                                                                          | State | Details                                                                                                    |
|-----------------------------------------------------------------------------------|-------|------------------------------------------------------------------------------------------------------------|
| DPI Victoria – Knoxfield Centre                                                   | Vic   | 621 Burwood Highway<br>Knoxfield VIC 3684<br>Ph: (03) 9210 9222; Fax: (03) 9800 3521                       |
| DPI Victoria – Horsham Centre                                                     | Vic   | Natimuk Rd<br>Horsham VIC 3400<br>Ph: (03) 5362 2111; Fax: (03) 5362 2187                                  |
| DPI New South Wales – Elizabeth Macarthur Agricultural Institute                  | NSW   | Woodbridge Road<br>Menangle NSW 2568<br>PMB 8 Camden NSW 2570<br>Ph: (02) 4640 6327; Fax: (02) 4640 6428   |
| DPI New South Wales – Tamworth Agricultural Institute                             | NSW   | 4 Marsden Park Road<br>Calala NSW 2340<br>Ph: (02) 6763 1100; Fax: (02) 6763 1222                          |
| DPI New South Wales – Wagga Wagga Agricultural Institute                          | NSW   | PMB Wagga Wagga<br>NSW 2650<br>Ph: (02) 6938 1999; Fax: (02) 6938 1809                                     |
| SARDI Plant Research Centre – Waite Main Building, Waite Research Precinct        | SA    | Hartley Grove<br>Urrbrae SA 5064<br>Ph: (08) 8303 9400; Fax: (08) 8303 9403                                |
| Grow Help Australia                                                               | QLD   | Entomology Building<br>80 Meiers Road<br>Indooroopilly QLD 4068<br>Ph: (07) 3896 9668; Fax: (07) 3896 9446 |
| Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories | WA    | 3 Baron-Hay Court<br>South Perth WA 6151<br>Ph: (08) 9368 3721; Fax: (08) 9474 2658                        |

## 11.6 Appendix 6: Communications strategy

A general Communications Strategy is provided in Appendix 6 of PLANTPLAN (Plant Health Australia, 2010).

## 11.7 Appendix 7: Market access impacts

Within the AQIS PHYTO database ([www.aqis.gov.au/phyto](http://www.aqis.gov.au/phyto)) export of some material may require an additional declaration regarding freedom from the virus. Should aphid transmitted viruses be detected or become established in Australia, some countries may require specific declaration. Latest information can be found within PHYTO, using an Advanced search “Search all text” for the particular virus.

**INDUSTRY BIOSECURITY PLAN  
FOR THE NURSERY & GARDEN INDUSTRY**

## **Threat Specific Contingency Plan**

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**Pierce's disease  
(*Xylella fastidiosa*)**

**Plant Health Australia**

**September 2011**



## Disclaimer

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## Further information

For further information regarding this contingency plan, contact Plant Health Australia through the details below.



|          |                                            |
|----------|--------------------------------------------|
| Address: | Suite 1, 1 Phipps Close<br>DEAKIN ACT 2600 |
|----------|--------------------------------------------|

|        |                 |
|--------|-----------------|
| Phone: | +61 2 6215 7700 |
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|      |                 |
|------|-----------------|
| Fax: | +61 2 6260 4321 |
|------|-----------------|

|        |                                                                             |
|--------|-----------------------------------------------------------------------------|
| Email: | <b><a href="mailto:biosecurity@phau.com.au">biosecurity@phau.com.au</a></b> |
|--------|-----------------------------------------------------------------------------|

|          |                                                                                             |
|----------|---------------------------------------------------------------------------------------------|
| Website: | <b><a href="http://www.planthealthaustralia.com.au">www.planthealthaustralia.com.au</a></b> |
|----------|---------------------------------------------------------------------------------------------|

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|          |                                                                 |           |
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# 1 Purpose and background of this contingency plan

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This contingency plan provides background information on the pest biology and available control measures to assist with preparedness for an incursion into Australia of Pierce's disease, the causal agent of which is *Xylella fastidiosa*. This contingency plan focuses specifically on the pathogen, but recognises that the introduction, spread and economic impact of the disease will depend strongly on the presence of one of its main vectors, the Glassy winged sharpshooter (*Homalodisca vitripennis*). A separate contingency plan has previously been prepared for Glassy winged sharpshooter (GWSS), and is referenced where appropriate in this contingency plan.

This contingency plan provides guidelines and options for steps to be undertaken and considered when developing a Response Plan for incursion of Pierce's disease. The control and management information provided in this document is specifically for the pathogen *Xylella fastidiosa*, as control of the main vector *Homalodisca vitripennis* is addressed in the Glassy winged sharpshooter contingency plan (Plant Health Australia 2009). Any Response Plan developed using information in whole or in part from either of these contingency plans must follow procedures as set out in PLANTPLAN and be endorsed by the National Management Group prior to implementation.

This contingency plan was developed for the Nursery and Industry Australia (NGIA), and therefore is focused on production nurseries covered by this association. In the event of an incursion, operations that are not covered by the NGIA or another Emergency Plant Pest Response Deed (EPPRD) signatory (e.g. retail nurseries), will not be represented or have a decision making say in any arrangements for emergency response.

The information for this plan has been primarily obtained from documents sourced electronically as cited in the reference section and the National Diagnostic Protocol for Pierce's Disease, *Xylella fastidiosa* (Luck *et al.* 2010). Information on background, life cycle, host range, distribution and symptoms is given, with the emphasis of this document on the management and control of the pathogen.

## 2 Australian nursery industry

---

The Australian nursery industry is a significant horticultural sector with a combined supply chain (production to retail/grower) valued at more than \$6 billion dollars annually. The industry employs approximately 45,000 people spread over more than 20,000 small to medium sized businesses including production nurseries and retail outlets. The industry is located predominantly along the Australian coastline and in major inland regions servicing urban and production horticulture.

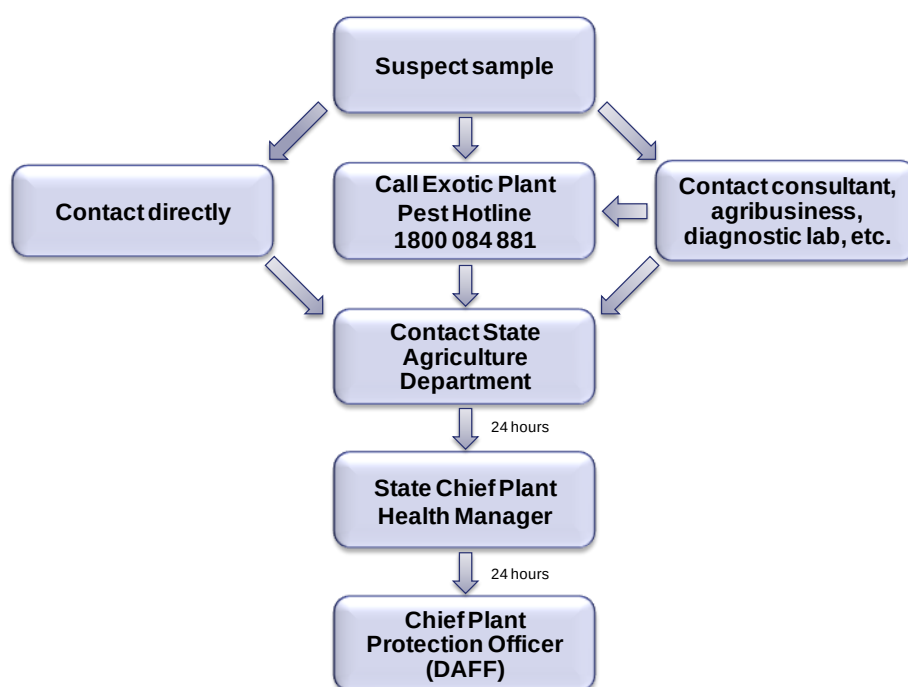
Nursery production is a highly diverse primary industry servicing the broader \$14 billion horticultural sector within Australia (Table 1). A pest incursion is likely to impact market access (see Section 10.5 Appendix 5 for further information).

**Table 1.** Nursery production supply sectors within Australian horticulture

| Production Nursery                    | Horticultural markets            | Economic value           |
|---------------------------------------|----------------------------------|--------------------------|
| Container stock <sup>1</sup>          | Ornamental/urban horticulture    | \$2 billion retail value |
| Foliage plants <sup>1</sup>           | Interior-scapes                  | \$87 million industry    |
| Seedling stock <sup>2</sup>           | Vegetable growers                | \$3.3 billion industry   |
| Forestry stock <sup>3</sup>           | Plantation timber                | \$1.7 billion industry   |
| Fruit and nut tree stock <sup>2</sup> | Orchardists (citrus, mango, etc) | \$5.2 billion industry   |
| Landscape stock <sup>1</sup>          | Domestic & commercial projects   | \$2 billion industry     |
| Plug and tube stock <sup>4</sup>      | Cut flower                       | \$319 million industry   |
| Revegetation stock <sup>1</sup>       | Farmers, government, landcare    | \$109 million industry   |
| Mine revegetation                     | Mine site rehabilitation         | Value unknown            |
| Total horticultural market value      |                                  | \$14.5 billion           |

## 2.1 Notification process for the reporting of suspect pests

Early detection and reporting may prevent or minimise the long-term impact of an incursion into Australia of the Pierce's disease (*Xylella fastidiosa*) and/or its vector the Glassy winged sharpshooter (*Homalodisca vitripennis*).

**Figure 1.** Notification process for the reporting of suspect pests

<sup>1</sup> Data sourced from Market Monitor

<sup>2</sup> Data sourced from Horticultural Handbook 2004

<sup>3</sup> Data sourced from ABARE 2005

<sup>4</sup> Data sourced from industry

### 3 Eradication or containment decision matrix

The decision to eradicate should be based on the potential economic impact of host damage resulting from Pierce's disease infection, the cost of eradication and on technical feasibility. Eradication costs must factor in long term surveys to prove the success of the eradication program. A minimum of three years with no detections of the pathogen may be necessary to confirm that Pierce's disease is absent and pest free status can be declared. The timeframe needs to be considered on a case by case basis, based both on the size of the infection, the degree and distribution of the pest, with the final decision determined by the National Management Group.

No specific eradication matrix has been determined for Pierce's disease; however, the general decision process as outlined in Figure 2 and Table 2 should be followed in determining if an incursion of this pest will be eradicated or managed/contained. The final decision between eradication and management will be made through the National Management Group.

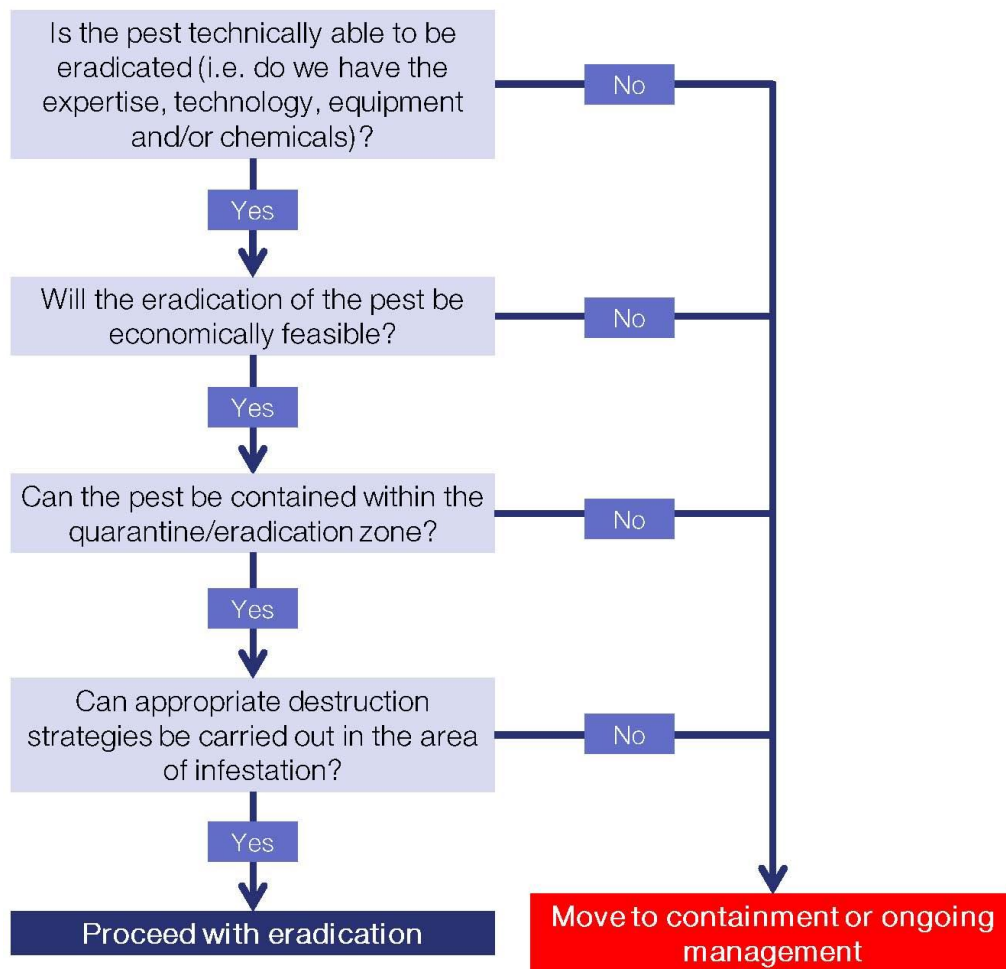


**Figure 2.** Decision outline for the response to an exotic pest incursion

**Table 2.** Factors considered in determining whether eradication or alternative action will be taken for an EPP Incident (taken from Appendix 12 of PLANTPLAN)

| Factors favouring eradication                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Factors favouring alternative action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Cost/benefit analysis shows significant economic or amenity loss to industry or the community if the organism establishes.</li> <li>• Physical barriers and/or discontinuity of hosts between production districts.</li> <li>• Cost effective control difficult to achieve (e.g. limited availability of protectant or curative treatments).</li> <li>• The generation time, population dynamics and dispersal of the organism favour more restricted spread and distribution.</li> <li>• Pest biocontrol agents not known or recorded in Australia.</li> <li>• Vectors discontinuous and can be effectively controlled.</li> <li>• Outbreak(s) few and confined.</li> <li>• Trace information indicates few opportunities for secondary spread.</li> <li>• Weather records show unfavourable conditions for pest development.</li> <li>• There is reasonable ease of access to outbreak site and any alternate hosts.</li> </ul> | <ul style="list-style-type: none"> <li>• Cost/benefit analysis shows relatively low economic or environmental impact if the organism establishes.</li> <li>• Major areas of continuous production of host plants.</li> <li>• Cost effective control strategies available.</li> <li>• Short generation times, potential for rapid population growth and long distance dispersal lead to rapid establishment and spread.</li> <li>• Widespread populations of known pest biocontrol agents present in Australia.</li> <li>• Vectors unknown, continuous or difficult to control.</li> <li>• Outbreaks numerous and widely dispersed.</li> <li>• Trace information indicates extensive opportunities for secondary spread.</li> <li>• Weather records show optimum conditions for pest development.</li> <li>• Terrain difficult and/or problems accessing and locating host plants.</li> </ul> |

## 4 Pest information/status

### 4.1 Pest details

|                     |                                                                                                                                                                                                                                                                                                                                                            |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Common name:        | Pierce's disease of grapes<br>Plum leaf scald<br>Phony disease of peach<br>Pecan leaf scorch<br>Pear leaf scorch<br>Almond leaf scorch<br>Citrus variegated chlorosis<br>Coffee leaf scorch<br>Dwarf lucerne<br>Leaf scorch disease (elm, sycamore, oleander, maple, oak)<br>Sweetgum dieback<br>Leaf scorch of purple-leafed plum<br>Mulberry leaf scorch |
| Scientific name:    | <i>Xylella fastidiosa</i>                                                                                                                                                                                                                                                                                                                                  |
| Taxonomic position: | Kingdom, Animalia; Phylum, Proteobacteria; Class, Gammaproteobacteria; Order, Xanthomonadales; Family, Xanthomonadaceae                                                                                                                                                                                                                                    |

#### 4.1.1 Background

Pierce's disease of grapevines was first discovered in 1892 in California, and is now a damaging pest in southern parts of the United States, Mexico and Central America. The disease is caused by the xylem-limited bacterium *Xylella fastidiosa* (Wells *et al.* 1987), which is also the causal agent of a range of disorders in other species. These include leaf scorch of oak, oleander, elm, sycamore and maple (Hearon *et al.* 1980), Sweetgum dieback and Leaf scorch of purple-leafed plum (Hernandez-Martinez *et al.* 2009) and diseases of agriculturally important crops such as peach, plum, pear, coffee, lucerne, citrus, almond and pecan (Hopkins 1989; Leu and Su 1993; de Lima *et al.* 1998).

Pierce's disease is a lethal grapevine disease killing grapevines outright by blocking the xylem tissue. The plant can die within 1-2 years of the initial infection date. The disease and the vector can persist all year round (Luck *et al.* 2010).

Several molecular studies have shown that distinct groups or clusters of *X. fastidiosa* exist (e.g. Chen *et al.* 1995, Pooler *et al.* 1995, Henderson *et al.* 2001). Schaad *et al.* (2004) described three subspecies of *X. fastidiosa* based on genetic and phenotypic evidence, namely subsp. *piercei*; subsp. *multiplex* and subsp. *pauca*. *Xyella fastidiosa* subsp. *pauca* causes Citrus veinal chlorosis only, whilst subsp. *piercei* and subsp. *multiplex* can cause disease symptoms in multiple hosts. Schuenzel *et al.* (2005) further classified a group of Oleander leaf scorch isolates as a separate subspecies, *X. fastidiosa* subsp. *sandyi*. More recently, Janse and Obradovic (2010) described five subspecies:

- (i) *Xylella fastidiosa* subsp. *fastidiosa* (erroneously named *X. f.* subsp. *piercei*), which causes Pierce's disease and Almond leaf scorch. Strains have been isolated from cultivated grape, lucerne, almond, and maple;

- (ii) *X. fastidiosa* subsp. *multiplex* which causes Phony disease of peach and Plum leaf scald. Strains have been isolated from peach, elm, plum, pigeon grape, sycamore and almond;
- (iii) *X. fastidiosa* subsp. *pauca*, which causes Citrus variegated chlorosis. Strains have been isolated from citrus and probably include those from coffee;
- (iv) *X. fastidiosa* subsp. *sandyi* which causes Oleander leaf scorch. Strains have been isolated from *Nerium oleander*;
- (v) *X. fastidiosa* subsp. *Tashke*. Strains of this subspecies have been isolated from the ornamental tree *Chitalpa tashkentensis*.

Despite these classifications, the relationship between strains and hosts appears complex and is still not fully understood and is further complicated by the existence of pathovars (within plant-host strains) (Schuenzel *et al.* 2005). For example, some pathovars causing Almond leaf scorch can also cause Pierce's disease in grapes, yet other pathovars are limited to causing disease symptoms only in almonds (Hendson *et al.* 2001). However, the sequencing of the *X. fastidiosa* genome (Simpson *et al.* 2000) and subsequent sequencing of various strains of *X. fastidiosa* should improve understanding of host-strain relationships in the years to come.

#### 4.1.2 Life cycle

A generic life cycle of the pathogen in shade trees is depicted in Figure 3. The bacteria proliferate in the xylem vessels of susceptible hosts, and notably, are maintained or can multiply in wild hosts. Survival of the bacteria depends strongly on winter climate, as persistence in plants over winter is limited by cold conditions (Purcell 1980). The bacteria is sensitive to dry conditions, such as those found in many seeds, but despite this, seed transmission of the bacteria is known to occur in citrus (CABI 2011). The bacteria can also persist in the gut of vector insects indefinitely, with the ability to multiply in the foregut (Janse and Obradovic 2010). In particular, the presence of vectors that overwinter as adults (as opposed to eggs or nymphs) appears to be a major factor in disease prevalence, as these vectors have the capacity to establish early season infections (Purcell 1997).

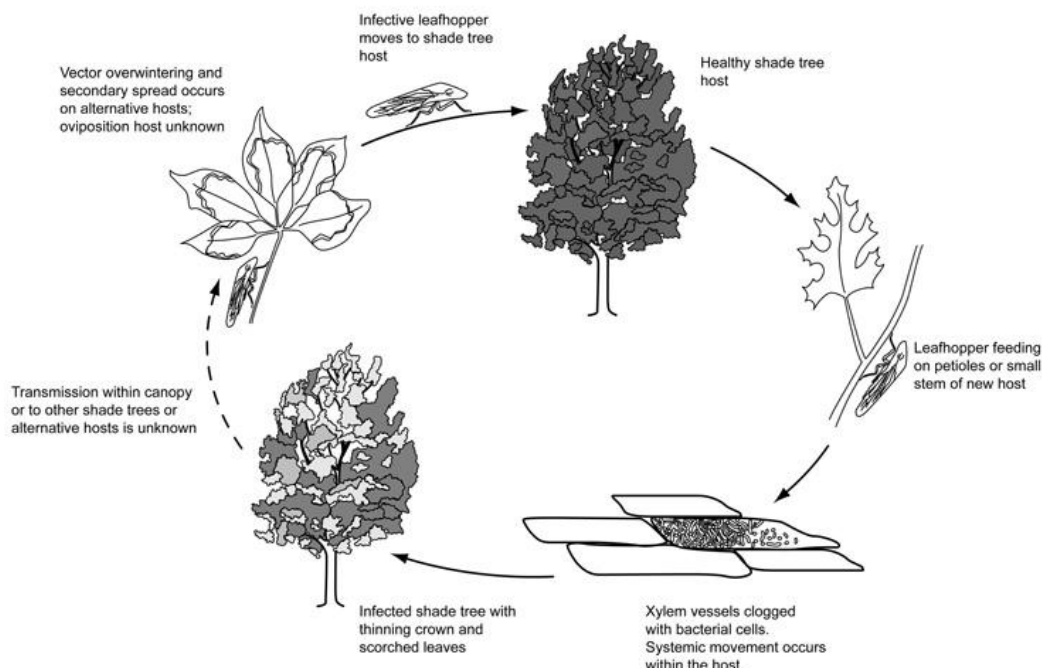


**Figure 3:** Disease cycle of *X. fastidiosa* in shade trees (Gould and Lashomb 2007)

#### 4.1.3 Dispersal

Pierce's disease can be transmitted and dispersed by graft transmission and by propagative material (Smith *et al.* 1997). Seed transmission and spread from tree to tree has been reported in citrus (Laranjeira *et al.* 1998; Li *et al.* 2003), but these mechanisms of spread are not common for other species. Other research has shown the disease is not transmitted by contaminated pruning shears (Varela 2000).

Dispersal typically occurs through using infected grafting material or by insect vectors which include nearly all sucking insects that feed predominantly on xylem fluid (Purcell 1989). The most common vector species in North America are Leafhoppers (Cicadellidae) in the subfamily Cicadellinae (sharpshooters) and spittle bugs or froghoppers (Cercopidae). The bacteria adhere to the mouthparts and are released directly when the insect feeds again. Few live cells are needed for effective transmission (Purcell *et al.* 1979; Hill and Purcell 1995). Transmission is usually from wild, generally symptomless hosts to cultivated hosts (grapevines, peaches) rather than between cultivated hosts, though the latter can occur.

Once acquired, the bacteria can persist in the gut of vectors indefinitely (Janse and Obradovic 2010) who then can transmit the disease in the subsequent season. The vector identified as the greatest threat to Australia is the Glassy winged sharpshooter (GWSS), which has a wide host range, flies long distances and unlike other vectors, often feeds directly on stems rather than leaves or extremities so pruning is not a viable control measure. For information on dispersal of the GWSS, refer to the Threat specific contingency plan for GWSS prepared for the NGIA (Plant Health Australia 2009).

Plant parts liable to carry *X. fastidiosa* in trade/transport are:

- Bulbs, Tubers, Corms, Rhizomes: Borne internally, not visible to naked eye but usually visible under light microscope
- Flowers, Inflorescences, Cones, Calyx: Borne internally, not visible to naked eye but usually visible under light microscope
- Fruits (inc. pods): Borne internally, not visible to naked eye but usually visible under light microscope
- Leaves: Borne internally, not visible to naked eye but usually visible under light microscope
- Roots: Borne internally, not visible to naked eye but usually visible under light microscope
- Seedlings, Micropropagated plants: Borne internally, not visible to naked eye but usually visible under light microscope
- Stems (above ground), Shoots, Trunks, Branches: Borne internally, not visible to naked eye but usually visible under light microscope
- True seeds (inc. grain): Borne internally, not visible to naked eye but usually visible under light microscope

Plant parts not known to carry the pest in trade/transport are: bark, growing medium accompanying plants and wood.

Vectors can also be carried internationally on plants or plant products (usually as viable egg masses on plants), which is a major concern to Australia because no vectors are known to exist in Australia at present.

Australia has no record of Pierce's disease or Glassy winged sharpshooter.

## 4.2 Affected hosts

### 4.2.1 Host range

*Xylella fastidiosa* has an extremely wide host range as listed in Section 10.1 Appendix 1. The majority of hosts are wild hosts on which no leaf scorch symptoms are observed. It is worth noting that the host range of vectors, in particular the GWSS, will have a bearing on the spread of the disease. Hosts of the GWSS are listed in the GWSS contingency plan.

### 4.2.2 Current geographic distribution

Diseases caused by *X. fastidiosa* have so far been limited to the Americas and Taiwan (Pear leaf scorch only; Leu and Su 1993). Coffee leaf scorch and Citrus variegated chlorosis have been restricted to South America. There are also unconfirmed and unreliable reports of *X. fastidiosa* in Kosovo, Morocco, India and Turkey (CABI 2011).

The geographic distribution of Pierce's disease appears to be related to the ability of the bacteria to survive winter temperatures (Varela 2000). In general the disease is less prevalent where winter temperatures are colder. Wet winters also promote survival of vector populations and favour disease spread in regions with dry summers.



As winter weather conditions in Australia are not as severe as those in the USA, the effects of winter are likely to favour survival of the bacterium in Australia (Luck *et al.* 2010).

### 4.2.3 Symptoms

#### 4.2.3.1 PIERCE'S DISEASE OF GRAPEVINES

Leaf scorch is the most characteristic symptom of primary infection, with early signs including sudden drying of parts of green leaves, which then turn necrotic with adjacent tissues turning yellow or red (Figure 4). Scorched leaves may shrivel and drop, leaving bare petioles attached to stems. Diseased stems often mature irregularly, with patches of brown and green tissue. In later years, infected plants develop late and produce stunted chlorotic shoots. Chronically infected plants may have small, distorted leaves with interveinal chlorosis (Figure 5) and shoots with shortened internodes (CABI 2011). Highly susceptible cultivars rarely survive more than 2-3 years while tolerant cultivars may survive chronic infection for more than 5 years (Goodwin and Purcell 1992).

It can take four to five months for the symptoms to appear, with only one or two canes showing symptoms in year 1. With young vines the symptoms appear more quickly covering the entire vine in a single season (Varela *et al.* 2001).



**Figure 4:** Leaf symptoms in the field include yellowing and reddening of leaf tissue. Image courtesy of ENSA-Montpellier Archive, Ecole nationale supérieure agronomique de Montpellier, Bugwood.org



**Figure 5:** Leaf symptoms of pierce's disease (right) on Chardonnay grape compared to healthy leaf (left). Image courtesy of Alex. H. Purcell, University of California - Berkeley, Bugwood.org

#### 4.2.3.2 PHONY PEACH DISEASE

Young shoots are stunted with greener, denser foliage than healthy trees (CABI 2011). The shortening of internodes is accompanied by increased development of lateral branches that grow horizontally or droop (Janse and Obradovic 2010). Leaves and flowers appear early, and leaves remain on the tree longer than on healthy trees. Trees are not generally killed, but suffer fruit yield losses and are susceptible to attack from insects and other diseases.

#### 4.2.3.3 CITRUS VARIEGATED CHLOROSIS

Typical symptoms on trees up to 10 years of age include foliar chlorosis resembling zinc deficiency with interveinal chlorosis (Figure 6); symptoms in older trees appear as a few diseased branches. As the leaves mature, small, light-brown, slightly raised gummy lesions (becoming dark-brown or even necrotic) appear on the underside, directly opposite the yellow chlorotic areas on the upper side. Newly affected trees show sectoring of symptoms, whereas trees which have been affected for a period of time show variegated chlorosis throughout the canopy. Affected trees show stunting and slow growth rate; twigs and branches die back and the canopy thins, but affected trees do not die (CABI 2011). Trees may also wilt. Fruit are smaller (Figure 7) with a hard rind and higher sugar content (CABI 2011).





**Figure 6:** Leaf interveinal chlorosis caused by *Citrus variegated chlorosis* disease. Image courtesy of Alex. H. Purcell, University of California, Bugwood.org



**Figure 7:** Fruit are smaller, and small raised lesions appear on the underside of leaves. Image courtesy of Alex. H. Purcell, University of California, Bugwood.org



#### 4.2.3.4 OTHER LEAF SCORCH DISEASES CAUSED BY *X. FASTIDIOSA*

‘Scorching’ or bronzing of the leaf margins is the classic early symptom of diseases caused by *X. fastidiosa* (Figure 8). The bronzing may intensify (Figure 9) and become water soaked before browning and drying (Janse and Obradovic 2010). Symptoms usually appear on just a few branches but later spread to cover the entire plant. Depending on the plant, dieback, stunting, fruit distortion or plant death may occur.



**Figure 8:** Bronzing of oak leaves caused by *X. fastidiosa*. Image courtesy of Randy Cyr, Greentree, Bugwood.org



**Figure 9:** Bronzing intensifies over time (leaf from American Sycamore). Image courtesy of Theodor D. Leininger, USDA Forest Service, Bugwood.org

## 4.3 Diagnostic information

An endorsed National Diagnostic Protocol (NDP6) for Pierce's Disease, *Xylella fastidiosa* has been prepared by Luck *et al.* (2010). This protocol describes three methods for the positive identification of *X. fastidiosa* including morphological methods, serological test, Enzyme Linked Immunosorbent Assay (ELISA) or Polymerase Chain Reaction (PCR) methodology (Varela 2000).

For a list of diagnostic facilities and advisory services that can be utilised in the event of an incursion see Section 10.2 Appendix 2 and Section 10.3 Appendix 3.

### 4.3.1 Morphological methods

Specialised media has been developed for isolating and growing the bacterium (Luck *et al.* 2002 & 2010).

*X. fastidiosa* is a Gram-negative, slow growing rod-shaped bacterium that lacks flagella for motility and is strictly aerobic (Janse and Obradovic 2010). Bacterial cells typically possess a rippled (undulating) cell wall and terminal fimbriae (surface structures, shorter than flagella, that help to anchor the cells together in the xylem stream) (Gould and Lashomb 2007). As the name suggests, *X. fastidiosa* has fastidious nutrient requirements and grows only on selective media to form small colonies that appear white to yellow (Gould and Lashomb 2007).

### 4.3.2 Molecular methods

Luck *et al.* (2010) provide detailed protocols for the detection/diagnosis of *X. fastidiosa* in Australia for all three diagnostic methods, but recommend using PCR followed by bacterial culturing to confirm a positive result. Further advances in PCR-based methods that allow detection of all strains of the pathogen in plant or vector insect tissues and a description of primers required are given in Janse and Obradovic (2010).

## 5 Risk assessments for pathways and potential impacts

---

*X. fastidiosa* and its vector GWSS are not present in Australia, but both pests have the potential for establishment of spread and economic consequences in Australia, and therefore meet the criteria for a quarantine pest.

The risk assessments in this section focus on the major pathways identified for the potential introduction of *X. fastidiosa*. Unlike most other pests, the risk of establishment and spread will depend both on the commodity on which it enters Australia and also whether or not the vector is present.

Much of the data on the risk of entry, probability of establishment, probability of spread has been sourced on *X. fastidiosa* from the 'Final IRA report: Stone fruit from California, Idaho, Oregon and Washington (2010) and the 'Report on Pierce's disease and the Glassy winged sharpshooter' more specifically with reference to importing grapes from the USA (Scott and De Barro 2000). For further information on the phytosanitary risk of *X. fastidiosa* with the vector GWSS refer to the Contingency plan developed for NGIA (Plant Health Australia 2009).

## 5.1 Entry of the pathogen with a vector

All sucking insects that feed on xylem sap are potential vectors of *X. fastidiosa*, with all known vectors limited to the Homoptera suborder (Purcell 1999). Insects currently known to be capable of transmitting *X. fastidiosa* all belong to the spittlebug/ froghopper family (Cercopidae) and the 'sharpshooter' subfamily.

Xylem feeding insects acquire the bacterium from infected hosts. The bacterium adheres to and is retained in the foregut of the vector where it replicates and from which it is transmitted to new hosts almost immediately (Purcell and Hopkins 1996) with virulence maintained throughout the life of adult vectors (Redak *et al.* 2004).

GWSS is a major vector for *X. fastidiosa* and there is potential to introduce infected GWSS with importation of fruit.

### 5.1.1 Entry potential

#### Rating: Medium

Entry pathways for GWSS to arrive in Australia are shown in Table 3. The most likely pathway of entry for GWSS is as a hitchhiker on plant material and transport machinery, including on imported nursery stock. Evidence suggests that the leafhopper entered California in nursery stock as eggs, which are difficult to detect. Since then the agriculture quarantine inspections have frequently intercepted leafhopper specimens.

Table grape exports into Australia could also be a potential entry pathway for sharpshooter. The risk of GWSS arriving in Australia would in some part be related to the number of insects present in the source areas from which the table grape exports originate. In the early part of the table grape season when the insect is extremely active and all forms of the insect can be found in vineyards and in other orchards the risk of the insect entering Australia would be higher.

The risk of entry of GWSS into Australia is **medium**. Given the reasonable likelihood that the vectors that enter may also be harbouring *X. fastidiosa*, the entry potential of the pathogen in the presence of the vector is also **medium**.

### 5.1.2 Establishment potential

#### Rating: Medium

The wide host range of GWSS together with suitable environmental conditions, would allow for the establishment of GWSS in many regions of Australia. The likelihood of GWSS establishment in Australia following entry, and therefore the likelihood of establishment of *X. fastidiosa*, is considered **medium**.

**Table 3.** Potential entry pathways for GWSS into Australia<sup>5</sup>

| Parameter                                                 | Details                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Plant parts that can carry GWSS in transport/trade        | <ul style="list-style-type: none"> <li>• Fruits (including pods) can carry eggs internally – visible to the naked eye</li> <li>• Leaves can carry eggs and nymphs both internally and externally – visible to the naked eye</li> <li>• Stems, shoots, trunks and branches can carry nymphs and adults externally – visible to the naked eye</li> </ul> |
| Plant parts not known to carry GWSS in transport/trade    | <ul style="list-style-type: none"> <li>• Bark</li> <li>• Bulbs, tubers, corms and rhizomes</li> <li>• Growing medium accompanying plants</li> <li>• Flowers, inflorescences, cones and calyx</li> <li>• Seedlings and micropropagated plants</li> <li>• Roots</li> <li>• True seeds (include grain)</li> <li>• Wood</li> </ul>                         |
| Transport pathways for long distance transport            | <ul style="list-style-type: none"> <li>• Adults can be carried within transport vehicles</li> <li>• Adults and nymphs can be moved in storage and transport bins</li> </ul>                                                                                                                                                                            |
| Main pathways for the likely entry of GWSS into Australia | <ul style="list-style-type: none"> <li>• Nursery stock for planting (excluding seeds and fruit) of known susceptible hosts</li> <li>• Foliage of cut branches (for ornamental purposes) of susceptible foliar hosts</li> <li>• Fruit of susceptible hosts</li> </ul>                                                                                   |

### 5.1.3 Spread potential

#### Rating: High

GWSS adults are strong flyers allowing rapid movement of the insect. In addition, all life stages can move on machinery, equipment and plant material. These factors combined with the wide distribution of suitable host species results in a **high** spread potential for GWSS.

The wide host range *X. fastidiosa* and lack of latent period and retention of the pathogen in the gut of vectors result in a **high** spread potential for the pathogen in the presence of the vector.

### 5.1.4 Economic impact

#### Rating: High

The pathogen has a high economic impact on grapevines in southern USA (Hopkins 2005) and on a range of other agricultural and amenity plants in North and South America (Schaad *et al.* 2004). Australian climatic conditions that favour pathogen survival (e.g. milder winters), wide host range and lack of chemical/physical control methods or plant resistance to the pathogen suggest that economic impact of the pathogen in Australia would be **high**.

<sup>5</sup> Information taken from CABI (2011)

### 5.1.5 Environmental impact

#### Rating: Medium

The pathogen is damaging to a number of ornamental and amenity trees in the USA (Schaad *et al.* 2004), many of which are found in parks and gardens in Australia (oaks, sycamores, maples, elm, oleander). Other potential environmental effects would be the increased use of pesticides.

### 5.1.6 Overall risk

#### Rating: Medium

Based on the individual ratings above, the combined overall risk is considered **medium**.

## 5.2 Entry of the pathogen in the absence of a vector

### 5.2.1 Entry potential

#### Rating: Low

Given the strict import requirements for fruit from the USA and post entry quarantine requirements for nursery stock, the entry potential for the pathogen in the absence of a known vector is **low**.

### 5.2.2 Establishment potential

#### Rating: Medium

If *X. fastidiosa* were distributed in a viable state to a suitable host it could establish in Australia given the wide range of hosts spread throughout the country. Hopkins (1989) has shown that non-virulent strains are known to multiply in susceptible hosts. A vector would not be needed for initial multiplication of the bacterium as the initially infected host plant would be sufficient.

*X. fastidiosa* proliferates in the USA in environments with warm conditions and mild winters and with such similar climates, *X. fastidiosa* could establish in Australia. *X. fastidiosa* is sensitive to cold and with Australia's winters less severe than those in North America, the Australian environments may allow for growth of the bacterium throughout the year.

*X. fastidiosa* reproduces inside its hosts by cell division, doubling in population in less than 48 hours (Hopkins 1989). This short generation time suggests there would be potential for genetic variation leading to adaption to new environments.

Based on this information, the establishment potential for *X. fastidiosa* is considered **Medium**.

### 5.2.3 Spread potential

#### Rating: Low

With the warmer conditions and milder winters in Australia compared with the USA, *X. fastidiosa* would be expected to spread more easily all year round. The broad host range of *X. fastidiosa* includes many host weeds, crops and native plants present in Australia, and suggests the pathogen could have many potential hosts within close proximity to an infection allowing spread to occur readily.



Without either a vector, or movement of nursery stock and other propagative material, the spread of *X. fastidiosa* is limited to the host plant. Interstate quarantine controls may also limit the rate of spread.

The pathogen could be spread in planting material, but this pathway has not been considered a major risk for grapevine in North America (Goheen and Hopkins 1988). As the pathogen is already widely distributed in America, infected plant material is seen as a relatively minor pathway for new introduction and establishment. This is not the case in the European Plant Protection Organisation (EPPO) region where the pathogen is not present and large areas of susceptible grapevines are at risk. If the pathogen was introduced on grapevine planting material or on symptomless plant hosts it is considered that spread could occur easily especially in the presence of the vector (EPPO 1990).

Information on the presence of the pathogen in fruit and seeds and the capacity of vectors to penetrate xylem in infected fruits is limited. Long distance transmission of *X. fastidiosa* can occur through the transport of infected plant propagative material. However, it may be difficult to detect the disease in asymptomatic plants.

Information presented in previous sections shows that the main issue in the spread or establishment of *X. fastidiosa* is the availability of a vector. Without the vector the disease is unlikely to be a serious threat to Australian viticulture (Scott and De Barro 2000). The risk of spread in the absence of the vector is considered **low**.

#### 5.2.4 Economic impact

**Rating: Medium-Unknown**

It is extremely difficult to predict the economic impact of *X. fastidiosa* in the absence of any known vectors. If Australian native insects were capable of vectoring the disease it is most likely that the epidemiology would be similar to that observed in Californian riparian environments prior to the introduction of the GWSS, where the disease can be managed and losses can be kept to manageable levels (Merriman et al. 2001). If native insects were able to vector the disease the economic impact may be more severe.

#### 5.2.5 Environmental impact

**Rating: Medium**

The pathogen is damaging to a number of ornamental and amenity trees in the USA (Schaad *et al.* 2004), many of which are found in parks and gardens in Australia (oaks, sycamores, maples, elm, oleander). Other potential environmental effects would be the increased use of pesticides.

#### 5.2.6 Overall risk

**Rating: Low**

Based on the individual ratings above, the combined overall risk is considered **low**.

## 6 Pest management

### 6.1 Response checklist

The following checklist (Table 4) provides a summary of generic requirements to be identified and implemented within a Response Plan.

**Table 4.** Checklist of requirements to be identified in a Response Plan

| Checklist item                                                    | Further information  |
|-------------------------------------------------------------------|----------------------|
| Destruction methods for plant material, soil and disposable items | Section 7.1.1, 7.1.2 |
| Disposal procedures                                               | Section 7.1.5        |
| Quarantine restrictions and movement controls                     | Section 7.3          |
| Decontamination and property cleanup procedures                   | Section 7.5          |
| Diagnostic protocols and laboratories                             | Section 4.3          |
| Trace back and trace forward procedures                           | Section 7.6          |
| Protocols for delimiting, intensive and ongoing surveillance      | Section 6.2          |
| Zoning                                                            | Section 7.4          |
| Reporting and communication strategy                              | Section 10.4         |

For a range of specifically designed procedures for the emergency response to a pest incursion and a general communication strategy refer to PLANTPLAN (Plant Health Australia 2010). Additional information is provided by Merriman and McKirdy (2005)<sup>6</sup> in the Technical Guidelines for Development of Pest Specific Response Plans.

### 6.2 Surveys and epidemiology studies

Information provided in Section 6.2.1 to 6.2.3 provides a framework for the development of early detection and delimiting surveys for diseases caused by *X. fastidiosa*.

Where *X. fastidiosa* is found in a production nursery that is in close proximity to potential plants (including weeds) periodically inspect nearby hosts for symptoms caused by *X. fastidiosa* (leaf scorching) by examining leaves closely and looking for symptoms. Infected sources within a production nursery may provide an opportunity for *X. fastidiosa* to spread outside the production nursery. With the vector GWSS, *X. fastidiosa* would be spread more rapidly.

Leaf scorching is the most typical symptom across the range of hosts that show symptoms. Agricultural inspectors and other production nursery visitors should avoid moving infested plant material between production nurseries. Shoes, tools and vehicle tyres should be thoroughly washed of soil and then sanitised with a registered disinfectant. Extra precaution should be taken when working in areas known to be infected, including disposable overboots that may be used and disposed of on-site.

<sup>6</sup> Available on the PHA website ([www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information](http://www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information))

### 6.2.1 Technical information for planning surveys

When developing surveys for *X. fastidiosa* presence and/or distribution, the following characteristics of the pest provide the basic biological knowledge that impact on the survey strategy:

- *X. fastidiosa* (and the GWSS vector) have a wide host range and share many of the same hosts
- Leaf scorch symptoms may look similar to other abiotic or biotic stress symptoms
- Host species in Australia are likely to be numerous and widely dispersed
- Movement of *X. fastidiosa* can occur by human assistance through the transfer of nursery stock or with the GWSS vector by flight
- The risk of pest movement on machinery, equipment and personal effects is high
- Production nursery greenhouses and significant proportions of Australia have favourable climatic conditions for the spread and establishment of *X. fastidiosa* (and its vector)
- As the *X. fastidiosa* vector spreads readily in a greenhouse or production nursery environment the tracing of plant material from one nursery to another needs to be taken into consideration

### 6.2.2 Surveys for early detection of an incursion in a production nursery

The success of an eradication response to a *X. fastidiosa* incursion in a production nursery is more likely following early detection of the pest before it has had the opportunity to disperse to a wide area. This is especially so if the vector GWSS was present. It is therefore necessary to consider pathways and plan surveys accordingly: see the contingency plan for the Glassy winged sharpshooter (Plant Health Australia 2009) for information on surveys in an incursion of the vector). Important points to consider when developing early detection surveys for *X. fastidiosa* in production nurseries are:

- Systematic and careful inspection of crops and propagative plant material is essential to prevent introduction of the *X. fastidiosa* pathogen and limit its spread within and from contaminated outdoor and greenhouse production areas. Early detection of the pathogen (and if the vector is present), while at low levels, will provide the best chance of eradication
- An inspector must be trained to recognise *X. fastidiosa* pathogen symptoms and other similar disorders for comparison (see Section 4.2.3). A layout map of the outdoor and greenhouse production area that includes approximate locations of target species will be required to develop a strategy for surveys. A survey map should include species and cultivar names, locations, approximate quantity and sources of targeted plants within the area. During the survey walkthrough, record the date, observations, and sampling information directly onto the survey map. The recorded information should be reviewed and used to develop an efficient survey strategy each time the production area is inspected
- Awareness information should be targeted at people who are in regular close contact with potential hosts in high risk areas or movement vectors (e.g. production nursery operators)
- Should the presence of *X. fastidiosa* be detected in Australia and movement of potential host material is permitted, any new host material entering nurseries from suspected areas of infection should be quarantined prior to distribution throughout the property to allow for visual inspection or testing for the presence of the pest

If an incursion of GWSS (and the pathogen) is to be eradicated in a production nursery, it must be detected early, before the insect has had the opportunity to disperse over a large area.

### 6.2.3 Delimiting surveys in the event of an incursion

- In the event of an incursion, delimiting surveys are essential to inform the decision-making process
- The size of the survey area will depend on the size of the infected area and the severity of the infection, as well prevailing winds and movement of plant material during the period prior to detection (Figure 10). Other considerations are for example, movement of people or plant material equipment as a result of trace-forward and trace-backs
- If vectors are present, they can readily spread by flying long distances or by being transported on infested plants
- Initial surveys should be carried out in 2 km radius of the initial detection but if GWSS is present, and as GWSS is an active flier the survey radius should be expanded to a 30 km radius as the delimitation progresses. It should be noted this will only take into account natural dispersal and survey range will need to be extended if human assisted dispersal is considered a factor, especially after taking into account tracing information
- All potential host species (refer to Appendix 1) should be surveyed, with particular attention paid to the species in which the pest was initially detected
- In addition to inspection of possible host plants, material should be collected for diagnostic purposes (refer to Section 6.2.4). Complete destruction should not occur until sufficient material has been collected for diagnostic purposes
- If the incursion is in a populated area, publication and distribution of information sheets and appeals for public assistance may be helpful

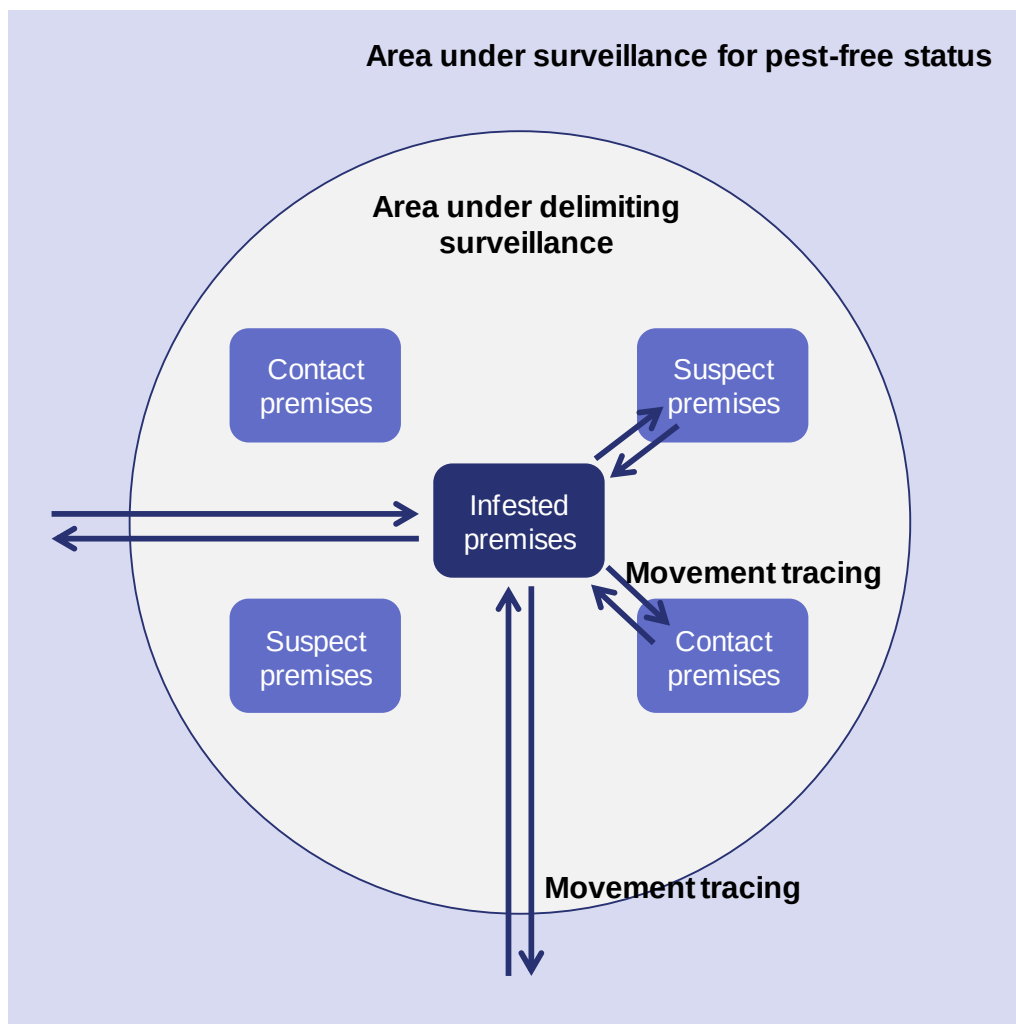


**Figure 10.** Diagram of a delimiting survey showing surveillance activities from the infected premises

#### 6.2.4 Collection and treatment of samples

Protocols for the collection, transport and diagnosis of suspect Emergency Plant Pests (EPPs) must follow PLANTPLAN (Plant Health Australia 2010). Any personnel collecting samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (Plant Health Australia 2010). Containers should be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of plant species/parts affected, location of nursery and affected plant within the nursery (preferably with a GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650. For protocols on collecting samples of the vector, see the GWSS contingency plan.

See the contingency plan for the GWSS (Plant Health Australia 2009) for information on the collection and treatment of samples for the GWSS vector. The following refers to the collection and treatment of

*X. fastidiosa* samples based on the National Diagnostic Protocol for Pierce's disease by Luck *et al.* (2010).

#### **6.2.4.1 COLLECTION OF SPECIMENS**

##### ***Sampling procedures***

Grapevine samples should ideally be collected late summer to autumn. In chronically infected vines, bacteria do not move into the new season's growth until the middle of the summer. Leaves attached to the cane generally give the most reliable result.

##### ***Number of specimens to be collected***

Collect leaf material showing symptoms of *X. fastidiosa* infection which is attached to the cane. From each suspect plant collect 4-5 canes. The most optimum tissue to sample for the detection of *X. fastidiosa* the mid-rib and petiole from symptomatic leaves. Select five leaves from affected canes and treat as one sample (Luck *et al.* 2010).

Record the identity of the host plant where the samples were collected. Record the location, preferably as GPS co-ordinates, or alternatively, a map reference or distance and direction from a suitable landmark. If the land is privately owned, record the owner's details including contact telephone numbers.

##### ***How to collect and send plant samples***

Samples should be treated in a manner that allows them to arrive at the laboratory in a fresh, well preserved state.

Wrap the cane samples in damp newspaper and place inside a sealed plastic bag.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (Plant Health Australia 2010; Appendix 3). Containers should then be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of plant species/parts affected, location of affected plant (where available include GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650.

##### ***Precaution***

Overheating or desiccation of samples prior to despatch should be prevented.

##### ***Receipt***

On receipt of the samples the diagnostic laboratory should follow strict quarantine and processing guidelines. In keeping with ISO 17025 refer to PLANTPLAN (Plant Health Australia 2010).

#### **6.2.5 Epidemiological study**

The extent of infection in a production nursery, on a property or within a region will depend on the initial population size and whether conditions have been favourable for the pest to spread from the

initial location. Sampling should be based upon the origins of the initial suspect sample(s). Factors to consider will be:

- The proximity of other susceptible plants to the initial infestation source, including both current and previous crops. This will include crops in the production nursery or on the property with the initial detection and those on neighbouring properties
- Machinery or vehicles that have been into the infested area or in close proximity to the infestation source
- The extent of human movements into and around the infested area including follow up of any recent trips overseas. A possible link to the recent importation of plant material from other regions should also be considered
- The source of any production nursery stock propagation material and whether any other crops have been propagated from the same source and/or distributed from the affected nurseries
- If the vector is present, the lifecycle and spread potential of the vector will also need to be considered

### 6.2.6 Models of spread potential

No models of spread potential have been developed for diseases caused by *X. fastidiosa*.

### 6.2.7 Pest Free Area guidelines

Determination of Pest Free Areas (PFAs) should be completed in accordance with the International Standards for Phytosanitary Measures (ISPMs) 8 and 10 (IPPC 1998a, 1999).

General points to consider are:

- Design of a statistical delimiting survey for symptoms on host plants (see Section 6.2 for points to consider in the design)
- Surveys should be completed as described in the BioSecure HACCP manual (Nursery and Garden Industry Australia 2008), including monitoring processes (summarised in Table 5 and Table 6), and assessment of indicator plants and weed monitoring
- Surveys should also consider alternative hosts (see Section 4.2.1) and not be limited to the primary infected host
- Information (including absence of the pest) should be recorded

**Table 5.** Summary of monitoring processes for protected production areas as described in BioSecure HACCP Guidelines

|                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wear protective clothing when handling suspect samples                                                                                                                            |
| Walk at random through the area in a zigzag pattern                                                                                                                               |
| Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m <sup>2</sup> of production area                                                                          |
| Inspect the tops and bottoms or leaves, looking for any direct evidence of insects                                                                                                |
| Inspect the entire plant if it has less than six leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually |
| Inspect the length of all stems and branches for insects and symptoms                                                                                                             |
| During individual plant inspection, examine the foliage for any damage                                                                                                            |
| If any plants show suspect symptoms (refer to Section 4.2.3) take a sample (refer to Section 6.2.4) to be formally diagnosed (refer to Section 4.3)                               |
| Check for a problem that have occurred regularly in the past, until you are certain it is not present                                                                             |
| Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest                                                                                                  |
| Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed                    |

Additional information is provided by the IPPC (1995) in Requirements for the Establishment of Pest Free Areas. This standard describes the requirements for the establishment and use of pest free areas as a risk management option for phytosanitary certification of plants and plant products. Establishment and maintenance of a PFA can vary according to the biology of the pest, pest survival potential, means of dispersal, availability of host plants, restrictions on movement of produce, as well as PFA characteristics (e.g. size, degree of isolation and ecological conditions).



**Table 6.** Summary of monitoring processes for field production areas as described in BioSecure HACCP Guidelines

|                                                                                                                                                                                                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wear protective clothing when handling suspect samples                                                                                                                                            |
| Pay particular attention to areas on the windward side, the sides bordering ditches, canals or other uncultivated areas and growing block centres                                                 |
| Place a flag or other marker at the entrance to the block or sampling area at the beginning of each inspection                                                                                    |
| Vary the entrance point in the sampling area (1 m to 3 m) for each subsequent sampling so that the same plants are not inspected each time                                                        |
| Walk at random through the area in a zigzag pattern                                                                                                                                               |
| The scout should follow the same general pattern at each sampling                                                                                                                                 |
| Make an effort to select those plants that appear less healthy for visual inspection                                                                                                              |
| Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m <sup>2</sup> of production area                                                                                          |
| Inspect the tops and bottoms or leaves, looking for any direct evidence of plant damage (or the vector)                                                                                           |
| Inspect the entire plant if it has less than six leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually                 |
| Inspect the length of all stems and branches for symptoms (or the insect vector)                                                                                                                  |
| If any plants show suspect symptoms (or evidence of eggs or larvae of the vector) (refer to Section 4.2.3) take a sample (refer to Section 6.2.4) to be formally diagnosed (refer to Section 4.3) |
| Check for a problem that may have occurred regularly in the past, until you are certain it is not present                                                                                         |
| Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest                                                                                                                  |
| Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed                                    |

## 6.3 Availability of control methods

### 6.3.1 General procedures for control

- Keep traffic out of affected areas and minimise movement in adjacent areas
- Adopt best-practice property hygiene procedures to retard the spread of the pest between glasshouses, fields and adjacent properties
- After surveys are completed, and permission has been obtained from the Chief Plant Health Manager, destruction of the infested plant material is an effective control
- On-going surveillance of infected areas to ensure the pest is eradicated
- Do not use any material from infected plants for propagation

### 6.3.2 Phytosanitary measures

As Pierce's disease is an extremely difficult to control in grape vines it is recommended that importation of grapevine planting material is severely restricted from countries where the pathogen is present. As recommended by EPPO (OEPP/EPPO, 1990), if planting material is imported under licence, it should be maintained in post-entry quarantine for two years and shown to be free from the

pest. Imported plants and fruits should be free from vectors, possibly by use of an appropriate treatment. Heat treatments has been shown to eliminate the pathogen (45°C for at least 3 h) (Goheen *et al.* 1973), and could have potential as a phytosanitary measure.

### 6.3.3 Chemical control

Chemical control of *Xylella* diseases in the field has not been successful. Hopkins and Mortenson (1971) showed that a tetracycline drench could cause a temporary remission of symptoms in potted grapevines.

### 6.3.4 Cultural Control

Literature from the USA has shown the use of tolerant cultivars is an effective control for Pierce's disease in areas at high risk for development of Pierce's disease (see University of California IPM website for details).

## 7 Course of action

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Additional information is provided by the IPPC (1998b) in Guidelines for Pest Eradication Programmes. This standard describes the components of a pest eradication programme which can lead to the establishment or re-establishment of pest absence in an area. A pest eradication programme may be developed as an emergency measure to prevent establishment and/or spread of a pest following its recent entry (re-establish a pest free area) or a measure to eliminate an established pest (establish a pest free area). The eradication process involves three main activities: surveillance, containment, and treatment and/or control measures.

### 7.1 Destruction strategy

#### 7.1.1 Destruction protocols

- General protocols:
  - No plant material should be removed from the infested area unless part of the disposal procedure
  - Disposable equipment, infested plant material or growing media/soil should be disposed of by autoclaving, high temperature incineration or deep burial
  - Any equipment removed from the site for disposal should be double-bagged
  - Machinery used in destruction processes need to be thoroughly washed, preferably using a detergent or farm degreaser

#### 7.1.2 Decontamination protocols

Machinery, equipment and vehicles in contact with infested plant material or growing media/soil, or present within the Quarantine Area, should be washed to remove plant material and growing

media/soil using high pressure water or scrubbing with products such as a degreaser or a bleach solution (1% available chlorine) in a designated wash down area. When using high pressure water, care should be taken not to spread plant material. High pressure water should be used in wash down areas which meet the following guidelines:

- Located away from crops or sensitive vegetation
- Readily accessible with clear signage
- Access to fresh water and power
- Mud free, including entry and exit points (e.g. gravel, concrete or rubber matting)
- Gently sloped to drain effluent away
- Effluent must not enter water courses or water bodies
- Allow adequate space to move larger vehicles
- Away from hazards such as power lines
- Waste water, growing media/soil or plant residues should be contained (see Appendix 18 of PLANTPLAN [Plant Health Australia 2010])
- Disposable overalls and rubber boots should be worn when handling infested plant material or growing media/soil in the field. Boots, clothes and shoes in contact with infested plant material or growing media/soil should be disinfected at the site or double-bagged to remove for cleaning
- Skin and hair in contact with infested plant material or growing media/soil should be washed

Procedures for the sterilisation of plant containers and growing media are provided within the BioSecure HACCP Guidelines, however, in the event of a *X. fastidiosa* incursion, additional or modified procedures may be required for the destruction of the pest. Any sterilisation procedure must be approved for use in the endorsed Response Plan.

### 7.1.3 Priorities

- Confirm the presence of the pest
- Limit movement of people and prevent movement of vehicles and equipment through affected areas
- Stop the movement of any plant material that may be infested with the pest
- Determine the strategy for the eradication/decontamination of the pest and infested host material
- Determine the extent of infestation through survey and plant material trace back and trace forward which would be assessed on a case by case basis and included within the response plan

### 7.1.4 Plants, by-products and waste processing

- Any growing media/soil or infected plant material removed from the infected site should be destroyed by (enclosed) high temperature incineration, autoclaving or deep burial

- As the pest can be spread with plant material, plant debris from the destruction zone must be carefully handled and transported
- Infested areas or production nursery yards should remain free of susceptible host plants until the area has been shown to be free from the pathogen (and/or vector)

### 7.1.5 Disposal issues

- Particular care must be taken to minimise the transfer of infected plant material from the area
- Host material including leaf litter should be collected and incinerated or double bagged and deep buried in an approved site

## 7.2 Containment strategies

For some exotic pest incursions where eradication is considered impractical, containment of the pest may be attempted to prevent or slow its spread and to limit its impact on other parts of the state or country. Containment is currently being considered for inclusion within the Emergency Plant Pest Response Deed (EPPRD). The decision on whether to eradicate or contain the pest will be made by the National Management Group, based on scientific and economic advice. Emergency interim containment measures are possible under EPPRD arrangements to gather information to determine if eradication is technically feasible.

## 7.3 Quarantine and movement controls

Consult PLANTPLAN (Plant Health Australia 2010) for administrative details and procedures.

### 7.3.1 Quarantine priorities

- Plant material and growing media/soil at the site of infestation to be subject to movement restrictions
- Machinery, equipment, vehicles and disposable equipment in contact with infested plant material or growing media/soil, or present in close proximity to the site of infestation to be subject to movement restrictions

### 7.3.2 Movement controls

Movement controls need to be put in place to minimise the potential for transport of the pest, and this will apply to all plant material, growing media and other items within the quarantined area.

Movement of people, vehicles, equipment and plant material, from and to affected properties or areas, must be controlled to ensure that the pest is not moved off-property. Movement controls can be achieved through the following, however specific measures must be endorsed in the Response Plan:

- Signage to indicate quarantine area and restricted movement into and within these zones
- Fenced, barricaded or locked entry to quarantine areas

- Movement of equipment, machinery, plant material or growing media/soil by permit only. Therefore, all non-essential operations in the area or on the property should cease
- Where no dwellings are located within these areas, strong movement controls should be enforced
- Where dwellings and places of business are included within the Restricted and Control Areas movement restrictions are more difficult to enforce, however limitation of contact with infested plants should be enforced
- If a production nursery is situated within the Restricted Area, all nursery trading in host and non-host material must cease and no material may be removed from the site without permission, due to the high likelihood of pest spread. Movement restrictions would be imposed on both host and non-host material
- Residents should be advised on measures to minimise the inadvertent transport of vectors, should the pathogen and vector both be present
- Clothing and footwear worn at the infested site should either be double-bagged prior to removal for decontamination or should not leave the site until thoroughly disinfected, washed and cleaned
- Plant material or plant products must not be removed from the site unless part of an approved disposal procedure
- All machinery and equipment should be thoroughly cleaned down with a high pressure cleaner (see Section 7.1.2) or scrubbing with products such as a farm degreaser or a 1% bleach (available chlorine) solution, prior to leaving the affected area. Machinery should be inspected for the presence of insects and if found, treatment with insecticide may be required. The clean down procedure should be carried out on a hard surface, preferably a designated wash-down area, to avoid mud being re-collected from the affected site onto the machine. When using high pressure water, care should be taken to contain all plant material and mud dislodged during the cleaning process

## 7.4 Zoning

The size of each quarantine area will be determined by a number of factors, including the location of the incursion, biology of the pest, climatic conditions and the proximity of the infested property to other infested properties. This will be determined by the National Management Group during the production of the Response Plan. Further information on quarantine zones in an Emergency Plant Pest (EPP) incursion can be found in Appendix 10 of PLANTPLAN (Plant Health Australia 2010). These zones are outlined below and in Figure 11.

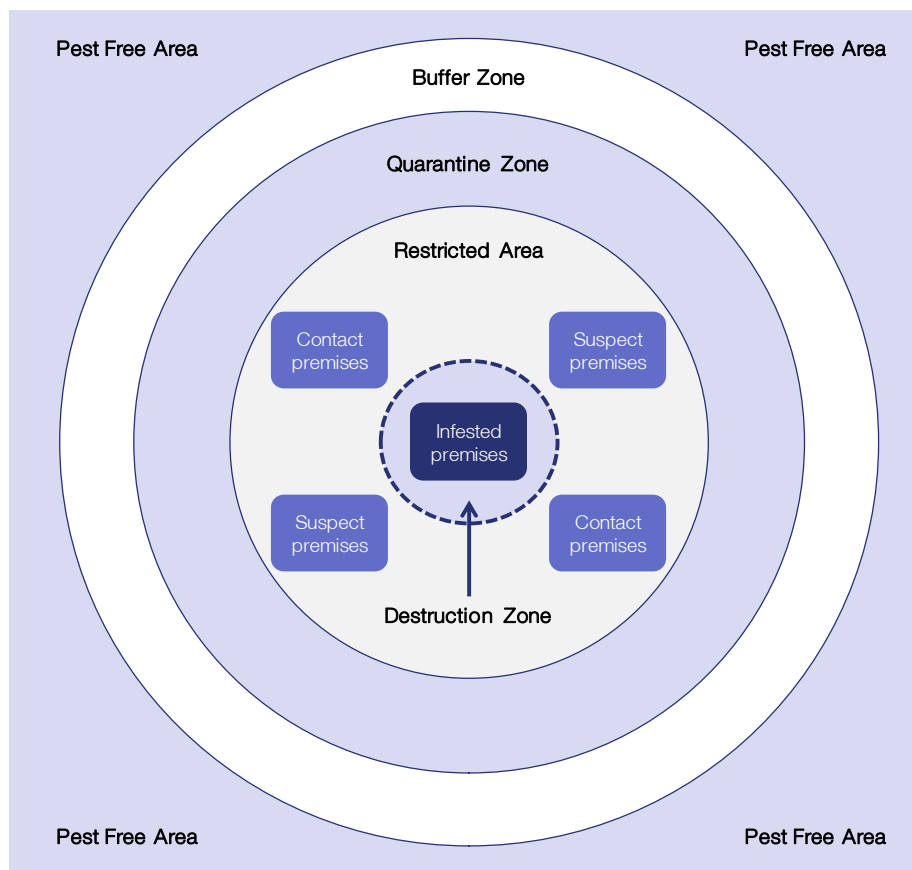


**Figure 11.** Schematic diagram of quarantine zones used during an EPP incursion (not drawn to scale)

#### 7.4.1 Destruction Zone

The size of the destruction zone (i.e. zone in which the pest and all host material is destroyed) will depend on the ability of the pest to spread, distribution of the pest (as determined by delimiting surveys), time of season (and part of the pest life cycle being targeted) and factors which may contribute to the pest spreading.

All host plants should be destroyed after the level of infestation has been established. The delimiting survey will determine whether or not neighbouring plants are infested and need to be destroyed. Non-host plant material within this zone may be destroyed, based on recommendations in the Response Plan. The Destruction Zone may be defined as contiguous areas associated with the same management practices as, or in contact with, the infested area (i.e. the entire production nursery, property or area if spread could have occurred prior to the infection being identified).

Particular care needs to be taken to ensure that plant material (including non-hosts) is not moved into surrounding areas.

### 7.4.2 Quarantine Zone

The Quarantine Zone is defined as the area where voluntary or compulsory restraints are in place for the affected property or properties. These restraints may include restrictions or movement control for removal of plants, people, growing media/soil or contaminated equipment from an infected property.

### 7.4.3 Buffer Zone

A Buffer Zone may or may not be required depending on the incident. It is defined as the area in which the pest does not occur but where movement controls or restrictions for removal of plants, people, soil or equipment from this area are still deemed necessary. The Buffer Zone may enclose an infested area (and is therefore part of the Control Area) or may be adjacent to an infested area.

### 7.4.4 Restricted Area

The Restricted Area is defined as the zone immediately around the infected premises and suspected infected premises. The Restricted Area is established following initial surveys that confirm the presence of the pest. The Restricted Area will be subject to intense surveillance and movement control with movement out of the Restricted Area to be prohibited and movement into the Restricted Area to occur by permit only. Multiple Restricted Areas may be required within a Control Area.

### 7.4.5 Control Area

The Control Area is defined as all areas affected within the incursion. The Control Area comprises the Restricted Area, all infected premises and all suspected infected premises and will be defined as the minimum area necessary to prevent spread of the pest from the Quarantine Zone. The Control Area will also be used to regulate movement of all susceptible plant species to allow trace back, trace forward and epidemiological studies to be completed.

## 7.5 Decontamination and farm clean up

Decontaminant practices are aimed at eliminating the pathogen thus preventing its spread to other areas.

### 7.5.1 Decontamination procedures

General guidelines for decontamination and clean up:

- Refer to PLANTPLAN (Plant Health Australia 2010) for further information
- Keep traffic out of affected area and minimise it in adjacent areas
- Adopt best-practice property hygiene procedures to retard the spread of the pest between growing areas/fields and adjacent properties
- Machinery, equipment, vehicles in contact with infested plant material or growing media/soil present within the Quarantine Zone, should be washed to remove growing media/soil and

plant material using high pressure water or scrubbing with products such as a degreaser or a bleach solution in a designated wash down area as described in Section 7.1.2

- Only recommended materials are to be used when conducting decontamination procedures, and should be applied according to the product label
- Infested plant material should be disposed of by autoclaving, high temperature (enclosed) incineration or deep burial

## 7.5.2 General safety precautions

For any chemicals used in the decontamination, follow all safety procedures listed within each MSDS.

## 7.6 Surveillance and tracing

### 7.6.1 Surveillance

Detection and delimiting surveys are required to delimit the extent of the incursion, ensuring areas free of the pest retain market access and appropriate quarantine zones are established.

Initial surveillance priorities include the following:

- Surveying all host growing properties and businesses in the pest quarantine area
- Surveying all properties and businesses identified in trace-forward or trace-back analysis as being at risk
- Surveying all host growing properties and businesses that are reliant on trade with interstate or international markets which may be sensitive to the pathogens (and/or vectors) presence
- Surveying production nurseries selling at risk host plants
- Surveying other host growing properties and backyards

### 7.6.2 Survey regions

Establish survey regions around the surveillance priorities identified above. These regions will be generated based on the zoning requirements (see Section 7.4), and prioritised based on their potential likelihood to currently have or receive an incursion of this pest. Surveillance activities within these regions will either allow for the area to be declared pest free and maintain market access requirements or establish the impact and spread of the incursion to allow for effective control and containment measures to be carried out. Detailed information that will assist develop surveys for Pierce's disease have been outlined elsewhere in this plan (refer to Section 6.2).

Steps outlined in Table 7 form a basis for a survey plan. Although categorised in stages, some stages may be undertaken concurrently based on available skill sets, resources and priorities.



**Table 7. Phases to be covered in a survey plan**

|         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Phase 1 | Identify properties that fall within the buffer zone around the infested premise<br>Complete preliminary surveillance to determine ownership, property details, production dynamics and tracings information (this may be an ongoing action)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Phase 2 | Preliminary survey of host crops in properties in buffer zone establishing points of pest detection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Phase 3 | Surveillance of an intensive nature, to support control and containment activities around points of pest detection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Phase 4 | <p>Surveillance of contact premises. A contact premise is a property containing susceptible host plants, which are known to have been in direct or indirect contact with an infested premises or infected plants. Contact premises may be determined through tracking movement of materials from the property that may provide a viable pathway for spread of the disease. Pathways to be considered are:</p> <ul style="list-style-type: none"> <li>• Movement of plant material and growing media/soil from controlled and restricted areas</li> <li>• Items of equipment and machinery which have been shared between properties including bins, containers, irrigation lines, vehicles and equipment</li> <li>• The producer and retailer of infected material if this is suspected to be the source of the outbreak</li> <li>• Labour and other personnel that have moved from infected, contact and suspect premises to unaffected properties (other growers, tradesmen, visitors, salesmen, crop scouts, harvesters and possibly beekeepers)</li> <li>• Storm and rain events and the direction of prevailing winds that result in air-borne dispersal of the pathogen during these weather events</li> </ul> |
| Phase 5 | Surveillance of production and greenlife retailers, including garden centres, hardware outlets and supermarkets, as well as gardens and public land where plants known to be hosts of pathogen are being grown                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Phase 6 | Agreed area freedom maintenance, post control and containment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

### 7.6.3 Post-eradication surveillance

The period of pest freedom sufficient to indicate that eradication of the pest has been achieved will be determined by a number of factors, including growth conditions, the previous level of infection, the control measures applied and the pest biology.

Specific methods to confirm eradication of Pierce's disease may include:

- Monitoring of sentinel plants that have been grown at the affected sites. Plants are to be grown *in situ* under quarantine conditions and monitored for symptoms of infection or other indications of Pierce's disease (and/or the vector)
- If symptoms are detected, samples are to be collected and stored and plants destroyed
- Targeted surveys for the pathogen (and/or the vector) should be undertaken within the Quarantine Zone to demonstrate pest absence
- Alternate non-host crops should be grown on the site and any self-sown plants sprayed out with a selective herbicide

## 8 Technical debrief and analysis for stand down

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Refer to PLANTPLAN (Plant Health Australia 2010) for further details

The emergency response is considered to be ended when either:

- Eradication has been deemed successful by the lead agency, with agreement by the Consultative Committee on Emergency Plant Pests and the Domestic Quarantine and Market Access Working Group.
- Eradication has been deemed impractical and procedures for long-term management of the disease risk have been implemented.

A final report should be completed by the lead agency and the handling of the incident reviewed.

Eradication will be deemed impractical if, at any stage, the results of the delimiting surveys lead to a decision to move to containment/control.

## 9 References

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## 9.1 Related Websites

Center for Invasive Species and Ecosystem Health - Bugwood network 2010 [www.bugwood.org](http://www.bugwood.org)

CABI 2011 [www.cabicompendium.org/cpc/home.asp](http://www.cabicompendium.org/cpc/home.asp)

PaDil 2011 [www.padil.gov.au/](http://www.padil.gov.au/)

University of California IPM 2011 [www.ipm.ucdavis.edu/PMG/r302101211.html](http://www.ipm.ucdavis.edu/PMG/r302101211.html)

# 10 Appendices

## 10.1 Appendix 1 – Host range of *Xylella fastidiosa* (all strains) where host status has been confirmed<sup>7</sup>

| Scientific name              | Common name        | Scientific name                 | Common name     |
|------------------------------|--------------------|---------------------------------|-----------------|
| <i>Acacia longifolia</i>     | Golden wattle      | <i>Canna sp.</i>                | Canna           |
| <i>Acer macrophyllum</i>     | Big leaf maple     | <i>Chenopodium ambrosioides</i> | Mexican tea     |
| <i>Acer negundo</i>          | Box elder          | <i>Citrus limon</i>             | Lemon 'Meyer'   |
| <i>Aesculus californica</i>  | California buckeye | <i>Citrus reticulata</i>        | Tangerine       |
| <i>Agropyron sp.</i>         | Crested wheatgrass | <i>Citrus sinensis</i>          | Sweet orange    |
| <i>Alnus rhombifolia</i>     | White alder        | <i>Claytonia perfoliata</i>     | Miner's lettuce |
| <i>Ampelopsis arborea</i>    | Peppervine         | <i>Commelina sp.</i>            | Commelina       |
| <i>Amsinckia douglasiana</i> | Buckthorn weed     | <i>Conium maculatum</i>         | Poison hemlock  |
| <i>Artemisia absinthium</i>  | Mugwort            | <i>Coprosma baueri</i>          | Coprosma        |

<sup>7</sup> Sourced from [www.cnr.berkeley.edu/xylella](http://www.cnr.berkeley.edu/xylella)

| Scientific name                         | Common name          | Scientific name                         | Common name            |
|-----------------------------------------|----------------------|-----------------------------------------|------------------------|
| <i>Artemisia douglasiana</i>            | Mugwort              | <i>Cotoneaster francheti</i>            | Cotoneaster            |
| <i>Avena fatua</i>                      | Wild oat             | <i>Cotoneaster pyracantha</i>           | Cotoneaster pyracantha |
| <i>Baccharis halimifolia</i>            | Eastern baccharis    | <i>Cotoneaster rotundifolia</i>         | Cotoneaster            |
| <i>Baccharis pilularis</i>              | Coyote brush         | <i>Cynodon dactylon</i>                 | Bermuda grass          |
| <i>Baccharis salicifolia</i>            | Mule fat             | <i>Cyperus acuminatus</i>               | Sedge                  |
| <i>Beta vulgaris</i>                    | Sugar beet           | <i>Cyperus eragrostis</i>               | Purple nutsedge        |
| <i>Bidens leucantha</i>                 | Beggarticks          | <i>Cyperus esculentus</i>               | Yellow nutsedge        |
| <i>Bidens pilosa</i> var. <i>pilosa</i> | Beggar-ticks         | <i>Cytisus scoparius</i>                | Scotch broom           |
| <i>Brassica rapa</i>                    | Field mustard        | <i>Daucus carota</i> var. <i>sativa</i> | Short white carrot     |
| <i>Bromus catharticus</i>               | Rescue grass         | <i>Daucus carota</i>                    | Wild carrot            |
| <i>Bromus rigidus</i>                   | Ripgut grass         | <i>Digitaria sanguinalis</i>            | Hairy crabgrass        |
| <i>Bromus</i> sp.                       | Russian brome grass  | <i>Diospyros</i> sp.                    | Persimmon              |
| <i>Callicarpa americana</i>             | American beautyberry | <i>Distichlis spicata</i>               | Saltgrass              |
| <i>Callistephus chinensis</i>           | China aster          | <i>Duranta repens</i>                   | Pigeon-berry           |
| <i>Calycanthus occidentalis</i>         | Spicebush            | <i>Echinochloa crus-galli</i>           | Water grass            |
| <i>Elymus</i> sp.                       | Wild rye             | <i>Lathyrus clymenium</i>               | Lathyrus               |
| <i>Epilobium californicum</i>           | Willow-herb          | <i>Lathyrus sativa</i>                  | Grass pea              |
| <i>Epilobium paniculatum</i>            | Panicked willow-herb | <i>Lolium multiflorum</i>               | Italian ryegrass       |
| <i>Eragrostis diffusa</i>               | Diffuse love grass   | <i>Lolium temulentum</i>                | Darnel                 |
| <i>Erodium cicutarium</i>               | Red stem filaree     | <i>Lonicera japonica</i>                | Japanese honeysuckle   |
| <i>Escallonia montevidensis</i>         | Escallonia           | <i>Ludwigia peruviana</i>               | Primrose willow        |
| <i>Eschscholzia californica</i>         | California poppy     | <i>Majorana hortensis</i>               | Sweet majoram          |
| <i>Eugenia myrtifolia</i>               | Aust. brush-cherry   | <i>Malus sylvestris</i>                 | Apple                  |
| <i>Eupatorium capillifolium</i>         | Small (dog) fennel   | <i>Malva parvifolia</i>                 | Cheeseweed             |
| <i>Fragaria californica</i>             | Wild strawberry      | <i>Matricaria suaveolens</i>            | Pineapple weed         |
| <i>Franseria acanthicarpa</i>           | Annual bur-sage      | <i>Medicago hispida</i>                 | Burr clover            |
| <i>Fraxinus dipetala</i>                | California ash       | <i>Melilotus alba</i>                   | White meliot           |
| <i>Fraxinus latifolia</i>               | Oregon ash           | <i>Melilotus indica</i>                 | Hubam clover           |
| <i>Fritillaria</i> sp.                  | Fritillary           | <i>Melilotus officinalis</i>            | Yellow sweet clover    |
| <i>Fuchsia magellanica</i>              | Fuchsia              | <i>Melilotus</i> sp.                    | Sweet clover           |
| <i>Genista monspessulana</i>            | French broom         | <i>Melissa officinalis</i>              | Garden balm            |

| Scientific name                    | Common name                | Scientific name                | Common name           |
|------------------------------------|----------------------------|--------------------------------|-----------------------|
| <i>Hedera helix</i>                | English ivy                | <i>Mentha sp.</i>              | Mint                  |
| <i>Helianthus sp.</i>              | Wild sunflower             | <i>Mimulus aurantiacus</i>     | Bush monkeyflower     |
| <i>Heteromeles arbutifolia</i>     | Toyon                      | <i>Morus rubra</i>             | Mulberry              |
| <i>Hordeum murinum</i>             | Common foxtail             | <i>Myrica cyrifer</i>          | Southern waxmyrtle    |
| <i>Hordeum nodosum</i>             | Wild barley                | <i>Nasturtium officinale</i>   | Water cress           |
| <i>Hordeum vulgare</i>             | Barley                     | <i>Nerium oleander</i>         | Oleander              |
| <i>Hydrangea paniculata</i>        | Hydrangea                  | <i>Nicotiana tabacum</i>       | Tobacco               |
| <i>Juglans californica</i>         | Calif. black walnut        | <i>Oeanthe sarmetosa</i>       | Water parsley         |
| <i>Koeleruteria paniculata</i>     | Golden raintree            | <i>Oenothera hookeri</i>       | Evening primrose      |
| <i>Lactuca serriola</i>            | Prickly lettuce            | <i>Panicum sp.</i>             | Panicum               |
| <i>Lantana camara</i>              | Lantana                    | <i>Lathyrus clymenium</i>      | Lathyrus              |
| <i>Lathyrus cicera</i>             | Lathyrus                   | <i>Lathyrus sativa</i>         | Grass pea             |
| <i>Parthenocissus quinquefolia</i> | Virginia creeper           | <i>Pyracantha augustifolia</i> | Firethorn             |
| <i>Parthenocissus tricuspidata</i> | Boston ivy                 | <i>Quercus agrifolia</i>       | Coast live oak        |
| <i>Paspalum dilatatum</i>          | Dallisgrass                | <i>Quercus domosa</i>          | Scrub oak             |
| <i>Pelargonium hortorum</i>        | Fish geranium              | <i>Quercus falcata</i>         | Southern red oak      |
| <i>Pennisetum clandestinum</i>     | Kikuyugrass                | <i>Quercus imbricaria</i>      | Shingle oak           |
| <i>Phalaris minor</i>              | Mediterranean canary grass | <i>Quercus laurifolia</i>      | Laurel oak            |
| <i>Phalaris paradoxa</i>           | Gnawed canary grass        | <i>Quercus lobata</i>          | Valley oak            |
| <i>Philadelphus lewisii</i>        | Syringa                    | <i>Rhus sp.</i>                | Sumac                 |
| <i>Phleum pratense</i>             | Timothy grass              | <i>Reseda odorata</i>          | Common mignonette     |
| <i>Pittosporum crassifolium</i>    | Karo                       | <i>Rhamnus californica</i>     | Calif. coffeeberry    |
| <i>Plantago lanceolata</i>         | English plantain           | <i>Rheum rhaponticum</i>       | Rhubarb               |
| <i>Platanus occidentalis</i>       | Sycamore                   | <i>Rhus sp.</i>                | Sumac                 |
| <i>Poa annua</i>                   | Annual bluegrass           | <i>Rosa californica</i>        | California wild rose  |
| <i>Poa pratensis</i>               | Kentucky bluegrass         | <i>Rosmarinus officinalis</i>  | Rosemary              |
| <i>Polygonum convolvulus</i>       | Black bindweed             | <i>Rubus discolor</i>          | Himalayan blackberry  |
| <i>Polygonum persicaria</i>        | Lady's thumb               | <i>Rubus sp.</i>               | Blackberry            |
| <i>Polygonum ramosissimum</i>      | Knot weed                  | <i>Rubus ursinus</i>           | California blackberry |
| <i>Polypogon monspeliensis</i>     | Rabbit foot grass          | <i>Rumex crispus</i>           | Curly dock            |
| <i>Populus fremontii</i>           | Fremont cottonwood         | <i>Salix bebbiana</i>          | Willow                |



| Scientific name                    | Common name         | Scientific name                    | Common name              |
|------------------------------------|---------------------|------------------------------------|--------------------------|
| <i>Populus sp.</i>                 | Cottonwood          | <i>Salix laevigata</i>             | Red willow               |
| <i>Portulaca oleracea</i>          | Common purslane     | <i>Salix lasiolepis</i>            | Arroyo willow            |
| <i>Prunus armeniaca</i>            | Apricot             | <i>Salix sessilifolia</i>          | Sandbar willow           |
| <i>Prunus demissa</i>              | Western chokecherry | <i>Sambucus canadensis</i>         | American elder           |
| <i>Prunus mume</i>                 | Japanese apricot    | <i>Sambucus mexicana</i>           | Blue elderberry          |
| <i>Prunus persica</i>              | Peach               | <i>Setaria lutescens</i>           | Yellow bristle grass     |
| <i>Prunus salicana</i>             | Plum                | <i>Solidago fistulosa</i>          | Goldenrod                |
| <i>Prunus serotina</i>             | Black cherry        | <i>Sonchus asper</i>               | Prickly sowthistle       |
| <i>Prunus sp.</i>                  | Wild plum           | <i>Sorghum halepense</i>           | Johnson grass            |
| <i>Pseudotsuga menziesii</i>       | Douglas-fir         | <i>Sorghum vulgare</i>             | Sudangrass               |
| <i>Symphoricarpos albus</i>        | Snowberry           | <i>Umbellularia californica</i>    | California bay or laurel |
| <i>Syringa vulgaris</i>            | Lilac               | <i>Urtica dioica ssp. gracilis</i> | Stinging nettle          |
| <i>Tatragonia expansa</i>          | New Zealand spinach | <i>Vaccinium pennsylvanicum</i>    | Blueberry                |
| <i>Toxicodendron diversilobum</i>  | Poison oak          | <i>Veronica sp.</i>                | Speedwell                |
| <i>Trifolium fragarium</i>         | Strawberry clover   | <i>Vicia monathus</i>              | Vetch                    |
| <i>Trifolium hybridum</i>          | Aliske clover       | <i>Vinca major</i>                 | Greater periwinkle       |
| <i>Trifolium incarnatum</i>        | Crimson clover      | <i>Vinca minor</i>                 | Periwinkle               |
| <i>Trifolium pratense</i>          | Red clover          | <i>Vitis californica</i>           | Calif. wild grape        |
| <i>Trifolium repens</i>            | White clover        | <i>Vitis rupestris</i>             | St. George               |
| <i>Trifolium repens var. latum</i> | Ladino clover       | <i>Vitis vinifera</i>              | grape 'Pinot Noir'       |
| <i>Ulmus alata</i>                 | Winged elm          | <i>Vulpia myuros var. hirsuta</i>  | Foxtail fescue           |
| <i>Ulmus americana</i>             | American elm        | <i>Xanthium strumarium</i>         | Cocklebur                |

## 10.2 Appendix 2: Standard diagnostic protocols

For a range of specifically designed procedures for the emergency response to a pest incursion refer to Plant Health Australia's PLANTPLAN ([www.planthealthaustralia.com.au/plantplan](http://www.planthealthaustralia.com.au/plantplan)).



## 10.3 Appendix 3: Resources and facilities

Table 8 provides a list of diagnostic facilities for use in professional diagnosis and advisory services in the case of an incursion.

**Table 8. Diagnostic service facilities in Australia**

| Facility                                                                          | State | Details                                                                                                    |
|-----------------------------------------------------------------------------------|-------|------------------------------------------------------------------------------------------------------------|
| DPI Victoria – Knoxfield Centre                                                   | Vic   | 621 Burwood Highway<br>Knoxfield VIC 3684<br>Ph: (03) 9210 9222; Fax: (03) 9800 3521                       |
| DPI Victoria – Horsham Centre                                                     | Vic   | Natimuk Rd<br>Horsham VIC 3400<br>Ph: (03) 5362 2111; Fax: (03) 5362 2187                                  |
| DPI New South Wales – Elizabeth Macarthur Agricultural Institute                  | NSW   | Woodbridge Road<br>Menangle NSW 2568<br>PMB 8 Camden NSW 2570<br>Ph: (02) 4640 6327; Fax: (02) 4640 6428   |
| DPI New South Wales – Tamworth Agricultural Institute                             | NSW   | 4 Marsden Park Road<br>Calala NSW 2340<br>Ph: (02) 6763 1100; Fax: (02) 6763 1222                          |
| DPI New South Wales – Wagga Wagga Agricultural Institute                          | NSW   | PMB Wagga Wagga<br>NSW 2650<br>Ph: (02) 6938 1999; Fax: (02) 6938 1809                                     |
| SARDI Plant Research Centre – Waite Main Building, Waite Research Precinct        | SA    | Hartley Grove<br>Urrbrae SA 5064<br>Ph: (08) 8303 9400; Fax: (08) 8303 9403                                |
| Grow Help Australia                                                               | QLD   | Entomology Building<br>80 Meiers Road<br>Indooroopilly QLD 4068<br>Ph: (07) 3896 9668; Fax: (07) 3896 9446 |
| Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories | WA    | 3 Baron-Hay Court<br>South Perth WA 6151<br>Ph: (08) 9368 3721; Fax: (08) 9474 2658                        |

## 10.4 Appendix 4: Communications strategy

A general Communications Strategy is provided in Appendix 6 of PLANTPLAN (Plant Health Australia, 2010).

## 10.5 Appendix 5: Market access impacts

Within the AQIS PHYTO database ([www.aqis.gov.au/phyto](http://www.aqis.gov.au/phyto)) there is currently no additional phytosanitary statement required that declares Pierce's disease is not known to occur in Australia (as at May 2011). Should Pierce's disease be detected or become established in Australia, countries may require specific declaration or supplementary measures upon export. Latest information can be found within PHYTO, using an Advanced search "Search all text" for Pierce's disease.

INDUSTRY BIOSECURITY PLAN  
FOR THE NURSERY & GARDEN INDUSTRY

## Threat Specific Contingency Plan

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### Thrips transmitted viruses

Specific examples detailed in this plan:

*Chrysanthemum stem necrosis virus*

*Tomato spotted wilt virus*

*Impatiens necrotic ringspot tospovirus*

*Pelargonium flower break virus*

Plant Health Australia

September 2011



## Disclaimer

The scientific and technical content of this document is current to the date published and all efforts have been made to obtain relevant and published information on the pest. New information will be included as it becomes available, or when the document is reviewed. The material contained in this publication is produced for general information only. It is not intended as professional advice on any particular matter. No person should act or fail to act on the basis of any material contained in this publication without first obtaining specific, independent professional advice. Plant Health Australia and all persons acting for Plant Health Australia in preparing this publication, expressly disclaim all and any liability to any persons in respect of anything done by any such person in reliance, whether in whole or in part, on this publication. The views expressed in this publication are not necessarily those of Plant Health Australia.

## Further information

For further information regarding this contingency plan, contact Plant Health Australia through the details below.



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|-----------------|--------------------------------------------------------------------------------------|
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| <b>Fax:</b>     | +61 2 6260 4321                                                                      |
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# 1 Purpose and background of this contingency plan

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This contingency plan provides background information on the pest biology and available control measures to assist with preparedness for an incursion into Australia of a range of viruses that are transmitted by five genera of thrips (*Thrips*, *Frankliniella*, *Scirtothrips*, *Microcephalothrips* and *Ceratothripoides*). In this contingency plan viruses have been used as examples of those considered to be of greatest economic impact and risk to the Nursery Industry. It should be noted that some thrips transmitted viruses with a high economic impact are already present in Australia and there has been a recent incursion in Australia of *Impatiens necrotic spot virus* (INSV).

The contingency plan provides guidelines and options for steps to be undertaken and considered when developing a Response Plan for incursion of the virus pests. 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.

This contingency plan was developed for the Nursery and Industry Australia (NGIA), and therefore is focused on production nurseries covered by this association. In the event of an incursion, operations that are not covered by the NGIA or another Emergency Plant Pest Response Deed (EPPRD) signatory (e.g. retail nurseries), will not be represented or have a decision making say in any arrangements for emergency response.

The information for this plan has been primarily obtained from documents as cited in the reference section. For each virus, information on background, life cycle, host range, distribution, symptoms and management/control is given.

## 2 Australian nursery industry

---

The Australian nursery industry is a significant horticultural sector with a combined supply chain (production to retail/grower) valued at more than \$6 billion dollars annually. The industry employs approximately 45,000 people spread over more than 20,000 small to medium sized businesses including production nurseries and retail outlets. The industry is located predominantly along the Australian coastline and in major inland regions servicing urban and production horticulture.

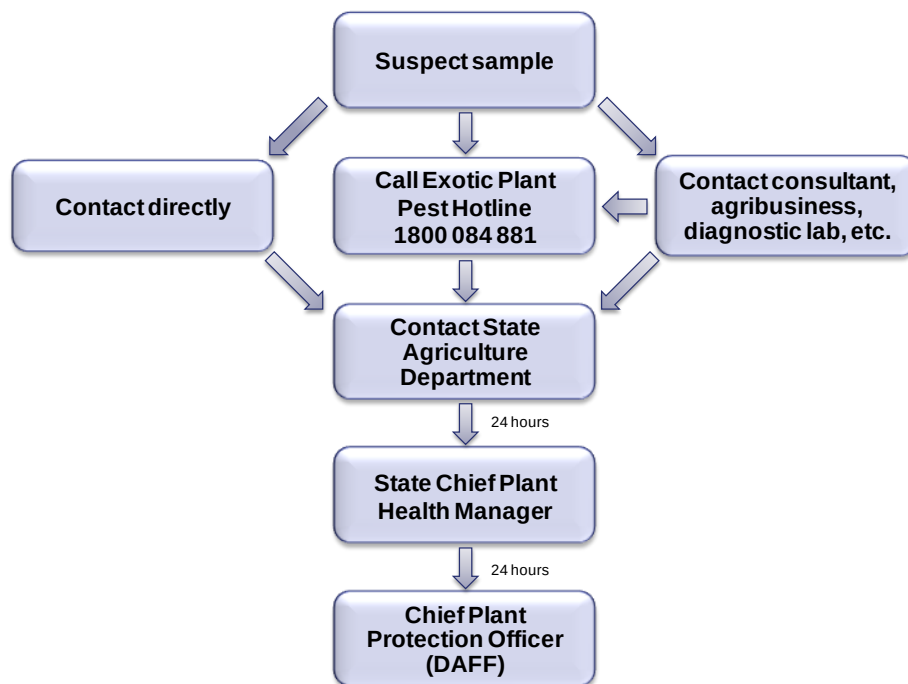
Nursery production is a highly diverse primary industry servicing the broader \$14 billion horticultural sector within Australia (Table 1). A pest incursion is likely to impact market access (see Appendix 3 for more information).

**Table 1.** Nursery production supply sectors within Australian horticulture

| Production Nursery                    | Horticultural markets            | Economic value           |
|---------------------------------------|----------------------------------|--------------------------|
| Container stock <sup>1</sup>          | Ornamental/urban horticulture    | \$2 billion retail value |
| Foliage plants <sup>1</sup>           | Interior-scapes                  | \$87 million industry    |
| Seedling stock <sup>2</sup>           | Vegetable growers                | \$3.3 billion industry   |
| Forestry stock <sup>3</sup>           | Plantation timber                | \$1.7 billion industry   |
| Fruit and nut tree stock <sup>2</sup> | Orchardists (citrus, mango, etc) | \$5.2 billion industry   |
| Landscape stock <sup>1</sup>          | Domestic & commercial projects   | \$2 billion industry     |
| Plug and tube stock <sup>4</sup>      | Cut flower                       | \$319 million industry   |
| Revegetation stock <sup>1</sup>       | Farmers, government, landcare    | \$109 million industry   |
| Mine revegetation                     | Mine site rehabilitation         | Value unknown            |
| Total horticultural market value      |                                  | \$14.5 billion           |

## 2.1 Notification process for the reporting of suspect pests

Early detection and reporting may prevent or minimise the long-term impact of an incursion into Australia of Thrips transmitted viruses.

**Figure 1.** Notification process for the reporting of suspect pests

<sup>1</sup> Data sourced from Market Monitor

<sup>2</sup> Data sourced from Horticultural Handbook 2004

<sup>3</sup> Data sourced from ABARE 2005

<sup>4</sup> Data sourced from industry

### 3 Eradication or containment decision matrix

The decision to eradicate should be based on the potential economic impact of host damage resulting from Thrips transmitted virus infection, the cost of eradication and on technical feasibility. Eradication costs must factor in long term surveys to prove the success of the eradication program. A minimum of two years with no detections of the virus may be necessary to confirm that no thrips transmitted virus infestations remain before pest free status can be declared. The timeframe needs to be considered on a case by case basis, based both on the size of the infection, the degree and distribution of the pest with the final decision determined by the National Management Group.

No specific eradication matrix has been determined for thrips transmitted viruses; however the general decision process as outlined in Figure 2 and Table 2 should be followed in determining if an incursion of this pest will be eradicated or managed/contained. The final decision between eradication and management will be made through the National Management Group.

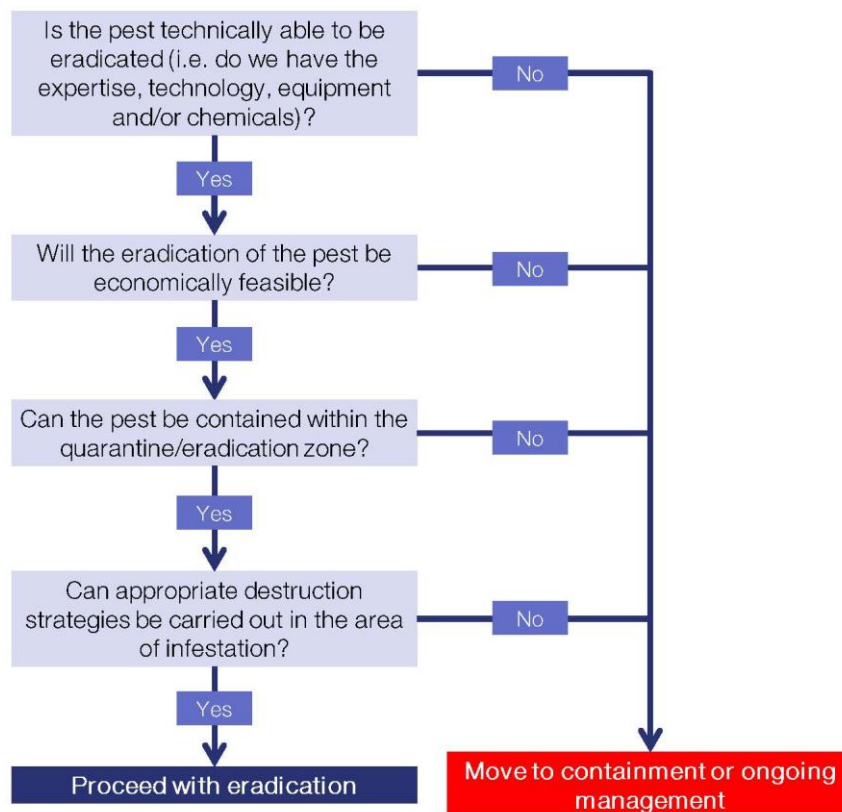


**Figure 2.** Decision outline for the response to an exotic pest incursion

**Table 2.** Factors considered in determining whether eradication or alternative action will be taken for an EPP Incident (taken from Appendix 12 of PLANTPLAN)

| Factors favouring eradication                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Factors favouring alternative action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Cost/benefit analysis shows significant economic or amenity loss to industry or the community if the organism establishes.</li> <li>• Physical barriers and/or discontinuity of hosts between production districts.</li> <li>• Cost effective control difficult to achieve (e.g. limited availability of protectant or curative treatments).</li> <li>• The generation time, population dynamics and dispersal of the organism favour more restricted spread and distribution.</li> <li>• Pest biocontrol agents not known or recorded in Australia.</li> <li>• Vectors discontinuous and can be effectively controlled.</li> <li>• Outbreak(s) few and confined.</li> <li>• Trace back information indicates few opportunities for secondary spread.</li> <li>• Weather records show unfavourable conditions for pest development.</li> <li>• Ease of access to outbreak site and location of alternate hosts.</li> </ul> | <ul style="list-style-type: none"> <li>• Cost/benefit analysis shows relatively low economic or environmental impact if the organism establishes.</li> <li>• Major areas of continuous production of host plants.</li> <li>• Cost effective control strategies available.</li> <li>• Short generation times, potential for rapid population growth and long distance dispersal lead to rapid establishment and spread.</li> <li>• Widespread populations of known pest biocontrol agents present in Australia.</li> <li>• Vectors unknown, continuous or difficult to control.</li> <li>• Outbreaks numerous and widely dispersed.</li> <li>• Trace back information indicates extensive opportunities for secondary spread.</li> <li>• Weather records show optimum conditions for pest development.</li> <li>• Terrain difficult and/or problems accessing and locating host plants.</li> </ul> |

## 4 Pest information/status – Thrips/virus complex

### 4.1 Pest details

In this contingency plan specific pest information and status will be given for the thrips vector, as well as examples of virus species that are transmitted by thrips. The viruses have been chosen in consultation with the Nursery and Garden Industry Australia (NGIA) due to their economic importance and potential relevance to the Australian nursery industry. This plan will specifically examine three Tospoviruses and one Carmovirus whose vectors are already present in Australia that would potentially have a high impact on the nursery & garden industry should they enter and become established; namely, the Tospoviruses *Chrysanthemum stem necrosis virus* and *Impatiens necrotic spot virus*, the Carmovirus *Pelargonium flower break virus*, as well as the Tospovirus *Tomato spotted wilt virus* that is already present.

Five genera of thrips are known to transmit viruses: *Thrips*, *Frankliniella*, *Scirtothrips*, *Microcephalothrips* and *Ceratothripoides* (Jones 2005). The majority of viruses transmitted by thrips are tospoviruses which can be vectored by three species of *Thrips*, six species of *Frankliniella* and one species each of *Scirtothrips* and *Ceratothripoides* (Jones 2005). Thrips vectors of all but one virus (*Zucchini lethal chlorosis virus*) are already present in Australia (Table 3). Note that other thrips species that are serious pests to the nursery & garden industry, such as *Poinsettia thrips* (*Echinothrips americanus*), are not known to vector viruses.

The focus of this contingency plan is exotic viruses transmitted by thrips and specific information will be given for the thrips vector as well as three exotic and one endemic thrips-transmitted virus. These viruses have been chosen because of their economic importance and potential relevance to the nursery and garden industry and because they act as examples within different virus families. It should be noted however that for each virus in a family, specific information would be required on symptoms, host range, diagnosis, geographic distribution as well as risk ratings for entry, establishment, spread and economic impact.

**Table 3.** Thrips transmitted Tospoviruses and their vectors (virus and vector data from Whitfield et al. 2005 and Persley et al. 2006). Vectors not currently present in Australia are highlighted in bold font.

| Virus                                    | Acronym | Present in Australia | Thrips vector                                                                                                                                                                     |
|------------------------------------------|---------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Calla lily chlorotic spot virus</i>   | CCSV    | No                   | <i>Thrips palmi</i>                                                                                                                                                               |
| <i>Capsicum chlorosis virus</i>          | CaCV    | Yes                  | <i>Frankliniella schultzei</i> ,<br><i>Ceratothripoides claratris</i> ,<br><i>T. palmi</i> ,                                                                                      |
| <i>Chrysanthemum stem necrosis virus</i> | CSNV    | No                   | <i>F. occidentalis</i><br><i>F. schultzei</i>                                                                                                                                     |
| <i>Groundnut bud necrosis virus</i>      | GBNV    | No                   | <i>F. schultzei</i><br><i>T. palmi</i><br><i>Scirtothrips dorsalis</i>                                                                                                            |
| <i>Groundnut ringspot virus</i>          | GRSV    | No                   | <i>F. occidentalis</i><br><i>F. schultzei</i>                                                                                                                                     |
| <i>Impatiens necrotic spot virus</i>     | INSV    | No                   | <i>F. occidentalis</i>                                                                                                                                                            |
| <i>Iris yellow spot virus</i>            | IYSV    | Yes                  | <i>T. tabaci</i>                                                                                                                                                                  |
| <i>Melon yellow spot virus</i>           | MYSV    | No                   | <i>T. palmi</i>                                                                                                                                                                   |
| <i>Peanut chlorotic fanspot virus</i>    | PCFV    | No                   | <i>S. dorsalis</i>                                                                                                                                                                |
| <i>Peanut yellow spot virus</i>          | PYSV    | No                   | <i>S. dorsalis</i>                                                                                                                                                                |
| <i>Tomato chlorotic spot virus</i>       | TCSV    | No                   | <b><i>F. intonsa</i></b><br><i>F. occidentalis</i><br><i>F. schultzei</i>                                                                                                         |
| <i>Tomato spotted wilt virus</i>         | TSWV    | Yes                  | <b><i>F. bispinosa</i></b><br><b><i>F. fusca</i></b><br><b><i>F. intonsa</i></b><br><i>F. occidentalis</i><br><i>F. schultzei</i><br><b><i>T. setosus</i></b><br><i>T. tabaci</i> |
| <i>Tomato yellow fruit ring virus</i>    | Unknown | No                   | Unknown                                                                                                                                                                           |
| <i>Watermelon bud necrosis virus</i>     | WBNV    | No                   | <i>T. palmi</i>                                                                                                                                                                   |
| <i>Watermelon silver mottle virus</i>    | WSMoV   | No                   | <i>T. palmi</i>                                                                                                                                                                   |
| <i>Zucchini lethal chlorotic virus</i>   | ZLCV    | No                   | <b><i>F. zucchini</i></b>                                                                                                                                                         |

'Tospovirus' is derived from the type species of the genus, *Tomato spotted wilt virus* (TSWV), which was first discovered and named in Australia in the early 1900s. The *Tospovirus* genus includes 16 species presently recognised by the International Committee on Taxonomy of Viruses (ICTV)(Table 3), distinguished on the basis of the serological properties and amino acid sequence identity of the viral structural proteins (Whitfield *et al.* 2005). Two groups of viruses that appear to have evolved independently exist in the genus *Tospovirus*: an American cluster that includes TSWV, INSV, *Groundnut ringspot virus* (GRSV), *Tomato chlorotic spot virus* (TCSV), *Chrysanthemum stem necrosis virus* (CSNV) and *Zucchini lethal chlorosis virus* (ZLCV) and a Eurasian cluster which includes *Groundnut bud necrosis virus* (GBNV), *Watermelon silver mottle virus* (WSMoV) and *Iris yellow spot virus* (IYSV)(Nagata *et al.* 2007). Despite assigning various vector species to different viruses; it has become clear in recent years that individual isolates of viruses may not be transmitted by all known vectors of that virus (Persley *et al.* 2006).

Three of the Tospoviruses listed in Table 3 are already present in Australia (TSWV, IYSV and *Capsicum chlorosis virus* [CaCV]), along with five species of thrips vectors: *F. occidentalis* (Western flower thrips), *F. schultzei* (Tomato thrips), *T. palmi* (Melon thrips), *T. tabaci* (Onion thrips) and *S. dorsalis*. TSWV remains the most widespread and damaging of the Tospoviruses in Australia (Persley *et al.* 2006).

CaCV was found in capsicum and tomato crops in Qld in 1999 (McMichael *et al.* 2000), but may have been detected seven years earlier without being conclusively identified (Persley *et al.* 2006). CaCV infects capsicum, tomato, peanut and some weeds and is transmitted by Tomato thrips and Melon thrips. IYSV was detected in Australia as early as 1998 but was first confirmed and reported to be present in NSW, Vic and WA in onions and leeks in 2003 (Coutts *et al.* 2003).

In addition to the genus *Tospovirus*, there are five known viruses from four other genera that are transmitted by thrips (Table 4). The Ilarviruses, *Tobacco streak virus* (TSV) and *Prunus necrotic ringspot virus* (PNRV), the Carmovirus *Pelargonium flower break virus* (PFBV) and the Sobemovirus *Sowbane mosaic virus* (SoMV) are transmitted by thrips moving virus-infected pollen between plants, which then infects through feeding wounds (Jones 2005). SoMV can also be acquired by thrips during feeding and transmitted when infected thrips feed on healthy plants, as per Tospoviruses. The mode of transmission of the Machlomovirus *Maize chlorotic mottle virus* (MCMV) is not known, but it is thought to be transmitted by thrips (Ullman *et al.* 1992).

**Table 4.** Thrips transmitted viruses from genera other than tospovirus (data from Jones 2005). Note: all Thrips vectors are currently present in Australia.

| Virus genera  | Virus                                 | Acronym | Present in Australia | Thrips vector                                                                                                                       |
|---------------|---------------------------------------|---------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Carmovirus    | <i>Pelargonium flower break virus</i> | PFBV    | No                   | <i>F. occidentalis</i>                                                                                                              |
| Ilarvirus     | <i>Tobacco streak virus</i>           | STV     | Yes                  | <i>F. occidentalis</i><br><i>F. schultzei</i><br><i>T. tabaci</i><br><i>T. parvispinus</i><br><i>Microcephalothrips abdominalis</i> |
| Ilarvirus     | <i>Prunus necrotic ringspot virus</i> | PNRV    | Yes                  | <i>T. tabaci</i>                                                                                                                    |
| Machlomovirus | <i>Maize chlorotic mottle virus</i>   | MCMV    | No                   | <i>T. tabaci</i>                                                                                                                    |
| Sobemovirus   | <i>Sowbane mosaic virus</i>           | SoMV    | Yes                  | <i>T. tabaci</i>                                                                                                                    |



SoMV was first reported in Australia in 1968 (Teakle 1968). TSV was first reported in Australia in 1971 and has subsequently been reported on tobacco, strawberry, dahlia and various weed species, mostly from south-eastern Qld (Greber *et al.* 1991). More recently, TSV has been reported infecting sunflower, cotton, mung bean and chickpea Qld (Sharman *et al.* 2008). Typical symptoms of TSV on beans are shown in Figure 3.

PNRV is also present in Australia and has a wide host range including important commercial crops such as roses (garden roses, cut flower roses and essential oil-bearing roses), apple, peach, hop, apricot, almond and plum (Kulshrestha *et al.* 2009).

While Australia is currently free of the tospovirus ZLCV and its vector (*F. zucchini*), the control and management procedures for this pest would likely be the same as for those exotic viruses whose vectors are already present in Australia. The presumption for this is that it is highly likely that the ZLCV would only enter Australia via plant or soil material infested with eggs/larvae/pupae of a viruliferous thrips vector. The virus is not seed-borne and has a host range limited to zucchini and other cucurbits and is currently found only in Brazil. Australia does not currently import any cucurbit produce from Brazil, and all cucurbit nursery stock must pass through quarantine; hence it is extremely unlikely that the virus would enter Australia in the absence of the vector, *F. zucchini*.



**Figure 3.** A common bean plant showing rednode necrosis and leaf chlorosis caused by the Tobacco streak virus (TSV). Image courtesy of Howard F. Schwartz, Colorado State University, Bugwood.org

## 5 Pest information/status – the thrips vector

### 5.1 Pest details

#### Taxonomic position:

Kingdom, Animalia; Phylum, Arthropoda; Class, Insecta; Order, Thysanoptera, Haliday, 1836

#### 5.1.1 Background

Thrips are minute insects belonging to the order Thysanoptera. Thrips have a distinctive fringe of long hairs around the wing margins and, unlike other insects, have only one mandible that is used to punch a hole in a plant to suck out the cell sap using a stylet. They also have a bladder like appendage to cling to plant surfaces. Thrips have an adult body size ranging from 0.5 to 5 mm and adults usually having four slender wings. About 5000 species of thrips have been recognised with the potential for many more. Nine families are known with 95% of the known species being members of the Thripidae and Phlaeothripidae families (Jones 2005). The species that are known virus vectors are members of the Thripidae subfamily Thripinae. This subfamily has 1400 species in 230 genera.

Thrips can be an economic problem in a wide range of crops including ornamentals, vegetables, strawberries, grapes, pome fruit and stone fruit. The main economically important thrips species in Australia are presented in Table 5. Those thrips that transmit Tospoviruses are Western flower thrips, Tomato thrips, Melon thrips and Onion thrips

Thrips cause direct damage to plants: After piercing plant cells using their mouthparts, they feed on plant juices causing collapse of plant cells results in the formation of deformed flowers, leaves, stems, shoots and fruit. Thrips can also damage buds and flowers through their egg laying.

**Table 5.** Some important thrips threats in Australia (extract from 'A management guide to thrips and tospovirus' (Queensland DEEDI, Persley et al. 2007)).

| Species                                                      | Main Crops Affected                                 | Type of Injury                                                                         |
|--------------------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------------------------------|
| <i>Frankliniella occidentalis</i><br>(Western flower thrips) | Wide range of fruit, vegetable and ornamental crops | Damage to flowers and developing fruit. Tospovirus vector.                             |
| <i>Frankliniella schultzei</i><br>(Tomato thrips)            | Wide range of crop and weed hosts                   | Damage to leaves and young fruit. Tospovirus vector.                                   |
| <i>Thrips palmi</i><br>(Melon thrips)                        | Potato, cucurbits, capsicum, beans, eggplant        | Damage to leaves, growing points, scarring of fruit and fruit drop. Tospovirus vector. |
| <i>Thrips tabaci</i><br>(Onion thrips)                       | Onion, garlic                                       | Damage to leaves. Tospovirus vector.                                                   |
| <i>Thrips imaginis</i><br>(Plague thrips)                    | Stone, pome fruit, lucerne                          | Damage to flowers and young fruit.                                                     |
| <i>Thrips hawaiiensis</i><br>(Banana flower thrips)          | Banana                                              | Corky scab of fruit.                                                                   |
| <i>Chaetanaphothrips signipennis</i><br>(Banana rust thrips) | Banana                                              | Cracking and scarring of fruit.                                                        |



| Species                                                   | Main Crops Affected | Type of Injury                                       |
|-----------------------------------------------------------|---------------------|------------------------------------------------------|
| <i>Heliothrips haemorrhoidalis</i><br>(Greenhouse thrips) | Ornamentals         | Silvering of leaves.                                 |
| <i>Thrips simplex</i><br>(Gladiolus thrips)               | Gladiolus           | Damage to leaves and flowers.                        |
| <i>Megalurothrips usitatus</i><br>(Bean blossom thrips)   | French beans        | Flower feeding causing twisting and curling of pods. |
| <i>Limothrips cerealium</i>                               | Wheat               | Whitened spikelets with no or shrivelled grains.     |

Thrips also damage plants by transmitting viruses. Thrips acquire viruses when the newly hatched thrips (first instar nymphs) feed on a plant infected with the virus. In general older nymphs and adults cannot acquire the virus. If no source of infection is present, thrips cannot acquire or transmit the virus.



**Figure 4.** Adult (bottom right) and larval stages of thrips (images source: *Thrips and tospoviruses – A management guide* by DEEDI 2007).

### 5.1.2 Life cycle

In general, the thrips life cycle is mostly continuous and thrips can usually be found year round. In greenhouses they may produce 12-15 generations per year. Temperature determines the generation time with generation time for Western flower thrips varying from 9 days in summer to 15-20 days or more in winter.

Females of the common thrips drill a hole into a leaf, and push into this a single egg. Females lay 30 or more eggs. Eggs are laid individually just under the surface of the younger parts of leaves, stems,

flowers and inside the buds. The eggs hatch in 3-4 days, depending on temperature, with the larvae moving into more protected areas of the plant to feed.

There are four immature stages and two active larval stages which feed on leaves and in flowers, and two non-feeding pupa stages, usually in the soil. Thrips are unusual insects in that there are two pupal stages before the new adult emerges. This life cycle takes about three weeks, depending on temperature

([http://www.sardi.sa.gov.au/pestsdiseases/horticulture/horticultural\\_pests/integrated\\_pest\\_management/resources/greenhouse\\_pests/western\\_flower\\_thrips](http://www.sardi.sa.gov.au/pestsdiseases/horticulture/horticultural_pests/integrated_pest_management/resources/greenhouse_pests/western_flower_thrips)).

### 5.1.3 Dispersal

Thrips run, crawl or jump and can move rapidly. Thrips are poor fliers and their main methods of dispersal are by wind currents, or by passive dispersal by transport on affected fresh plant material, people or on equipment.

## 5.2 Affected hosts

### 5.2.1 Host range

Thrips have a wide host range with Western flower thrips (*Frankliniella occidentalis*) for example, being extremely polyphagous with over 200 plant species from more than 60 families recorded as hosts (Jones 2005).

### 5.2.2 Current geographic distribution

Thrips can be found in both warm and cold climates throughout Australia. For example, Onion thrips can seriously damage crops in Tasmania, Western flower thrips causing damage in temperate regions, and Melon thrips are present in the far north. In northern Australia, the native thrips are similar to species found in Indonesia, and are very different from the species that live in southern Australia. Generally, the diversity of thrips species is greater in the warmer climates than in temperate zones (<http://www.ala.org.au/explore/themes/thrips/>).

### 5.2.3 Symptoms

Thrips cause major damage through feeding on foliage, flowers and fruit including foliage discolouration or silverying, deformed new growth or flower buds and halo-spotting on leaves which is seen as small dark scars surrounded by white tissue.

Damage caused by Western flower thrips include discolouration of the upper leaf surface with indentations. Halo-spotting, silverying, deformity and brown bumps may also be present on leaves of ornamentals. Feeding can also cause discolouration and scarring of petals and deformity to buds (Jones 2005).

## 5.3 Diagnostic information

Accurate identification of thrips species is not easy and requires experience and training. Identification of thrips species by morphological procedures is restricted to adult specimens as there are no adequate keys for the identification of eggs, larvae or pupae.

## 5.4 Pest risk ratings and potential impacts

Thrips species can have a serious impact on the production of certain field crops as well as a wide range of protected horticultural crops. The appearance of new viruses in areas colonised by the thrips can be due to the fast development and broad host range of the thrips and transmission of the virus by the thrips.

# 6 Pest information/status – *Tospoviruses*

## 6.1 Pest details – example: Chrysanthemum stem necrosis virus

|                            |                                                                     |
|----------------------------|---------------------------------------------------------------------|
| <b>Common names:</b>       | <i>Chrysanthemum stem necrosis virus</i> (CSNV)                     |
| <b>Scientific name:</b>    | <i>Chrysanthemum stem necrosis virus</i>                            |
| <b>Synonyms:</b>           | Formerly thought to be a strain of <i>Tomato spotted wilt virus</i> |
| <b>Taxonomic position:</b> | Group: virus; Family: Bunyaviridae; Genus: Tospovirus               |

Within this contingency plan, this virus was chosen as an exemplar due to its economic impact on hosts that form a significant part of the nursery and garden industry. CSNV is listed as an EPPO A1 quarantine pest i.e. a pest that is not present in the EPPO region and is considered a significant threat (EPPO 2010a).

### 6.1.1 Background

*Chrysanthemum stem necrosis virus* (CSNV) was first recognised on chrysanthemum in Sao Paulo state in Brazil (Duarte *et al.* 1995) and described as a new virus (rather than a strain of Tomato spotted wilt virus (TSWV)) by Bezerra *et al.* (1996). The virus is spread by the thrips vectors *F. occidentalis* and *F. schultzei* (Bezerra *et al.* 1999; Nagata and de Ávila 2000), both of which are present in Australia. Studies have revealed that the virus cannot be vectored by *T. tabaci* (Bezerra *et al.* 1999). Successful transmission requires that the salivary glands contain large amounts of virus (Nagata *et al.* 1999). The failure of *T. tabaci* to transmit CSNV can be explained by the limited virus infection in the midgut and the absence of virus in the salivary glands (Nagata and de Ávila 2000).

CSNV has been successfully eradicated from the Netherlands and the UK, following its importation on chrysanthemum cuttings from Brazil (EPPO 2005). The virus has been reported in Slovakia and is under official control (Ravnikar *et al.* 2003).

CSNV is a significant threat to chrysanthemum and tomato crops where the major vector, Western flower thrips (*F. occidentalis*) is present and reported to have caused economic losses in Brazil

(Nagata *et al.* 2007). CSNV causes a more severe disease on chrysanthemum than TSWV (EPPO 2005).

### 6.1.2 Life cycle

CSNV has the typical biology of a tospovirus. Thrips (*F. occidentalis* and *F. shultzei*) acquire the virus in the first and early second larval stages (adult Thrips are unable to acquire the virus) and remain viruliferous for life, allowing multiple transmissions by adult insects (Sherwood *et al.* 2000).

Tospoviruses can replicate in the thrips vectors as well as in host plants (Ullman *et al.* 1993) and only short feeding periods are necessary for transmission. Thus, many plants can be infected as viruliferous vectors move through a crop. The G1 and G2 membrane glycoproteins of tospoviruses are involved in the vector-virus relationship (Jones 2005).

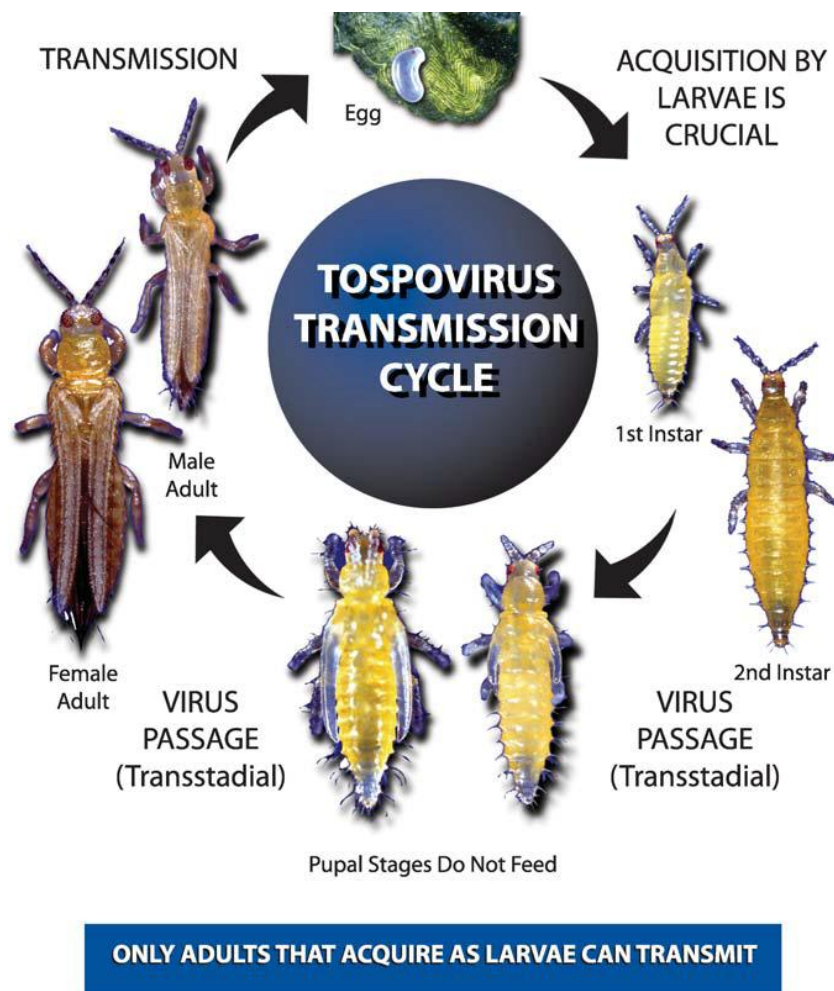


**Figure 5.** Graphic representation of the thrips life cycle and the tospovirus transmission cycle (for a more detailed explanation refer to Whitfield *et al.* 2005).

### 6.1.3 Dispersal

Dispersal over long distances is primarily due to the movement of plant material infested with infected thrips vectors *F. occidentalis* or *F. schultzei* (adults, eggs or larvae in flowers, fruit, leaves, or pupal stages in growing media). As a Tospovirus, CSNV is unlikely to be seed-transmitted (EPPO 2005).

The virus is spread from plant to plant by the vectors *F. occidentalis* and *F. schultzei*. Coutts *et al.* (2004) suggest that the spread of tospoviruses is typically monocyclic; that is, vectors introduce the virus into crops from outside sources rather than establishing foci within crops with subsequent secondary spread.

The virus could be spread over long distances with trade in cuttings and other vegetative plants for planting. CSNV is known to have spread to the Netherlands in chrysanthemum cuttings imported from Brazil (Verhoeven *et al.* 1996) as well as to the UK by the same route (Mumford *et al.* 2003). These plants may not have shown symptoms at the time of dispatch.

### 6.1.4 Host range

Tomato (*Lycopersicon esculentum*) and chrysanthemum (*Dendranthema grandiflorum*) are the only known natural hosts.

### 6.1.5 Current geographic distribution

CSNV is currently found in Brazil and Japan and is reported to be under official control in Slovakia (Ravnikar *et al.* 2003). The virus has also been eradicated from the Netherlands and the UK (EPPO 2005).

### 6.1.6 Potential distribution in Australia

Given the widespread presence of the Western flower thrips (*F. occidentalis*) and Tomato thrips (*F. schultzei*) vectors and host plants (tomatoes and chrysanthemums), the virus has the potential to spread to all states and territories.

### 6.1.7 Symptoms

CSNV causes symptoms similar to those of Tomato spotted wilt virus on chrysanthemums, and may include necrotic streaks on stems, wilting of leaves and stems, chlorotic and necrotic spots and rings on leaves, and leaf distortion (EPPO 2005; Matsuura *et al.* 2007). However, symptoms of CSNV are more severe and can cause complete necrosis of the stem leading to wilting of sections of plants (Verhoeven *et al.* 1996). Duarte *et al.* (1995) reported necrotic lesions surrounded by yellow areas on leaves followed by necrosis on stems, peduncles and floral receptacles due to CSNV in Brazil.

**Table 6.** Summary of *Chrysanthemum stem necrosis virus* symptoms (CABI 2011).

| Plant parts   | List of symptoms                                             |
|---------------|--------------------------------------------------------------|
| Inflorescence | Lesions, flecking, streaks (not Poaceae)                     |
| Leaves        | Necrotic areas, abnormal colours, abnormal patterns, wilting |
| Stems         | Wilt, discoloration, necrosis                                |
| Whole plant   | Wilt                                                         |

### 6.1.8 Diagnostic information

Diagnosis based on symptoms is difficult because both CSNV and TSWV cause similar symptoms on chrysanthemum. Morphological characteristics can confirm the presence of a tospovirus with the following features: Tospoviruses form pleomorphic, spherical particles, 80–120 nm in diameter, that are surrounded by a lipid envelope with two surface glycoprotein (GN and GC) projections, enclosing three nucleocapsids (Persley *et al.* 2006). The RNA segments within the nucleocapsids are single-stranded, and are designated L (large), M (medium) and S (small), each associated with many copies of the virus-encoded N (nucleocapsid) protein and a few copies of RNA-dependent RNA polymerase (RdRp) (Persley *et al.* 2006).

Serological assays such as ELISA have become routine for detection and identification of tospoviruses and have been used to confirm the presence CSNV (Nagata and de Ávila 2000). Western immuno-blot analysis also distinguishes CSNV from other tospoviruses, although a slight cross-reaction with antibodies against TSWV, TCSV and GRSV was observed (Bezerra *et al.* 1999). Reverse Transcription (RT)- Polymerase Chain Reaction (PCR) can also be used to verify virus infection (Matsuura *et al.* 2007) and more recently Kuwabara *et al.* (2010) developed a multiplex RT-PCR that can detect and identify five tospovirus species, including CSNV, simultaneously.

### 6.1.9 Risk assessments for pathways and potential impacts

*Chrysanthemum stem necrosis virus* (CSNV) is not known to be present in Australia; however its vectors *F. occidentalis* and *F. schultzei* are both present and as vectors of CSNV have the potential for establishment of spread and economic consequences should CSNV enter Australia.

Within this contingency plan, a pest risk analysis has been carried out on this virus, taking into account the entry, establishment and spread potentials, together with the economic and environmental impact of establishment. A summary of these ratings are shown in Table 7. Based on this information, CSNV is considered a medium overall risk to Australia.



**Table 7.** Pest risk ratings for *Chrysanthemum stem necrosis virus*

| Potential or impact     | Rating     |
|-------------------------|------------|
| Entry potential         | Low        |
| Establishment potential | High       |
| Spread potential        | High       |
| Economic impact         | High       |
| Environmental impact    | Negligible |
| Overall risk            | Medium     |

**6.1.9.1 ENTRY POTENTIAL****Rating: Low**

The most likely pathway for CSNV to enter Australia is via plant material infested with infected thrips vectors carried in plant parts, fruit or growing media in international trade from countries where the virus is present (Japan and Brazil). Both vector species (*F. occidentalis* and *F. shultzei*) are highly polyphagous, and could enter on any number of host plants. However, given that the virus is only present in Japan and Brazil, and that the chance that the vectors may not be infected with CSNV should they enter Australia, the risk of entry is considered **Low**.

**6.1.9.2 ESTABLISHMENT POTENTIAL****Rating: High**

Hosts for the thrips vectors are widespread, as are hosts for the virus (chrysanthemums and tomatoes); hence, the establishment potential is **High**.

**6.1.9.3 SPREAD POTENTIAL****Rating: High**

Both vector species are already present in Australia and are almost ubiquitous, suggesting that if CSNV-infected thrips entered and established in Australia their spread potential, and therefore the spread potential of CSNV, would be **High**.

**6.1.9.4 ECONOMIC IMPACT****Rating: High**

The virus causes economic losses in tomato and chrysanthemum crops in Brazil (Nagata *et al.* 2007). Because the control measures for CSNV is targeted at eliminating or excluding the thrips vectors (*F. occidentalis* and *F. schultzei*) and given that Western flower thrips (*F. occidentalis*) readily develops resistance to chemicals used to control Western flower thrips, effective control of Western flower thrips and CSNV may prove difficult. For this reason the economic impact on CSNV on chrysanthemum and tomato production is likely to be **High**.

#### 6.1.9.5 ENVIRONMENTAL IMPACT

##### Rating: Negligible

The virus has a narrow host range (tomatoes and chrysanthemums) so the environmental impact is likely to be **Negligible**.

#### 6.1.9.6 OVERALL RISK

##### Rating: Medium

Based on the individual ratings above, the combined overall risk is considered **Medium**.

## 6.2 Pest details – example: Tomato spotted wilt tospovirus

|                            |                                                                                                                                                                                                                               |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Common names:</b>       | Tomato spotted wilt virus                                                                                                                                                                                                     |
| <b>Scientific name:</b>    | <i>Tomato spotted wilt virus</i>                                                                                                                                                                                              |
| <b>Synonyms:</b>           | Dahlia oakleaf virus; Dahlia ringspot virus ; Dahlia yellow ringspot virus; Groundnut ringspot virus; Mung bean leaf curl virus; Pineapple yellow spot virus; Tomato spotted wilt tospovirus; Tomato spotted wilt virus group |
| <b>Taxonomic position:</b> | Domain, virus; Group, “RNA viruses” Family: Bunyaviridae; Genus: Tospovirus                                                                                                                                                   |

*Tomato spotted wilt virus* (TSWV) is widespread in Australia however was chosen as an example as it was originally included in the Nursery and Garden Industry Biosecurity Plan.

Within this contingency plan, this virus was chosen as an example due to its economic impact on hosts that form a significant part of the nursery and garden industry. TSWV is listed as an EPPO A2 quarantine pest i.e. a pest that is present in some parts of the EPPO region and is considered a threat recommended for regulation (EPPO 2010b).

### 6.2.1 Background

Tomato spotted wilt virus (TSWV) is one of the most widespread and damaging viruses affecting vegetable crops in Australia. Though TSWV was first identified in Australia in 1915, the severity and incidence of the disease in Australia and overseas increased substantially with the spread of Western flower thrips, the major vector (Persley *et al.* 2006). Other thrips vectors (namely *F. shultzei*, *F. intonsa*, *F. bispinosa*, *Thrips tabaci* and *T. setosus*) were later shown to be efficient in transmitting TSWV (Wijkamp *et al.* 1995; Webb *et al.* 1998, Jones 2005). Persley *et al.* (2006) have also shown that *T. palmi* is able to transmit Australian isolates of TSWV. The crops most frequently and severely affected by TSWV are the solanaceous vegetables including tomato, capsicum, lettuce, potato and ornamental species like for example, aster, calendula and chrysanthemum. For cucumbers infections are symptomless. The arrival of the vector Western flower thrips has seen an increase in the seriousness of the disease, particularly in hydroponic and covered systems.

Once a plant is infected with TSWV it cannot be cured and therefore prevention or the use of tolerant varieties are the only management options available.

Typical symptoms of TSWV are shown in Figure 6.





**Figure 6.** Stunting and leaf necrosis on field-grown tomatoes due to TSWV. Image courtesy of Don Ferrin, Louisiana State University Agricultural Center, Bugwood.org.

### 6.2.2 Life cycle

All tospoviruses are transmitted and spread in nature by insects of the family Thripidae (Thysanoptera), belonging to the genera *Frankliniella* and *Thrips*. Thrips vectors can include *Frankliniella bispinosa* (Webb et al. 1998), *F. intonsa* (Wijkamp et al. 1995), *F. fusca*, *F. occidentalis*, *F. schultzei*, *Thrips palmi*, *T. setosus* and *T. tabaci*. *T. flavus* (Singh and Krishnareddy 1996), *F. tenuicornis* (Kormelink 1994) and *Scirtothrips dorsalis* (Amin et al. 1981) have been reported as vectors, but their status as such has yet to be confirmed.

### 6.2.3 Dispersal

TSWV is liable to spread naturally with its vectors (OEPP/EPPO 1990). In international trade, it may be carried by susceptible host plants, whether pot plants or plants for planting, and will be especially liable to spread if these plants also carry vectors. Seed transmission has not been demonstrated.

### 6.2.4 Host range

TSWV has one of the widest host ranges of any plant virus. A list previously compiled by Peters (1998) included more than 940 species in 90 dicotyledonous and 8 monocotyledonous families of TSWV with only 100 species more listed for all tospoviruses. Capsicum, lettuce, pea, tobacco, potato, tomato, and a large number of ornamental plant species are the main hosts of TSWV.

### 6.2.5 Current geographic distribution

TSWV is found in Europe, Africa, Asia, North, Central and South America, Oceania including Australia (CABI 2011). TSWV is listed as an A2 quarantine pest i.e. is present in some parts of the EPPO region (EPPO 2010b).

### 6.2.6 Symptoms

TSWV is mainly of concern in tomatoes, capsicum and lettuce where it can cause crop losses of up to 100%. Plants infected with TSWV can show one or more symptoms of the following; irregular necrotic (dead) spots on leaves, black or purple stem streaks, chlorosis yellowing (blotching, chlorotic or necrotic ring spots and line patterns on leaves and fruits, leaf distortion and deformation, dropping of leaves or shredding of buds, dieback and leaf collapse, strips on petals or plant death caused by wilting (Broughton *et al.* 2004). The fruit may also be discoloured or abnormal shape.

Symptoms are occasionally only found on the fruits (Pavan *et al.* 1996). Some fruits of TSWV-resistant plants can show unusual ringspot symptoms caused as a response to the feeding of viruliferous thrips on the fruit during the early stages of development (de Haan *et al.* 1996; Aramburu *et al.* 2000).

### 6.2.7 Diagnostic information

Diagnosis may be difficult if it is based on symptoms alone. A range of diagnostic methods exist for the detection of TSWV using ELISA for plant material and real time fluorescent RT-PCR (TaqMan) for individual thrips and plant material (OEPP/EPPO 2004).

## 6.3 Pest details – example: Impatiens necrotic spot virus

|                            |                                                  |
|----------------------------|--------------------------------------------------|
| <b>Common names:</b>       | Impatiens necrotic spot virus (INSV)             |
| <b>Scientific name:</b>    | <i>Impatiens necrotic spot virus</i>             |
| <b>Synonyms:</b>           | Tomato spotted wilt tospovirus, impatiens strain |
| <b>Taxonomic position:</b> | Family, Bunyaviridae; Genus, Tospovirus          |

Within this contingency plan, this virus was chosen as an example due to its economic impact on hosts that form a significant part of the nursery and garden industry. INSV is listed as an EPPO A2 quarantine pest i.e. a pest that is present in some parts of the EPPO region and is considered a threat recommended for regulation (EPPO 2010b). An incursion of INSV occurred in Australia in 2010 in a production nursery and an eradication response was mounted to destroy infected plants, indicating that it has previously entered and become established in Australia.

### 6.3.1 Background

Originally considered a strain of Tomato spotted wilt virus (TSWV), INSV was later recognised as a separate species (de Ávila *et al.* 1992). The biology of INSV is very similar to that of TSWV and like TSWV, INSV is transmitted mainly by *Frankliniella occidentalis* (de Angelis *et al.* 1994). INSV causes

significant losses in many glasshouse ornamentals in Europe and the USA and is widespread in these regions. The virus was detected in New Zealand in 2003 and has since infected a range of ornamental plants (Elliot *et al.* 2009).

### 6.3.2 Life cycle

All tospoviruses are transmitted and spread in nature by insects of the family Thripidae (Thysanoptera), belonging to the genera *Frankliniella* and *Thrips*, see Figure 5. *Graphic representation of the thrips life cycle and the tospovirus transmission cycle (for a more detailed explanation refer to Whitfield et al. 2005)*. Thrips vectors can include *Frankliniella bispinosa* (Webb *et al.* 1998), *F. intonsa* (Wijkamp *et al.* 1995), *F. fusca*, *F. occidentalis*, *F. schultzei*, *Thrips palmi*, *T. setosus* and *T. tabaci*. *T. flavus* (Singh and Krishnareddy 1996), *F. tenuicornis* (Kormelink 1994) and *Scirtothrips dorsalis* (Amin *et al.* 1981) have been reported as vectors, but their status as such has yet to be confirmed.

### 6.3.3 Dispersal

INSV is transmitted by adult Western flower thrips that have acquired the virus at the larval stage and so local dispersal will occur with the virus vector. The virus replicates in thrips but there is no evidence of transovarial transmission, and INSV is not transmitted congenitally or by seed. Long distance dispersal will occur through movement of nursery stock, either with plants carrying the thrips vector or through mechanical transmission to new nursery stock from infected plants introduced into new areas.

### 6.3.4 Host range

Hosts include the ornamental plants *Aconitum*, *Alstroemeria*, *Anemone*, *Antirrhinum*, *Asplenium*, *Begonia*, *Bouvardia*, *Callistephus*, *Chrysanthemum*, *Columnea*, *Cordyline*, *Cyclamen persicum*, *Dahlia*, *Dendranthema x grandiflorum*, *Eustoma grandiflorum*, *Exacum affine*, *Fatsia japonica*, *Freesia*, *Gerbera*, *Gladiolus*, *Impatiens*, *Limonium*, *Lobelia*, *Peperomia*, *Pittosporum*, *Primula*, *Ranunculus*, *Schefflera*, *Senecio cruentus*, *Sinningia speciosa*, *Spathiphyllum*, *Zantedeschia* sp. and the fern *Asplenium nidus-avis*.

Vegetable hosts include *Arachis hypogaea*, *Capsicum annum*, *Cichorium endivia*, *Cucumis sativus*, *Lactuca sativa*, *Ocimum basilicum*, *Rubus* sp., *Solanum lycopersicum*, *Solanum tuberosum* and *Valerianella olitoria*.

### 6.3.5 Current geographic distribution

INSV is found in Europe, USA, Canada, Costa Rica, Chile, New Zealand, Iran, Israel, Japan and China.

### 6.3.6 Symptoms

Typical symptoms of INSV are necrosis on leaves, stems and flowers, stunting of plants, leaf mosaics and mottling and distortion of the plant. Symptoms vary widely depending on plant age, time of year, the strain of virus etc; thus, diagnosing the virus by visual inspection is difficult.

### 6.3.7 Diagnostic information

INSV can be detected by ELISA, direct tissue-blot assay, dot blot immunoassay, and direct examination of plant tissues for characteristic viral inclusions (Daughtrey *et al.* 1997), and can be distinguished from TSWV by these methods (Nagata *et al.* 1997). Standard testing kits are available from Biosense (<http://www.biosense.com/nettbutikk/display.aspx?menuid=750&prodid=5567>). Molecular diagnosis is also possible using RT-PCR (Elliot *et al.* 2009).

### 6.3.8 Pathogen risk ratings and potential impacts

A pest risk analysis has been carried out on this insect, taking into account the entry, establishment and spread potentials, together with the economic and environmental impact of establishment. A summary of these ratings are shown in Table 8. Based on this information, INSV is considered a **High** overall risk to Australia.

**Table 8.** Pest risk ratings for *Impatiens necrotic spot virus* (INSV)

| Potential or impact     | Rating      |
|-------------------------|-------------|
| Entry potential         | Medium      |
| Establishment potential | High        |
| Spread potential        | High        |
| Economic impact         | High        |
| Environmental impact    | Low         |
| <b>Overall risk</b>     | <b>High</b> |

#### 6.3.8.1 ENTRY POTENTIAL

##### Rating: Medium

Australia has had a recent incursion of INSV, likely due to the virus entering on imported nursery stock. AQIS is moving to minimise the risk of entry of INSV via this pathway, however the current risk is still considered to be **Medium**.

#### 6.3.8.2 ESTABLISHMENT POTENTIAL

##### Rating: High

INSV has a similar biology to Tomato Spotted Wilt Virus, which is endemic in Australia. Host plants of INSV are also widespread throughout Australia, indicating a **High** risk of establishment.

#### 6.3.8.3 SPREAD POTENTIAL

##### Rating: High

Host plants and the major vector, Western flower thrips are widespread in Australia; hence, INSV has a **High** spread potential.

#### 6.3.8.4 ECONOMIC IMPACT

##### Rating: High

INSV is reported to have a devastating effect on protected ornamental crops in the presence of the vector Western Flower thrips (Daughtrey *et al.* 1997), which is already present in Australia. The economic risk rating is therefore **High**.

#### 6.3.8.5 ENVIRONMENTAL IMPACT

##### Rating: Low

While it is unlikely that Australian native plants will be significantly affected by INSV, the virus infects numerous amenity and landscape plants (Elliot *et al.* 2009), resulting in a **Low** environmental risk rating.

#### 6.3.8.6 OVERALL RISK

##### Rating: High

Based on the individual ratings above, the combined overall risk is considered **High**.

## 6.4 Pest details – example: Pelargonium flower break virus

|                            |                                          |
|----------------------------|------------------------------------------|
| <b>Common names:</b>       | Pelargonium flower break virus (PFBV)    |
| <b>Scientific name:</b>    | <i>Pelargonium flower break virus</i>    |
| <b>Synonyms:</b>           | n/a                                      |
| <b>Taxonomic position:</b> | Family, Tombusviridae; Genus, Carmovirus |

Within this contingency plan, this virus was chosen as an example of a Carmovirus and due to its economic impact on hosts that form a significant part of the nursery and garden industry. PFBV is listed as an EPPO A2 quarantine pest i.e. a pest that is present in some parts of the EPPO region and is considered a threat recommended for regulation (EPPO 2010b).

### 6.4.1 Background

Pelargonium flower break virus (PFBV) is one of the most prevalent viruses infecting geraniums (*Pelargonium* spp.) throughout the world (Adkins and Nameth 1989) and is the most common viral disease of florist's geranium (*P. x hortorum*). The virus was first reported and described in *Pelargonium zonale* in the UK (Stone and Hollings 1973). The virus does not usually kill plants but reduces growth and flower quality.

### 6.4.2 Life cycle

Little information is available on the life cycle of PFBV however, the virus is not known to replicate in the gut of the thrips vector in the same way that tospoviruses do. Presumably the virus replicates in live hosts. The virus remains infective after 10 minutes at 85°C, three weeks at 20°C or 27 weeks at

2°C (Stone and Hollings 1973).

Krczal *et al.* (1995) showed that higher rates of transmission occurred with a combination of the thrips vector, *F. occidentalis*, and pollen taken from PFBV-infected plants compared with infected pollen alone, indicating that infected pollen and mechanical damage caused by thrips feeding increases transmission of the virus.

### 6.4.3 Dispersal

PFBV is mainly transmitted by vegetative propagation, mechanical inoculation, in irrigation water and by *F. occidentalis* (Krczal *et al.* 1995). Transmission by *F. occidentalis* occurs via the movement of infected pollen adhered to the thrips, which then infects through feeding wounds (Jones 2005). The virus is not transmitted by aphids or seed. International trade of floral crops is considered one of the main vehicles for introducing viruses into new countries (Diez *et al.* 1999).

### 6.4.4 Host range

The natural host range of PFBV is limited to geraniums (*Pelargonium* spp.).

### 6.4.5 Current geographic distribution

The virus is known to be present in Denmark, Germany, the Netherlands, Norway, Spain, UK and USA.

### 6.4.6 Symptoms

The conspicuous symptoms, when present, are a colour breaking in the flowers; specifically, white flower streaking (Stone and Hollings 1973). Chlorotic spotting of leaves and growth reduction may also be observed. However, appearance of symptoms in infected plants is strongly affected by environmental factors and many cultivars are symptomless while still providing a reservoir for the virus.

### 6.4.7 Diagnostic information

The concentration of the virus is typically low in pelargoniums, so propagating local lesions in experimental hosts such as *Chenopodium quinoa* or *Nicotinia clevelandii* can be used to obtain more virus sample (Stone and Hollings 1973). However, *C. quinoa* is not an ideal indicator plant because the lesions developed look similar to many other virus symptoms (Stone and Holling 1973).

PFBV isometric particles are reported to contain a single coat protein of approximately 41 kDa which encapsidates a monopartite RNA of about 4 kb (Stone and Holling 1973).

Plants are generally tested using ELISA in propagation nurseries, and this technique is reliable year-round (Bouwen and Maat 1992). A non-radioactive dot hybridisation assay has also been developed and successfully used to diagnose PFBV (Ivars *et al.* 2004). PFBV can also be detected in *Pelargonium × hortorum* by immunosorbent electron microscopy (ISEM) (for methods see Blystad *et al.* 1995).

For further information on standard diagnostic protocols see Appendix 1. For a list of diagnostic facilities and advisory services that can be utilised in the event of an incursion see Appendix 2.

### 6.4.8 Pathogen risk ratings and potential impacts

In this contingency plan, a pest risk analysis has been carried out on this insect, taking into account the entry, establishment and spread potentials, together with the economic and environmental impact of establishment. A summary of these ratings are shown in Table 9. Based on this information, PFBV is considered a Medium overall risk to Australia.

**Table 9.** Pest risk ratings for *Pelargonium flower break virus*

| Potential or impact     | Rating     |
|-------------------------|------------|
| Entry potential         | Medium     |
| Establishment potential | High       |
| Spread potential        | High       |
| Economic impact         | Medium     |
| Environmental impact    | Negligible |
| Overall risk            | Medium     |

#### 6.4.8.1 ENTRY POTENTIAL

##### Rating: Medium

The most likely pathway for PFBV to enter Australia are via plant material infested with adult *F. occidentalis* carrying infected pollen from countries where the virus is present (Denmark, Germany, the Netherlands, Norway, Spain, UK and USA) or through the importation of symptomless nursery stock. *F. occidentalis* is highly polyphagous, and could enter on any number of host plants. However, it is not known how long the virus would remain infective in pollen.

#### 6.4.8.2 ESTABLISHMENT POTENTIAL

##### Rating: High

Pelargoniums are relatively widespread across Australia, providing hosts for both the vector and the virus hence the establishment potential if the virus entered on the vector is **High**. The establishment potential if the virus entered on symptomless nursery stock would also be **High**.

#### 6.4.8.3 SPREAD POTENTIAL

##### Rating: High

Given that the vector *F. occidentalis* is widespread in Australia, as are Pelargonium host plants, the spread potential of PFBV would be **High**.



#### 6.4.8.4 ECONOMIC IMPACT

##### Rating: Medium

While the incidence of PFBV is relatively high in many Western European countries (Diez *et al.* 1999), there is little information on the economic costs associated with virus outbreaks. The economic impact of PFBV on the Australian N&G industry is estimated to be **Medium**.

#### 6.4.8.5 ENVIRONMENTAL IMPACT

##### Rating: Negligible

The virus has a narrow host range (*Pelargonium* spp.) so the environmental impact is likely to be **Negligible**.

#### 6.4.8.6 OVERALL RISK

##### Rating: Medium

Based on the individual ratings above, the combined overall risk is considered **Medium**.

## 7 Pest management

### 7.1 Response checklist

The following checklist (Table 10) provides a summary of generic requirements to be identified and implemented within a Response Plan.

**Table 10.** Checklist of requirements to be identified in a Response Plan

| Checklist item                                                    | Further information                     |
|-------------------------------------------------------------------|-----------------------------------------|
| Destruction methods for plant material, soil and disposable items | Section 8.1.1, 8.1.2                    |
| Disposal procedures                                               | Section 8.1.5                           |
| Quarantine restrictions and movement controls                     | Section 8.3                             |
| Decontamination and property cleanup procedures                   | Section 8.5                             |
| Diagnostic protocols and laboratories                             | Section 5.3, 6.1.8, 6.2.7, 6.3.7, 6.4.7 |
| Trace back and trace forward procedures                           | Section 8.6                             |
| Protocols for delimiting, intensive and ongoing surveillance      | Section 7.2                             |
| Zoning                                                            | Section 8.4                             |
| Reporting and communication strategy                              | Section 7.1                             |



For a range of specifically designed procedures for the emergency response to a pest incursion and a general communication strategy refer to PLANTPLAN (Plant Health Australia, 2010<sup>5</sup>). Additional information is provided by Merriman and McKirdy (2005)<sup>6</sup> in the Technical Guidelines for Development of Pest Specific Response Plans.

## 7.2 Surveys and epidemiology studies

Information provided in Sections 7.2.1 to 7.2.3 provides a framework for the development of early detection and delimiting surveys for thrips transmitted viruses.

Where thrips are found in a production nursery that is in close proximity to potential host plants, periodically inspect nearby hosts for signs of virus symptoms by examining stems, leaves and fruit. Some hosts may be asymptomatic and leaf samples may be required from all known hosts as part of a targeted survey.

Infested sources within the production nursery may provide an opportunity for thrips to spread to trees and shrubs outside the production nursery. Personnel should avoid moving infected plant material (or any *Pelargonium* spp. in the case of PFBV as symptomless plants are common) between production nurseries to limit movement of both the vector and virus infect material.

Shoes, tools and vehicle tyres should be thoroughly washed of soil and then sanitised with a registered disinfectant. Extra precaution should be taken when working in areas known to be either infected with the virus or infested with thrips vectors, including disposable overboots that may be used and disposed of on-site.

### 7.2.1 Technical information for planning surveys

When developing surveys for presence and/or distribution of thrips transmitted viruses, the following characteristics of the pest provide the basic biological knowledge that informs the survey strategy:

- Virus infected plant material may be asymptomatic. In the case of PFBV, many *Pelargonium* cultivars or individual plants are asymptomatic so visual inspection alone may not be appropriate
- Host species in Australia are likely to be numerous and widely dispersed and may be present within relevant industries, nurseries as well as home gardens, landscape plantings and weeds
- Numerous thrips vectors are already present and widespread in Australia and many thrips have wide host ranges and share many of the same hosts with that of the virus
- The risk of thrips movement on nursery stock, machinery, equipment and personal effects is high; therefore, the spread potential of the virus is high
- Virus transmission can also occur through mechanical transmission involved with plant propagation or management
- *Chenopodium quinoa*, *Nicotiana benthamiana*, *N. clevelandii* and *N. glutinosa* may be useful indicator plants for INSV

<sup>5</sup> Available on the PHA website ([www.planthealthaustralia.com.au/plantplan](http://www.planthealthaustralia.com.au/plantplan))

<sup>6</sup> Available on the PHA website ([www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information](http://www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information))

- Production nursery greenhouses and significant proportions of Australia have favourable climatic conditions for both virus and thrips spread and establishment

### 7.2.2 Surveys for early detection of an incursion in a production nursery

The survey protocol used to monitor thrips is based on the protocols developed for Western flower thrips developed by the Department of Agriculture and Food Western Australia, Department of Primary Industry New South Wales, SARDI and DEEDI to support the management of Western flower thrips.

Points to consider in effectively monitoring thrips in commercial production nurseries are:

- Thrips are small and can be difficult to see
- As the thrips (adult and larva) are small, detection is dependent on careful visual inspection, preferably supplemented by use of a hand lens magnifier
- Sticky traps, visual monitoring and vacuum samplings are methods used to monitor for thrips. Blue traps may also be used for monitoring of Western flower thrips because they can be less attractive to other non-thrips species
  - Tapping, shaking or blowing gently into flowers over a white trap is recommended when susceptible crops are flowering
  - Monitoring using stick traps can be used to search for winged adults
- The survey should consist of two parts: an initial survey using yellow sticky card traps to determine the species of thrips present and then follow up for leaf samples
  - Yellow sticky card traps will determine the presence of thrips and other insect species such as whiteflies and aphids. It is recommended that traps be placed at a density of 1 trap per 300 to 400 plants positioning the trap bottom at canopy height. The traps should remain in place for one week
  - Crop monitoring includes making routine inspection and keeping good records. Check the underside of leaves for feeding larvae and adults. Sample the plants 2 to 3 metres apart in a Z or M set pattern, after sampling 10 plants move to a new site and continue until all areas within the glasshouse have been covered. Carefully check about 1% of all plants examining for thrips and symptoms of virus disease. If thrips are detected, leaves infested with thrips (nymphs and adults if possible) should be collected for identification of the species
  - The sampling method in outdoor crops uses the same approach for the position of leaves but samples the plants 5 to 10 metres apart in a zigzag pattern, sampling 10 plants before moving to a new site and continuing until all areas of the planting have been covered. It is recommended that for plantings up to 30 hectares a sample of 100 plants will be sufficient assessment for thrips populations

Points to consider in monitoring virus infected material in commercial production nurseries are:

- The host range of the potential virus incursion must be determined and grouped into risk categories for transmission and expression of the disease (high, medium and low)

- Conditions under which transmission, amplification and expression of the disease must be determined to assess the likelihood of detection and reporting through general surveillance and to assist develop protocols for targeted surveillance
- Potential pathways for distribution of virus-infected material must be determined
- Depending on the virus, distribution of the virus in the plant may be irregular or asymptomatic and plant material that is most likely to be infected should be determined
- Depending on the virus incursion, host species in Australia are likely to be numerous and widely dispersed and may be present within relevant industries, nurseries as well as home gardens, landscape plantings and weeds
- Virologist expertise will be needed to determine diagnostic protocols and sampling requirements including the age of plant material to be sampled, time of year and the potential to bulk samples from plant species or cultivars

If an incursion of a thrips transmitted virus is to be eradicated, it must be detected early, before it has had the opportunity to disperse very far. It is therefore necessary to consider pathways and plan surveys and/or sentinel plantings accordingly. If sentinel plants are used they should be comprised of clean material (i.e. material that has been brought from a non-infected region and tested as being free of virus). Important points to consider when developing early detection surveys are:

- Awareness information should be targeted at people who are in regular close contact with potential hosts in high risk areas or movement vectors (e.g. production nursery operators)
- Systematic and careful inspection of nursery crops and propagative plant material is essential to prevent introduction of a thrips transmitted virus and limit its spread within and from contaminated nurseries. Where possible, early detection of disease symptoms while at low levels, will provide the best chance of eradication
- An inspector must be trained to recognise a particular thrips vector and the virus symptoms and other similar disorders for comparison (see Section 5.2.3). A nursery layout map that includes approximate locations of target species will be required to develop a strategy for surveys. A survey map should include species and cultivar names, locations, approximate quantity and sources of targeted plants within the area. During the survey walkthrough, record the date, observations, and sampling information directly onto the survey map. The recorded information should be reviewed and used to develop an efficient survey strategy each time the nursery is inspected

### 7.2.3 Delimiting surveys in the event of an incursion

- In the event of an incursion, delimiting surveys are essential to inform the decision-making process
- The size of the survey area will depend on the size of the infected area and the severity of the infection, as well as distribution pathways for plant material and potential weather patterns during the period prior to detection (Figure 7). Other considerations are for example, movement of people or plant material equipment as a result of trace-forward and trace-backs
- Thrips vectors can fly and can readily spread long distances by floating with the wind or being transported on infested plants. New introductions can pose serious threats and complicate identification of naturalised populations

- All potential host species (refer to Section 5.2) should be surveyed, with particular attention paid to the species in which the virus was initially detected
- In addition to inspection of possible host plants, material should be collected for diagnostic purposes (refer to Section 7.2.4)
- If the incursion is in a populated area, publication and distribution of information sheets and appeals for public assistance may be helpful

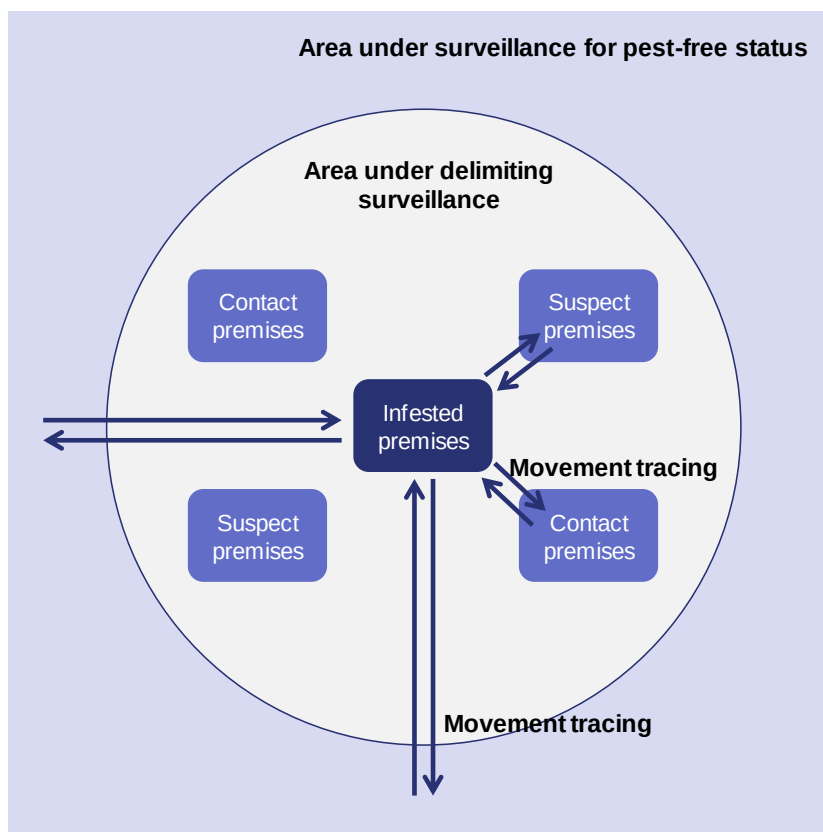


**Figure 7.** Diagram of a delimiting survey showing surveillance activities from the infected premises

#### 7.2.4 Collection and treatment of thrips samples

Protocols for the collection, transport and diagnosis of suspect Emergency Plant Pests (EPPs) must follow PLANTPLAN (Plant Health Australia 2010). Any personnel collecting samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (Plant Health Australia 2010). Containers should be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of plant species/parts affected, location of nursery and affected plant within the nursery (preferably with a GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650.

### **7.2.4.1 COLLECTION OF SPECIMENS**

#### ***Sampling procedures***

Samples can be collected on leaf samples or on yellow sticky traps (see section 7.2). The leaves should contain most thrips developmental stages.

#### ***Number of specimens to be collected***

Where possible, collect multiple specimens representative of all life stages of the population available. Adult thrips are preferred, as the adult life stage is the easiest with which to confirm identification.

Record the identity of the host plant where the thrips were collected. Record the location, preferably as GPS co-ordinates, or alternatively, a map reference or distance and direction from a suitable landmark. If the land is privately owned, record the owner's details including contact telephone numbers.

#### ***How to collect and send plant samples with eggs, larvae or pupae***

Leaf samples containing thrips nymphs and if possible adults are to be placed in a specimen container and placed in a portable fridge of insulated container with cool packs to prevent the insect and leaf samples from drying out.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (see Appendix 3 of PLANTPLAN [Plant Health Australia 2010]). Containers should then be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of plant species/parts affected, location of affected plant (where available include GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650.

#### ***Precaution***

Overheating or desiccation of samples prior to despatch should be prevented. Samples may be stored in a fridge (4-10°C) for a few days if necessary.

#### ***Receipt***

On receipt of the samples the diagnostic laboratory should follow strict quarantine and processing guidelines. In keeping with ISO 17025 refer to PLANTPLAN (Plant Health Australia 2010).

## **7.2.5 Collection and treatment of virus samples**

In general, plants showing virus like symptoms or suspected symptoms should be sampled. Any personnel collecting samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis. General protocols for collecting and dispatching samples are available within Appendix 3 of PLANTPLAN (Plant Health Australia 2010).

**Number of specimens to be collected**

In general, 5-10 samples of symptomatic plants should be collected for initial identification, with a minimum of 5 symptomatic leaves from each plant (Elliot *et al.* 2009). If a survey to determine the incidence of disease within a crop or geographic area is required, then a more formalised, statistical-based sampling strategy should be employed.

It is important to record the precise location of all samples collected, preferably using GPS, or if this is not available, map references including longitude and latitude and road names should be recorded. Property and owners names should also be included where possible.

**How to collect plant samples**

Samples should be treated in a manner that allows them to arrive at the laboratory in a fresh, well-preserved state. An esky with ice packs or portable fridge should be carried when sampling crops.

The samples should be kept cool, out of direct sunlight and clearly labelled. Aim to keep the tissue at less than 10°C. For appropriate labelling and packaging procedures for suspect emergency plant pests consult PLANTPLAN (Plant Health Australia 2010).

Sampling and collection of plant material will depend on the host and virus. Technical advice on sampling will be required for each virus if an incursion is suspected.

In general, infected plant material should be collected using scissors, with sterilisation to occur between each collection.

**How to preserve plant samples**

Collected material can be stored at 2-5°C. Do not expose plant samples to direct sunlight. It is important to keep the sampled plant tissue below 10°C where possible.

**How to transport plant samples**

Plant material should be mailed as a flat package. The samples should be either sent by a courier or by Express Post if overnight delivery to the diagnostic laboratory is guaranteed. Each laboratory has different labelling protocols and the receiving laboratory must be contacted before sending samples to ensure that these protocols are followed and that someone will be present to receive the samples. Email is not sufficient as a sole method of contact.

**7.2.6 Epidemiological study**

The extent of infestation in a production nursery, on a property or within a region will depend on the initial degree of virus infection (or infestation of viruliferous thrips vectors) and whether conditions have been favourable for the pest to spread from the initial location. Sampling should be based upon the origins of the initial suspect sample(s). Factors to consider will be:

- The proximity of other susceptible plants to the initial infestation source, including both current and previous crops. This will include crops in the production nursery or on the property with the initial detection and those on neighbouring properties
- Machinery or vehicles that have been into the infested area or in close proximity to the infestation source

- The extent of human movements into and around the infested area. A possible link to the recent importation of plant material from other regions should also be considered
- The source of any production nursery stock propagation material
- If any other crops have been propagated from the same source and/or distributed from the affected production nurseries
- Many vector- transmitted viruses can easily be spread by mechanical transmission in sap on contaminated machinery and equipment and also potentially be contact between plants

### 7.2.7 Models of spread potential

No models of spread potential have been developed for thrips transmitted viruses.

### 7.2.8 Pest Free Area guidelines

Determination of Pest Free Areas (PFAs) should be completed in accordance with the International Standards for Phytosanitary Measures (ISPMs) 8 and 10 (IPPC 1998a, 1999).

In the event of an incursion, specific guidelines for surveys and monitoring will be provided by the Consultative Committee on Emergency Plant Pests (CCEPP). General points to consider are:

- Design of a statistical delimiting survey for symptoms on host plants (see Section 10.2 for points to consider in the design)
- Plant sampling should be completed as described in the BioSecure HACCP manual (Nursery and Garden Industry Australia 2008), including monitoring processes (summarised in Table 11 and Table 12), indicator plants and weed monitoring
- Surveys should also consider alternative hosts and not be limited to the primary infected host.
- Information (including absence of the pest) should be recorded

**Table 11.** Summary of monitoring processes for protected production areas as described in BioSecure HACCP Guidelines. Further specific guidelines may be provided by a CCEPP

|                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wear protective clothing when handling suspect samples                                                                                                                            |
| Walk at random through the area in a zigzag pattern                                                                                                                               |
| Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m <sup>2</sup> of production area                                                                          |
| Inspect the tops and bottoms or leaves, looking for any direct evidence of insects                                                                                                |
| Inspect the entire plant if it has less than six leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually |
| Inspect the length of all stems and branches for insects and symptoms                                                                                                             |
| During individual plant inspection, examine the underside of the foliage for the presence of thrips                                                                               |
| If any plants show suspect symptoms or evidence of eggs or larvae (refer to Section 5.2.3) take a sample (refer to Section 7.2) to be formally diagnosed                          |
| Check for a problem that have occurred regularly in the past, until you are certain it is not present                                                                             |
| Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest                                                                                                  |
| Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed                    |

Additional information is provided by the IPPC (1995) in Requirements for the Establishment of Pest Free Areas. This standard describes the requirements for the establishment and use of pest free areas as a risk management option for phytosanitary certification of plants and plant products. Establishment and maintenance of a PFA can vary according to the biology of the pest, pest survival potential, means of dispersal, availability of host plants, restrictions on movement of produce, as well as PFA characteristics (size, degree of isolation and ecological conditions).



**Table 12.** Summary of monitoring processes for field production areas as described in BioSecure HACCP Guidelines. Further specific guidelines may be provided by a CCEPP

|                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wear protective clothing when handling suspect samples                                                                                                                            |
| Pay particular attention to areas on the windward side, the sides bordering ditches, canals or other uncultivated areas and growing block centres                                 |
| Place a flag or other marker at the entrance to the block or sampling area at the beginning of each inspection                                                                    |
| Vary the entrance point in the sampling area (1 m to 3 m) for each subsequent sampling so that the same plants are not inspected each time                                        |
| Walk at random through the area in a zigzag pattern                                                                                                                               |
| The scout should follow the same general pattern at each sampling                                                                                                                 |
| Make an effort to select those plants that appear less healthy for visual inspection                                                                                              |
| Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m <sup>2</sup> of production area                                                                          |
| Inspect the tops and bottoms or leaves, looking for any direct evidence of insects                                                                                                |
| Inspect the entire plant if it has less than six leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually |
| Inspect the length of all stems and branches for insects and symptoms                                                                                                             |
| During individual plant inspection, strike the foliage over a white sheet of paper, or a plastic or paper plate to dislodge small insects for easier viewing                      |
| If any plants show suspect symptoms or evidence of eggs or larvae take a sample (refer to Section 7.2) to be formally diagnosed                                                   |
| Check for a problem that have occurred regularly in the past, until you are certain it is not present                                                                             |
| Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest                                                                                                  |
| Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed                    |

## 7.3 Availability of control methods

### 7.3.1 General procedures for control

Control of thrips transmitted viruses is likely to be largely reliant on control measures for the thrips vectors however measures can also be taken to minimise the spread of virus-infected nursery stock. Specific control measures will be determined by a CCEPP however general procedures include:

- Keep traffic out of affected areas and minimise movement in adjacent areas
- Adopt best-practice property hygiene procedures to retard the spread of the pest between fields and adjacent properties
- After surveys are completed, and permission has been obtained from the Chief Plant Health Manager or OCPPO, destruction of the infested plant material is an effective control
- On-going surveillance of infected areas to ensure the virus is eradicated
- Do not use any material from infected plants for propagation

For general management (i.e. not eradication), controlling thrips populations before they reach large numbers in crops is very important and requires close monitoring of thrips populations early in the

season. If the adults occur in large numbers it becomes difficult to control the nymphal stages. Adults move between successive crops, so management approaches must be employed in all crops within the area.

To reduce early season populations, best management practices require consideration of several management approaches including the use of pest-free seedlings, weed management, chemical control and cleaning up of crop residue.

It should be recognised that it will be extremely difficult for effective eradication of thrips populations and this will in turn limit the ability to eliminate all transmission of a thrips transmitted virus.

### 7.3.2 Pest free (clean) seedlings

Seedlings are potentially a major means of spreading thrips and thrips transmitted viruses into new plantings. Young plants are more susceptible to damage from thrips, so early infestations need to be avoided. Clean seedlings can be the first line of protection against the development of damaging populations.

Growers should check their suppliers to determine how the seedlings are grown and what measures are being used to protect against thrips infestation. Inspect transplants carefully upon arrival for thrips eggs, nymphs and adults.

### 7.3.3 Weed management

The availability of a continuous source of hosts, whether they are crops, weeds or abandoned crops, can be a major contributing factor to a severe thrips problem. Even a small area of a favoured host can maintain a significant thrips population.

Minimising thrips hosts is important in reducing the base population at the start of the cropping season. A smaller base population then will delay the time it takes for thrips numbers to reach significant levels, reducing the number of sprays needed to control thrips populations.

Common weed species that carry high numbers of thrips include amaranth, cape weed, pigweed, mallows, blue heliotrope, fat hen, purple top, shepherd's purse, nightshades, scotch thistle and sow thistle. Control these weed species in farming areas and seedling nurseries to minimise a build-up in thrips populations.

### 7.3.4 Chemical control

Chemical control of viruses is not an option, but chemicals may be effective in trying to eliminate thrips vectors in an eradication campaign, or in the management of the thrips vectors should eradication be deemed unfeasible. In the event of an incursion of an exotic thrips transmitted virus, several chemicals are currently registered for the control of thrips in Australia. As the major vectors of thrips transmitted viruses (*F. occidentalis*, *F. schultzei*, *T. tabaci*, *T. palmi*) are present in Australia, chemicals are available for their control.

For long term management, the use of chemical recommendations currently available for the control of thrips in production systems is recommended until further research is undertaken. For example, the use of seedling drenches to prevent infection in nursery seedlings prior to transplanting has shown promise for minimising the impact and spread of TSWV by the thrips vectors (Persley *et al.* 2006).

Insecticide applications that target Western flower thrips can reduce populations and reduce the within-crop transmission of tospoviruses e.g. TSWV (NSW DPI 2007). As Western flower thrips is effective at developing resistance to chemicals used for their control, it is important to strictly adhere to the recommended resistance strategy (Herron *et al.* 2007). Often the first sign that Western flower thrips are present in a crop is the failure of the insecticide to control other thrips species.

In the event of an incursion of a thrips transmitted virus, several chemicals as listed on Infopest, are currently registered for the control of thrips in Australia (Table 13).

All insecticides listed above are registered for use in Australia against other insect pests by the Australian Pesticides & Veterinary Medicines Authority (APVMA, PO Box E240, Kingston, ACT 2604; ph. 02 6272 5158; [www.apvma.gov.au](http://www.apvma.gov.au)). If thrips transmitted viruses were detected in Australia, an additional permit may be required to enable the use of these chemicals for its management and/or destruction. Additional permits would be required from the Civil Aviation Safety Authority (CASA, phone 131 757, [www.casa.gov.au](http://www.casa.gov.au)) if it was intended the pesticide be aerially applied.

### 7.3.5 Integrated pest management (IPM)

IPM is a strategy that uses a range of management tools with a goal of using the least ecologically disruptive techniques to manage pests to within economically acceptable levels.

If eradication is not feasible, IPM appears to offer the best option for controlling thrips infestations without causing contamination of the environment in the long term. Beneficial insects are used alongside chemicals that offer a high level of selectivity, such as insect growth regulators. If crops or cultivars of a crop that offer resistance to the virus become available, these should also be incorporated into an IPM system.

If Western flower thrips numbers are high enough to be causing physical damage at vulnerable stages or a virus is present, then insecticide sprays may be needed. Always use recommended rates, adhere to the resistance management strategy and apply sprays to maximise spray coverage.

**Table 13.** Registered chemicals and chemical use permits for the control of thrips in crops (from Infopest 2011)

| Chemical group | Active ingredient                         | APVMA Permit | Use                                                        |
|----------------|-------------------------------------------|--------------|------------------------------------------------------------|
|                | abamectin 18 g L <sup>-1</sup>            | 10491        | Melon thrips in ornamentals                                |
|                | acephate 750-970 g kg <sup>-1</sup>       | 12378        | Western flower thrips in ornamentals, tomatoes and peppers |
|                | aldicarb 150 g kg <sup>-1</sup>           | 11105        | Garlic seed production crops                               |
|                | alpha-cypermethrin 100 g L <sup>-1</sup>  | 9355         | Thrips in silverbeet and spinach                           |
|                | chlorfenapyr 360 g L <sup>-1</sup>        | 11508        | Western flower thrips in spring onions and shallots        |
|                | chlorpyrifos 500 g kg <sup>-1</sup>       | 10700        | Bananas                                                    |
|                | diazinon 800 g L <sup>-1</sup>            | 11119        | Onion thrips in onions                                     |
|                |                                           | 10882        | Thrips in spring onions and shallots                       |
|                | Imidacloprid 200 g L <sup>-1</sup>        | 10497        | Thrips in Brassica leafy vegetables                        |
|                | lambda-cypermethrin 250 g L <sup>-1</sup> | 10714        | Onion thrips in bulb onions                                |
|                | maldison 500 g L <sup>-1</sup>            | 8762         | Onion thrips in spring onions, shallots and leek           |
|                | methamidophos 580 g L <sup>-1</sup>       | 10416        | Western flower thrips in lettuce                           |
|                | methidathion 400 g L <sup>-1</sup>        | 10265        | Thrips in ornamentals, peppers, tomatoes and eggplant      |
|                | methomyl 225 g L <sup>-1</sup>            | 6914         | Western flower thrips in shallots and spring onions        |
|                | Methyl bromide                            | 12389        | Post-harvest fumigation                                    |
|                |                                           | 11092        | Post-harvest fumigation                                    |
|                |                                           | 10699        | Post-harvest fumigation                                    |
|                |                                           | 10695        | Post-harvest fumigation                                    |
|                |                                           | 10145        | Fruit and fruiting vegetables                              |
|                | phorate 100 g kg <sup>-1</sup>            | 9895         | Thrips in leeks                                            |
|                | spinosad                                  | 10596        | Western flower thrips in spring onion and shallots         |

| Chemical group | Active ingredient                     | APVMA Permit | Use                          |
|----------------|---------------------------------------|--------------|------------------------------|
|                |                                       | 5815         | Melon thrips in eggplant     |
|                | spirotetramat 240 g L <sup>-1</sup>   | 11839        | Sorghum and maize seed crops |
|                | tau-fluvalinate 240 g L <sup>-1</sup> | 11821        | Stone fruit                  |

### 7.3.6 Clean-up crop residues

For control of thrips, movement of adults from older crops and crop residues is the main source of local infestation for younger crops. Post-harvest destruction of heavily infested crops often causes mass migration of thrips into adjacent crops. Therefore it is important to control thrips before they move into young crops.

Clean-up strategies for thrips infested crops/crop residues:

- For moderate thrips infestations, use an insecticide effective against adults
- Use high spray volumes for better coverage as defined on the label
- Re-entry/withholding periods still apply. Entry into crops should be avoided and produce should not be taken from the fields for consumption. Crop residues should not be fed to livestock
- Residues should be deep-buried or contained (sealed plastic bags) and disposed of via incineration

Clean-up of virus-infected plant material could include:

- Spraying of host material (including newly emerging plants) with herbicide to kill the plants *in situ*, followed by disposal of plant material by deep burial
- Break down of larger volumes of plant material under black plastic prior to deep burial (methodology to be confirmed by a CCEPP)
- Burning of plant material providing
  - Material is sufficiently dry to burn
  - Thrips populations have been controlled/eliminated to ensure they are not distributed in rising thermals or surrounding areas by burning
- Decontamination of all items in contact with decomposing plant material with a 1% a.i. sodium hypochlorite solution or by deep burial
- Keeping infested area free of hosts for a minimum of 12 months (or a period to be determined by a CCEPP)

### 7.3.7 Cultural Control

In an eradication campaign, preventing the movement of infected plant material and viruliferous thrips vectors is crucial. Destruction of all host crops (including weeds) in the control zone may be required. For PFBV, where the virus is predominantly spread through vegetative propagation, destruction of all Pelargonium propagation material in the control zone may be required because many plants will be symptomless.

If the exotic virus cannot be eradicated, then management should focus on the use of virus-free planting material and the use of screens (mesh size < 135 µm) to prevent entry of thrips into glasshouses and placing new plants in separate glasshouse compartments.

Crops are most susceptible to tospoviruses as seedlings; hence, raising seedlings away from production areas and preferably in thrips-proof netting (Jones 2005) will be beneficial. Controlling weed hosts of thrips vectors can also aid in preventing a large build-up of vectors. In the case of

PFBV, hygiene practices such as the use of sterilised/clean equipment and maintaining clean irrigation water will be essential for minimising the impact of the virus.

### 7.3.8 Host-Plant Resistance

In the case of tospoviruses, host plant resistance may provide some benefits but is unlikely to be the sole method of control. Experience with TSWV suggests that while some breeding programs around the world are actively pursuing resistant cultivars of some crops, there is a limited amount of resistant germplasm among many major hosts and the resistant genes are not particularly durable (summarised in Persley *et al.* 2006).

However, transgenic approaches to breeding resistance may prove useful: Yeh *et al.* (2005) recently showed broad spectrum resistance to tospoviruses in transgenic tobacco carrying the conserved region of the L protein of WSMoV. Similarly, expression of the PFBV coat protein in geranium confers some resistance to the carmovirus PFBV (Berthomé *et al.* 2000).

### 7.3.9 Biological control

Natural enemies have been investigated and biological control programs using predatory mites and other beneficial insects have been developed. They have been shown to be effective if environmental thrips pressure is not too great.

The predators *Typhlodromips montdorensis* and *Neoseiulus cucumeris* have controlled thrips in protected environments and are effective when applied early in the growing season at the first sign of thrips

([http://www.sardi.sa.gov.au/pestsdiseases/horticulture/horticultural\\_pests/integrated\\_pest\\_management/resources/greenhouse\\_pests/western\\_flower\\_thrips](http://www.sardi.sa.gov.au/pestsdiseases/horticulture/horticultural_pests/integrated_pest_management/resources/greenhouse_pests/western_flower_thrips)).

Entomopathogenic (insect infecting) fungi have also been shown to be effective against thrips and some other sap sucking insects.

### 7.3.10 Managing viruses

The two key points in managing the spread of thrips transmitted viruses are to:

- Prevent the movement of infected host plants, seedlings and thrips-infected plants
- Control thrips on-farm, in surrounding vegetation and in seedling nurseries using good farm management and farm hygiene practices
- For viruses that are spread mechanically, minimise handling during the growing season to reduce the mechanical spread (eg, TEV (AVRDC 2005))
- Use virus free nursery stock

## 7.4 Phytosanitary Measures

A number of thrips transmitted viruses have been added to the EPPO A1 or A2 quarantine lists (EPPO 2010 a and b), including INSV and CSNV.

## 8 Course of action

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Additional information is provided by the IPPC (1998b) in Guidelines for Pest Eradication Programmes. This standard describes the components of a pest eradication programme which can lead to the establishment or re-establishment of pest absence in an area. A pest eradication programme may be developed as an emergency measure to prevent establishment and/or spread of a pest following its recent entry (re-establish a pest free area) or a measure to eliminate an established pest (establish a pest free area). The eradication process involves three main activities: surveillance, containment, and treatment and/or control measures.

### 8.1 Destruction strategy

#### 8.1.1 Destruction protocols

- General protocols:
  - No plant material should be removed from the infested area unless part of the disposal procedure
  - Disposable equipment, infested plant material or growing media/soil should be disposed of by autoclaving, high temperature incineration or deep burial
  - Any equipment removed from the site for disposal should be double-bagged
  - Machinery used in destruction processes need to be thoroughly washed, preferably using a detergent or farm degreaser

#### 8.1.2 Decontamination protocols

Machinery, equipment and vehicles in contact with infested plant material or growing media/soil, or present within the Quarantine Area, should be washed to remove plant material and growing media/soil using high pressure water or scrubbing with products such as a degreaser or a bleach solution (1% available chlorine) in a designated wash down area. When using high pressure water, care should be taken not to spread plant material. High pressure water should be used in wash down areas which meet the following guidelines:

- Located away from crops or sensitive vegetation
- Readily accessible with clear signage
- Access to fresh water and power
- Mud free, including entry and exit points (e.g. gravel, concrete or rubber matting)
- Gently sloped to drain effluent away
- Effluent must not enter water courses or water bodies
- Allow adequate space to move larger vehicles
- Away from hazards such as power lines
- Waste water, growing media/soil or plant residues should be contained (see Appendix 18 of PLANTPLAN [Plant Health Australia 2010])



- Disposable overalls and rubber boots should be worn when handling infested plant material or growing media/soil in the field. Boots, clothes and shoes in contact with infested plant material or growing media/soil should be disinfected at the site or double-bagged to remove for cleaning
- Skin and hair in contact with infested plant material or growing media/soil should be washed

Procedures for the sterilisation of plant containers and growing media are provided within the BioSecure HACCP Guidelines, however, in the event of a thrips transmitted virus incursion, additional or modified procedures may be required for the destruction of the pest. Any sterilisation procedure must be approved for use in the endorsed Response Plan.

### 8.1.3 Priorities

- Confirm the presence of the pest
- Limit movement of people and prevent movement of vehicles and equipment through affected areas
- Stop the movement of any plant material that may be infested with the pest
- Determine the strategy for the eradication/decontamination of the pest and infested host material
- Determine the extent of infestation through survey and plant material trace back and trace forward which would be assessed on a case by case basis and included within the response plan

### 8.1.4 Plants, by-products and waste processing

- Any growing media/soil or infected plant material removed from the infected site should be destroyed by (enclosed) high temperature incineration, autoclaving or deep burial
- As some thrips transmitted viruses are easily spread and can be mechanically transmitted in sap, plant debris from the destruction zone must be carefully handled and transported
- Infected areas (and areas infested with the vectors) or production nursery property should remain free of susceptible host plants until the area has been shown to be free from the virus

### 8.1.5 Disposal issues

- Particular care must be taken to minimise the transfer of infected plant material from the area
- Host material including leaf litter should be collected and incinerated or double bagged and deep buried in an approved site

## 8.2 Containment strategies

For some exotic pest incursions where eradication is considered impractical, containment of the pest may be attempted to prevent or slow its spread and to limit its impact on other parts of the state or country. Containment is currently being considered for inclusion within the Emergency Plant Pest

Response Deed (EPPRD). The decision on whether to eradicate or contain the pest will be made by the National Management Group, based on scientific and economic advice. Emergency interim containment measures are possible under EPPRD arrangements to gather information to determine if eradication is technically feasible.

## 8.3 Quarantine and movement controls

Consult PLANTPLAN (Plant Health Australia 2010) for administrative details and procedures.

### 8.3.1 Quarantine priorities

- Plant material and growing media/soil at the site of infestation to be subject to movement restrictions
- Machinery, equipment, vehicles and disposable equipment in contact with infested plant material or growing media/soil, or present in close proximity to the site of infestation to be subject to movement restrictions

### 8.3.2 Movement controls

Movement controls need to be put in place to minimise the potential for transport of the pest, and this will apply to all plant material, growing media and other items within the quarantined area.

Movement of people, vehicles, equipment and plant material, from and to affected properties or areas, must be controlled to ensure that the pest is not moved off-property. Movement controls can be achieved through the following; however specific measures must be endorsed in the Response Plan:

- Signage to indicate quarantine area and restricted movement into and within these zones
- Fenced, barricaded or locked entry to quarantine areas
- Movement of equipment, machinery, plant material or growing media/soil by permit only. Therefore, all non-essential operations in the area or on the property should cease
- Where no dwellings are located within these areas, strong movement controls should be enforced
- Where dwellings and places of business are included within the Restricted and Control Areas movement restrictions are more difficult to enforce, however limitation of contact with infested plants should be enforced
- If a production nursery is situated within the Restricted Area, all trading in host and non-host material must cease and no material should be removed from the site without permission, due to the high likelihood of pest spread. Movement restrictions would be imposed on both host and non-host material
- Residents should be advised on measures to minimise the inadvertent transport of thrips vectors from the infected area to unaffected areas
- Clothing and footwear worn at the infested site should either be double-bagged prior to removal for decontamination or should not leave the site until thoroughly disinfected, washed and cleaned

- Plant material or plant products must not be removed from the site unless part of an approved disposal procedure
- All machinery and equipment should be thoroughly cleaned down with a high pressure cleaner (see Section 8.1.2) or scrubbing with products such as a farm degreaser or a 1% bleach (available chlorine) solution, prior to leaving the affected area. Machinery should be inspected for the presence of insects and if found, treatment with insecticide may be required. The clean down procedure should be carried out on a hard surface, preferably a designated wash-down area, to avoid mud being re-collected from the affected site onto the machine. When using high pressure water, care should be taken to contain all plant material and mud dislodged during the cleaning process

## 8.4 Zoning

The size of each quarantine area will be determined by a number of factors, including the location of the incursion, biology of the pest, climatic conditions and the proximity of the infested property to other infested properties. This will be determined by the National Management Group during the production of the Response Plan. Further information on quarantine zones in an Emergency Plant Pest (EPP) incursion can be found in Appendix 10 of PLANTPLAN (Plant Health Australia, 2010). These zones are outlined below and in Figure 8.

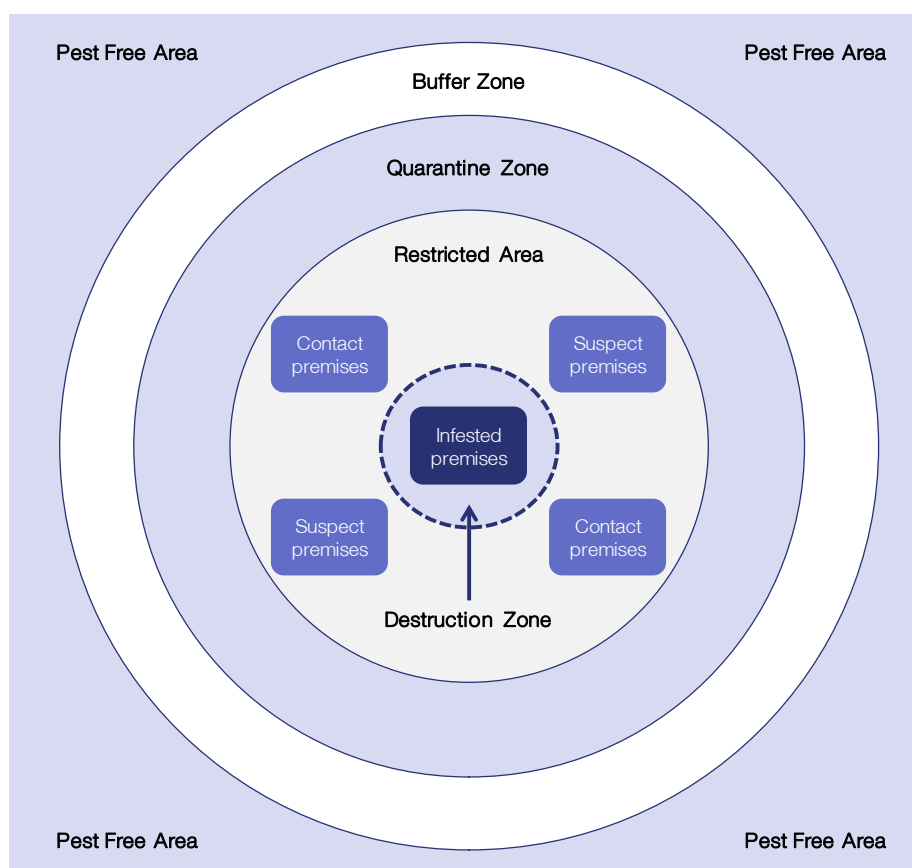


**Figure 8.** Schematic diagram of quarantine zones used during an EPP incursion (not drawn to scale)

### 8.4.1 Destruction Zone

The size of the destruction zone (i.e. zone in which the pest and all host material is destroyed) will depend on the ability of the pest to spread, distribution of the pest (as determined by delimiting surveys), time of season (and part of the pest life cycle being targeted) and factors which may contribute to the pest spreading.

All host plants should be destroyed after the level of infestation has been established. The delimiting survey will determine whether or not neighbouring plants are infested and need to be destroyed. Non-host plant material within this zone may be destroyed, based on recommendations in the Response Plan. The Destruction Zone may be defined as contiguous areas associated with the same management practices as, or in contact with, the infested area (i.e. the entire production nursery, property or area if spread could have occurred prior to the infection being identified).

Particular care needs to be taken to ensure that plant material (including non-hosts) is not moved into surrounding areas.

### 8.4.2 Quarantine Zone

The Quarantine Zone is defined as the area where voluntary or compulsory restraints are in place for the affected property or properties. These restraints may include restrictions or movement control for removal of plants, people, growing media/soil or contaminated equipment from an infected property.

### 8.4.3 Buffer Zone

A Buffer Zone may or may not be required depending on the incident. It is defined as the area in which the pest does not occur but where movement controls or restrictions for removal of plants, people, soil or equipment from this area are still deemed necessary. The Buffer Zone may enclose an infested area (and is therefore part of the Control Area) or may be adjacent to an infested area.

### 8.4.4 Restricted Area

The Restricted Area is defined as the zone immediately around the infected premises and suspected infected premises. The Restricted Area is established following initial surveys that confirm the presence of the pest. The Restricted Area will be subject to intense surveillance and movement control with movement out of the Restricted Area to be prohibited and movement into the Restricted Area to occur by permit only. Multiple Restricted Areas may be required within a Control Area.

### 8.4.5 Control Area

The Control Area is defined as all areas affected within the incursion. The Control Area comprises the Restricted Area, all infected premises and all suspected infected premises and will be defined as the minimum area necessary to prevent spread of the pest from the Quarantine Zone. The Control Area will also be used to regulate movement of all susceptible plant species to allow trace back, trace forward and epidemiological studies to be completed.

## 8.5 Decontamination and farm clean up

Decontaminant practices are aimed at eliminating the pathogen thus preventing its spread to other areas.

### 8.5.1 Decontamination procedures

General guidelines for decontamination and clean up:

- Refer to PLANTPLAN (Plant Health Australia 2010) for further information
- Keep traffic out of affected area and minimise it in adjacent areas
- Adopt best-practice property hygiene procedures to retard the spread of the pest between growing areas/fields and adjacent properties
- Machinery, equipment, vehicles in contact with infested plant material or growing media/soil present within the Quarantine Zone, should be washed to remove growing media/soil and plant material using high pressure water or scrubbing with products such as a degreaser or a bleach solution in a designated wash down area as described in Section 8.1.2
- Only recommended materials are to be used when conducting decontamination procedures, and should be applied according to the product label
- Infected or vector-infested plant material should be disposed of by autoclaving, high temperature (enclosed) incineration or deep burial

### 8.5.2 General safety precautions

For any chemicals used in the decontamination, follow all safety procedures listed within each MSDS.

## 8.6 Surveillance and tracing

### 8.6.1 Surveillance

Detection and delimiting surveys are required to delimit the extent of the outbreak, ensuring areas free of the pest retain market access and appropriate quarantine zones are established.

Initial surveillance priorities include the following:

- Surveying all host growing properties and businesses in the pest quarantine area
- Surveying all properties and businesses identified in trace-forward or trace-back analysis as being at risk
- Surveying all host growing properties and businesses that are reliant on trade with interstate or international markets which may be sensitive to pathogen presence
- Surveying production nurseries selling at risk host plants
- Surveying other host growing properties and backyards

## 8.6.2 Survey regions

Establish survey regions around the surveillance priorities identified above. These regions will be generated based on the zoning requirements (see Section 8.4), and prioritised based on their potential likelihood to currently have or receive an incursion of this pest. Surveillance activities within these regions will either allow for the area to be declared pest free and maintain market access requirements or establish the impact and spread of the incursion to allow for effective control and containment measures to be carried out. Detailed information regarding surveys for thrips transmitted viruses have been outlined elsewhere in this plan (refer to Section 7.2).

Steps outlined in Table 14 form a basis for a survey plan. Although categorised in stages, some stages may be undertaken concurrently based on available skill sets, resources and priorities.

**Table 14.** *Phases to be covered in a survey plan*

|                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Phase 1</b> | Identify properties that fall within the buffer zone around the infested premise<br>Complete preliminary surveillance to determine ownership, property details, production dynamics and tracings information (this may be an ongoing action)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Phase 2</b> | Preliminary survey of host crops in properties in buffer zone establishing points of pest detection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Phase 3</b> | Surveillance of an intensive nature, to support control and containment activities around points of pest detection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Phase 4</b> | Surveillance of contact premises. A contact premise is a property containing susceptible host plants, which are known to have been in direct or indirect contact with an infested premises or infected plants. Contact premises may be determined through tracking movement of materials from the property that may provide a viable pathway for spread of the disease. Pathways to be considered are: <ul style="list-style-type: none"> <li>• Movement of plant material and growing media/soil from controlled and restricted areas</li> <li>• Items of equipment and machinery which have been shared between properties including bins, containers, irrigation lines, vehicles and equipment</li> <li>• The producer and retailer of infected material if this is suspected to be the source of the outbreak</li> <li>• Labour and other personnel that have moved from infected, contact and suspect premises to unaffected properties (other growers, tradesmen, visitors, salesmen, crop scouts, harvesters and possibly beekeepers)</li> <li>• Storm and rain events and the direction of prevailing winds that result in air-borne dispersal of the pathogen during these weather events</li> </ul> |
| <b>Phase 5</b> | Surveillance of production and greenlife retailers, including garden centres, hardware outlets and supermarkets, as well as gardens and public land where plants known to be hosts of pathogen are being grown                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Phase 6</b> | Agreed area freedom maintenance, post control and containment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

## 8.6.3 Post-eradication surveillance

The period of pest freedom sufficient to indicate that eradication of the pest has been achieved will be determined by a number of factors, including growth conditions, the previous level of infection, the control measures applied and the pest biology.

Specific methods to confirm eradication of thrips transmitted viruses may include:

- Monitoring of sentinel plants. In the case of CSNV, it may be necessary to use *Datura stramonium* as an indicator plant to differentiate symptoms of CSNV from other viruses (such

as TSWV, which is widespread in Australia), because only CSNV causes stem necrosis after mechanical inoculation (Verhoeven *et al.* 1996).

- Sentinel plants are to be grown in containers or small plots at the affected site. Plants are to be grown *in situ* under quarantine conditions and monitored for symptoms of infection
- If symptoms are detected, samples are to be collected and stored and plants destroyed
- Surveys comprising host plant sampling for the virus should be undertaken for a minimum of three years after eradication has been achieved (or as endorsed by a CCEPP)
- Alternate non-host crops should be grown on the site and any self-sown plants sprayed out with a selective herbicide

## 9 Technical debrief and analysis for stand down

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Refer to PLANTPLAN (Plant Health Australia 2010) for further details

The emergency response is considered to be ended when either:

- Eradication has been deemed successful by the lead agency, with agreement by the Consultative Committee on Emergency Plant Pests and the Domestic Quarantine and Market Access Working Group
- Eradication has been deemed impractical and procedures for long-term management of the disease risk have been implemented

A final report should be completed by the lead agency and the handling of the incident reviewed.

Eradication will be deemed impractical if, at any stage, the results of the delimiting surveys lead to a decision to move to containment/control.

## 10 References

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EPPO website

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# 11 Appendices

## 11.1 Appendix 1: Standard diagnostic protocols

For a range of specifically designed procedures for the emergency response to a pest incursion refer to Plant Health Australia's PLANTPLAN ([www.planthealthaustralia.com.au/plantplan](http://www.planthealthaustralia.com.au/plantplan)).

## 11.2 Appendix 2: Resources and facilities

Table 15 provides a list of diagnostic facilities for use in professional diagnosis and advisory services in the case of an incursion.

**Table 15.** Diagnostic service facilities in Australia

| Facility                                                                          | State | Details                                                                                                    |
|-----------------------------------------------------------------------------------|-------|------------------------------------------------------------------------------------------------------------|
| DPI Victoria – Knoxfield Centre                                                   | Vic   | 621 Burwood Highway<br>Knoxfield VIC 3684<br>Ph: (03) 9210 9222; Fax: (03) 9800 3521                       |
| DPI Victoria – Horsham Centre                                                     | Vic   | Natimuk Rd<br>Horsham VIC 3400<br>Ph: (03) 5362 2111; Fax: (03) 5362 2187                                  |
| DPI New South Wales – Elizabeth Macarthur Agricultural Institute                  | NSW   | Woodbridge Road<br>Menangle NSW 2568<br>PMB 8 Camden NSW 2570<br>Ph: (02) 4640 6327; Fax: (02) 4640 6428   |
| DPI New South Wales – Tamworth Agricultural Institute                             | NSW   | 4 Marsden Park Road<br>Calala NSW 2340<br>Ph: (02) 6763 1100; Fax: (02) 6763 1222                          |
| DPI New South Wales – Wagga Wagga Agricultural Institute                          | NSW   | PMB Wagga Wagga<br>NSW 2650<br>Ph: (02) 6938 1999; Fax: (02) 6938 1809                                     |
| SARDI Plant Research Centre – Waite Main Building, Waite Research Precinct        | SA    | Hartley Grove<br>Urrbrae SA 5064<br>Ph: (08) 8303 9400; Fax: (08) 8303 9403                                |
| Grow Help Australia                                                               | QLD   | Entomology Building<br>80 Meiers Road<br>Indooroopilly QLD 4068<br>Ph: (07) 3896 9668; Fax: (07) 3896 9446 |
| Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories | WA    | 3 Baron-Hay Court<br>South Perth WA 6151<br>Ph: (08) 9368 3721; Fax: (08) 9474 2658                        |

## 11.3 Appendix 3: Market access impacts

Within the AQIS PHYTO database ([www.aqis.gov.au/phyto](http://www.aqis.gov.au/phyto)) export of some material may require an additional declaration regarding freedom from the virus. Should Thrips transmitted viruses be detected or become established in Australia, some countries may require specific declaration. Latest information can be found within PHYTO, using an Advanced search “Search all text” for the particular virus.

**INDUSTRY BIOSECURITY PLAN  
FOR THE NURSERY & GARDEN INDUSTRY**

## **Threat Specific Contingency Plan**

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### **Tarnished plant bug (*Lygus lineolaris*)**

**Plant Health Australia**

**September 2011**



## Disclaimer

The scientific and technical content of this document is current to the date published and all efforts were made to obtain relevant and published information on the pest. New information will be included as it becomes available, or when the document is reviewed. The material contained in this publication is produced for general information only. It is not intended as professional advice on any particular matter. No person should act or fail to act on the basis of any material contained in this publication without first obtaining specific, independent professional advice. Plant Health Australia and all persons acting for Plant Health Australia in preparing this publication, expressly disclaim all and any liability to any persons in respect of anything done by any such person in reliance, whether in whole or in part, on this publication. The views expressed in this publication are not necessarily those of Plant Health Australia.

## Further information

For further information regarding this contingency plan, contact Plant Health Australia through the details below.



|          |                                                                                      |
|----------|--------------------------------------------------------------------------------------|
| Address: | Suite 1, 1 Phipps Close<br>DEAKIN ACT 2600                                           |
| Phone:   | +61 2 6215 7700                                                                      |
| Fax:     | +61 2 6260 4321                                                                      |
| Email:   | <a href="mailto:biosecurity@phau.com.au">biosecurity@phau.com.au</a>                 |
| Website: | <a href="http://www.planthealthaustralia.com.au">www.planthealthaustralia.com.au</a> |

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## 1 Purpose and background of this contingency plan

---

This contingency plan provides background information on the pest biology and available control measures to assist with preparedness for an incursion into Australia of Tarnished plant bug (*Lygus lineolaris*).

This contingency plan provides guidelines and options for steps to be undertaken and considered when developing a Response Plan for incursion of this 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.

This contingency plan was developed for the Nursery and Garden Industry Australia (NGIA), and therefore is focussed on production nurseries covered by this association. In the event of an incursion, operations that are not covered by the NGIA or another Emergency Plant Pest Response Deed (EPPRD) signatory (e.g. retail nurseries), will not be represented or have a decision making say in any arrangements for emergency response.

The information for this plan has been sourced electronically including information sourced from CABI Crop Compendium ([www.cabicompendium.org](http://www.cabicompendium.org)) and import risk analysis reports from Biosecurity Australia (Biosecurity Australia 2008 & 2009). Modifications and additions to the plan have been completed to make the information relevant to an incursion of Tarnished plant bug for the NGIA.

## 2 Australian nursery industry

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The Australian nursery industry is a significant horticultural sector with a combined supply chain (production to retail/grower) valued at more than \$6 billion dollars annually. The industry employs approximately 45,000 people spread over more than 20,000 small to medium sized businesses including production nurseries and retail outlets. The industry is located predominantly along the Australian east coastline and in major inland regions servicing urban and production horticulture.

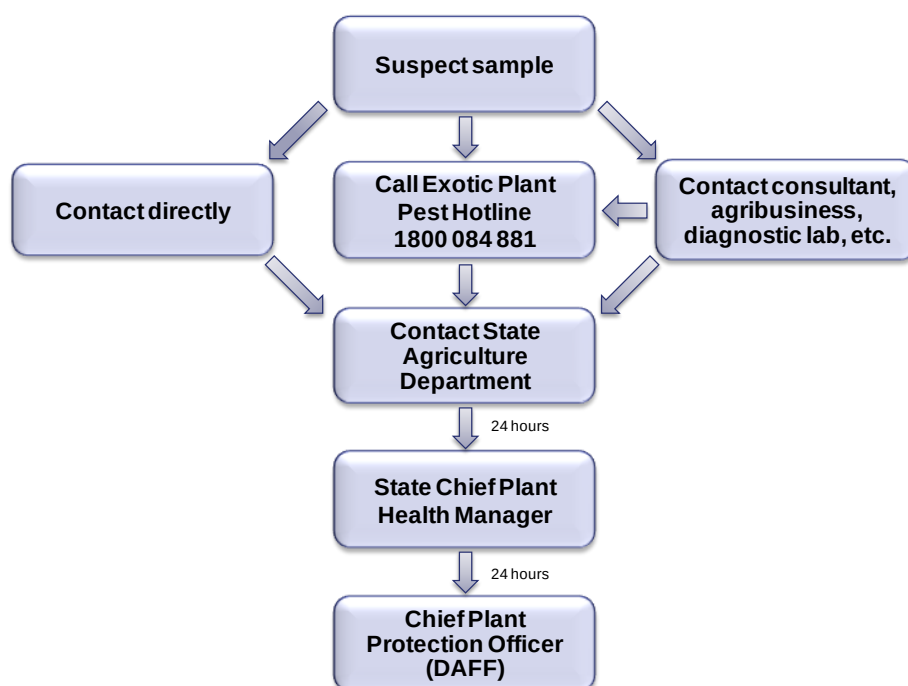
Nursery production is a highly diverse primary industry servicing the broader \$14 billion horticultural sector within Australia (Table 1). A pest incursion is likely to impact market access (see Appendix 3 for more information).

**Table 1.** Nursery production supply sectors within Australian horticulture

| Production Nursery                    | Horticultural markets            | Economic value           |
|---------------------------------------|----------------------------------|--------------------------|
| Container stock <sup>1</sup>          | Ornamental/urban horticulture    | \$2 billion retail value |
| Foliage plants <sup>1</sup>           | Interior-scapes                  | \$87 million industry    |
| Seedling stock <sup>2</sup>           | Vegetable growers                | \$3.3 billion industry   |
| Forestry stock <sup>3</sup>           | Plantation timber                | \$1.7 billion industry   |
| Fruit and nut tree stock <sup>2</sup> | Orchardists (citrus, mango, etc) | \$5.2 billion industry   |
| Landscape stock <sup>1</sup>          | Domestic & commercial projects   | \$2 billion industry     |
| Plug and tube stock <sup>4</sup>      | Cut flower                       | \$319 million industry   |
| Revegetation stock <sup>1</sup>       | Farmers, government, landcare    | \$109 million industry   |
| Mine revegetation                     | Mine site rehabilitation         | Value unknown            |
| Total horticultural market value      |                                  | \$14.5 billion           |

## 2.1 Notification process for the reporting of suspect pests

Early detection and reporting may prevent or minimise the long-term impact of an incursion into Australia of the Tarnished plant bug (*Lygus lineolaris*).

**Figure 1.** Notification process for the reporting of suspect pests

<sup>1</sup> Data sourced from Market Monitor

<sup>2</sup> Data sourced from Horticultural Handbook 2004

<sup>3</sup> Data sourced from ABARE 2005

<sup>4</sup> Data sourced from industry

### 3 Eradication or containment determination

The decision to eradicate should be based on the potential economic impact of host damage resulting from Tarnished plant bug infestation, the cost of eradication and on technical feasibility. Eradication costs must factor in long term surveys to prove the success of the eradication program. A minimum of two years with no detections of the pest may be necessary to confirm that no Tarnished plant bug remain before pest free status can be declared. This timeframe needs to be considered on a case by case basis, based both on the size of the infection, the degree and distribution of the pest and other technical information from the Consultative Committee for Emergency Plant Pests. The final decision on response to a new pest incursion is to be made by the National Management Group.

No specific eradication matrix has been determined for Tarnished plant bug; however the general decision process as outlined in Figure 2 and Table 2 should be followed in determining if an incursion of this pest will be eradicated or managed/contained. The final decision between eradication and management will be made through the National Management Group.

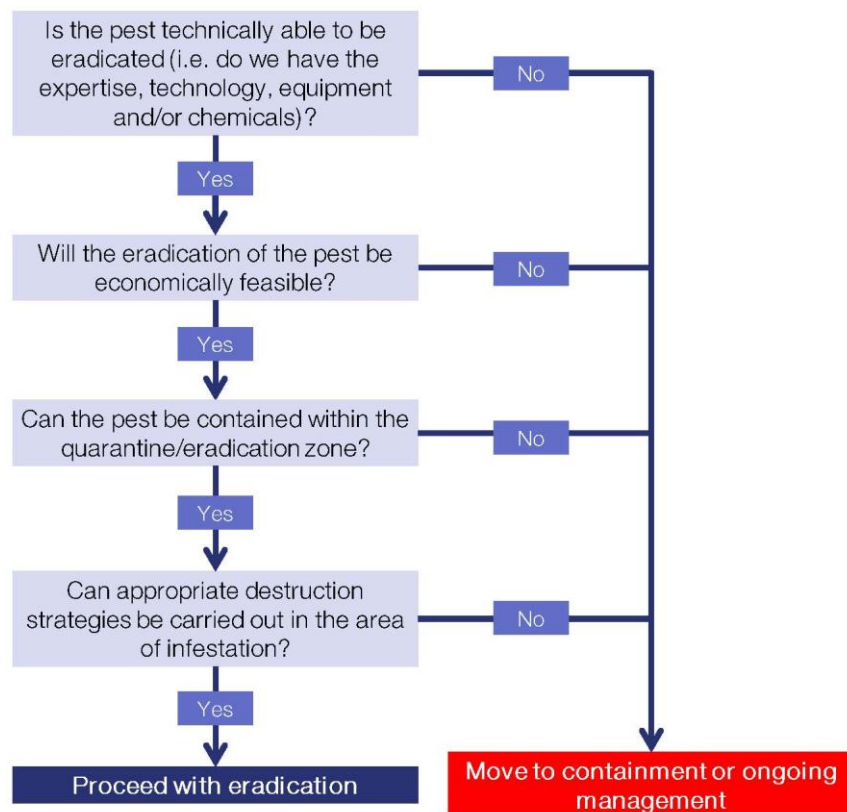


**Figure 2.** Decision outline for the response to an exotic pest incursion

**Table 2.** Factors considered in determining whether eradication or alternative action will be taken for an EPP Incident (taken from Appendix 12 of PLANTPLAN)

| Factors favouring eradication                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Factors favouring alternative action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Cost/benefit analysis shows significant economic or amenity loss to industry or the community if the organism establishes.</li> <li>• Physical barriers and/or discontinuity of hosts between production districts.</li> <li>• Cost effective control for long term management difficult to achieve (e.g. limited availability of protectant or curative treatments).</li> <li>• The generation time, population dynamics and dispersal of the organism favour more restricted spread and distribution.</li> <li>• Pest biocontrol agents not known or recorded in Australia.</li> <li>• Vectors discontinuous and can be effectively controlled.</li> <li>• Outbreak(s) few and confined.</li> <li>• Trace back information indicates few opportunities for secondary spread.</li> <li>• Weather records show unfavourable conditions for pest development.</li> <li>• Ease of access to outbreak site and location of alternate hosts.</li> </ul> | <ul style="list-style-type: none"> <li>• Cost/benefit analysis shows relatively low economic or environmental impact if the organism establishes.</li> <li>• Major areas of continuous production of host plants.</li> <li>• Cost effective control strategies available.</li> <li>• Short generation times, potential for rapid population growth and long distance dispersal lead to rapid establishment and spread.</li> <li>• Widespread populations of known pest biocontrol agents present in Australia.</li> <li>• Vectors unknown, continuous or difficult to control.</li> <li>• Outbreaks numerous and widely dispersed.</li> <li>• Trace back information indicates extensive opportunities for secondary spread.</li> <li>• Weather records show optimum conditions for pest development.</li> <li>• Terrain difficult and/or problems accessing and locating host plants.</li> </ul> |

## 4 Pest information/status

### 4.1 Pest details

|                     |                                                                                                                                                                                                                                              |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Common names:       | Tarnished plant bug                                                                                                                                                                                                                          |
| Scientific name:    | <i>Lygus lineolaris</i> Palisot de Beauvois, 1818                                                                                                                                                                                            |
| Synonyms:           | <i>Capsus flavonotatus</i> Provancher, 1872<br><i>Capsus lineolaris</i> Palisot de Beauvois, 1818<br><i>Capsus oblineatus</i> Say, 1832<br><i>Capsus strigulatus</i> Walker, 1873<br><i>Lygus pratensis</i> var. <i>rubidus</i> Knight, 1941 |
| Taxonomic position: | Kingdom, Animalia; Phylum, Arthropoda; Class, Insecta; Order, Hemiptera; Family, Miridae                                                                                                                                                     |

### 4.1.1 Background

The family Miridae includes a large range of species, most of which feed on plants. This family are referred to as plant bugs and are characterised as generalised plant feeding insects that use needle-like mouth parts to extract plant juices from their hosts during all stages of their life (from nymphs to adults).

The genus *Lygus* is a group of insects containing over 40 plant bug species. Three economically significant species in this genus are *Lygus hesperus*, *Lygus elisus* and *Lygus lineolaris* are not present in Australia (CABI 2011) and are considered quarantine pests of national concern. These species are all very similar in morphology (biology and taxonomy) and are highly polyphagous.

The Tarnished plant bug (*Lygus lineolaris*) is a true bug (order Hemiptera) with the crossed wings and piercing-sucking mouthparts characteristic of this order of insects. The piercing-sucking mouthparts are inserted into the plant tissues, concurrently introducing toxic saliva into the plant and feeding. This pest causes various types of injury, including deformed leaves (as in beets and chard) and scarred, discolored stems or leaf petioles. In a number of fruits, the buds of the developing fruit are dwarfed and pitted. The tops of dill plants are often killed and blackened above the feeding wound.

It is a highly polyphagous species which attacks more than 130 economically important plant species from nursery stock and broadacre and horticultural crops. *L. lineolaris* can be found throughout the USA, Canada and Mexico on a range of crops and ornamentals (Young 1986). This pest has caused significant yield losses in cotton, canola, mustard, seed lucerne, vegetable crops, fruit crops and also nursery stock and is the main pest of these crops in the eastern and southern USA (Schwartz and Footitt 1992). It has also been found to be a problem on many glasshouse species used as cut flowers including *Aster*, chrysanthemums, *Dahlia*, *Impatiens* and *Tagetes*.

More than 50% of cultivated plant pests grown in the United States are listed as host plants for Tarnished plant bugs (Capinera 2001). In its natural habitat in the United States, populations are greatest in flowering meadows and weedy patches. Tarnished plant bug populations will increase when flowers are abundant then decline when plants senesce. Some of the common flowers attacked by Tarnish plant bug are curly dock, cutleaf evening primrose, wild carrot, vetch and clover (Penn State University).

In the United States and Canada the Tarnished plant bug has also become a pest in conifer nurseries affecting plantings of pine (*Pinus* spp.), larch (*Larix* spp.) and Douglas fir (*Pseudotsuga* spp.) (Dixon 1989) where the main damage is caused by feeding on the newly emerged seedlings. Distortion of the terminal shoots and a loss of apical dominance may lead to seedlings forming multiple stems (Bryan 1989). This bug can also be a pest of poplar (*Populus* spp.) nursery stock (Sapio *et al.* 1982; Wilson and Moore 1985). Although it primarily feeds on plants, it has also been shown to feed on the eggs and larvae of Heliothis insects (Cleveland 1987).

The pest feeds on all aerial plant parts preferring leaf and flower buds, flowers, fruit and seeds. Damage is caused by the nymphs and adults piercing plant tissues then sucking out nutrient rich juices. *Lygus lineolaris* does not commonly transmit plant diseases but has been reported to transmit *Erwinia amylovora* to pear fruits (Stahl and Luepschen 1977).

Plant bugs are quick moving and easily disturbed. The adults are very active readily dispersing to new areas by flight in search of suitable hosts, when they attack the buds of fruit trees, seriously injuring the terminal shoots and fruits. They do not appear to lay their eggs on these plants to any great extent, but rather migrate to various herbaceous weeds, vegetables and flowers, where the eggs are either inserted full length into the stems, petioles or midribs of leaves or into buds, or are tucked in among the florets of the flower heads. Adults are oval shaped, light green to brown in colour (approx.

6 mm long) with black-tipped yellow triangles on the forewings with the wings sloping downward at the end. Nymphs are yellow green with five black dots and the eggs are long and curved.

### 4.1.2 Life cycle

The Tarnished plant bug is a small, flattened bug, which is generally brown in colour and mottled with splotches of white, yellow, reddish-brown and black. Tarnished plant bugs develop through five nymphal stages. The nymphs are very small and greenish-yellow, marked dorsally with four black dots on the thorax and one on the abdomen. Like the adults, the nymphs have piercing-sucking mouth parts and feed on plant tissues. The wings of the adults have a hard wing cover similar to that of a beetle with a smoky-brown membranous tip. The adults will fly readily when disturbed.

The adult bugs over-winter amongst weeds, leaves and bark (Cleveland 1982). As with all bugs there is no pupal stage, the life cycle only involves the egg, nymph and adult stages with the adults and nymphs tending to feed on the same material.

Adults become active as temperatures increase emerging early in the spring and feeding on newly developing buds and shoots before migrating to other plants to lay eggs on the leaves or flowers. Females may deposit eggs in stems, leaf parts as well as the flowers of host plants laying 1 to 3 eggs per day and between 30 to 120 eggs over her lifespan.



**Figure 3.** Adult Tarnished plant bug. Image courtesy of University of Illinois.

The adults are approximately 6 mm in length, and although they are true bugs (suborder Heteroptera), they have a flat, 'beetle-like' appearance with a small head projecting in front. Colour patterns vary considerably, ranging from greenish-yellow to brown (Kelton 1980). Males are generally darker than females. The body is marked with white, yellowish-brown, reddish-brown and black splotches. A distinguishing characteristic often seen is small but distinct yellow cream coloured 'Y'-shaped mark in the centre of the back (scutellum) behind the head. The cuneus (triangular section on the forewings) is pale with a black tip. The lateral margins of the mesoscutum are yellow or red (Schwartz and Footitt, 1992). The antennae and legs are long with the over-wintered adults being much darker in colour than the summer adults (Capinera 2001).





**Figure 4.** Life cycle of the Tarnished plant bug (5 instars). Image courtesy of University of Georgia, Bugwood.org.

Oviposition is usually restricted to the composite family (non-conifers). Typically, eggs are inserted into flowerlets or blossoms. The eggs are small (1 mm approx.) white in colour and slightly curved. They are oviposited into plant tissues. The hatchling nymph emerges from the opening where the top of the egg joins the surface of the plant tissue (Capinera 2001).



**Figure 5.** Tarnished plant bug egg. Image courtesy of Scott Stewart, University of Tennessee, Bugwood.org

Eggs hatch into nymphs about 7 days after being laid. Newly hatched nymphs are yellow to green in colour and 1 mm in length (approx.). There are five instars or nymphal stages, nymphs gradually becoming more like adults in appearance with each moult. The nymphs resemble adults without wings because of their incomplete metamorphosis. As the nymphs mature in later instars they develop yellow, green or black markings and wing pads in their final instar (Schwartz and Footitt, 1992) growing in size to 4.5 mm long.



**Figure 6.** *Lygus lineolaris* nymph feeding on broccoli during a feeding test. Image courtesy of Allen Cohen, USDA Agricultural Research Service

The length of the life cycle can vary depending on temperature and environmental conditions. At 34°C the Tarnished plant bug may take 12.5 days to progress through the five nymphal instars but at 12°C the time can increase to 40 days.

On average, the life cycle is completed in approximately three to four weeks with three to five generations per year depending on location and latitude (Sutherland 1989; Broadbent *et al.* 2006). Pickel *et al.* 2006 reported that for some plant bug species there have been up to ten overlapping generations in a year. Numbers of tarnished plant bugs increase significantly by midsummer but they are well camouflaged and often go unnoticed (Rakickas and Watson 1974; Ridgeway and Gyrisco 1960). In cooler climates the adults overwinter in litter or other trash in protected areas, such as woods or ditch banks along fields.

Most greenhouse nursery damage in the northern hemisphere occurs during late spring to early summer (from mid-April to late June) (Cleveland 1982; Haseman 1918; Anonymous 1988). Good sanitation or chemical control methods are needed to control Tarnished plant bug populations. Once established in greenhouses Tarnished plant bug populations are hard to control. Reinfestation usually occurs through unscreened vents or doors during ventilation.

Plant bugs can also lay eggs and feed on weedy hosts. Control of weeds is encouraged as the presence of weeds can influence the number of plant bugs found in a commercial crop (Anthon 1993; Caprile *et al.* 2006). In British Columbia (and parts of the US), the importance of *L. lineolaris* on coniferous nursery stock has increased with the reporting of the plant bug feeding on and damaging conifer seedlings (Dixon 1989).

### 4.1.3 Dispersal

The adult *L. lineolaris* is a very active and mobile insect that flies readily when disturbed. Research has shown that this pest moves both within cotton fields and to disperse between fields and adjacent areas in California, with adults readily moving up to 15 metres/day (Bancroft 2005). It has also been shown that the both the Tarnished plant bug and Western tarnished plant bug are well adapted colonisers that are capable of flying with a full complement of eggs enabling them to exploit new habitats (Blackmer *et al.* 2004).

As adults are very active, they are unlikely to be included in commodity shipments. The movement of fruit is unlikely to be a significant factor in the spread of plant bugs between regions. Nymphs on the other hand are reclusive and could potentially hide in commodities such as cut flowers. Eggs are very small and as they are positioned in plant tissues they would also be difficult to detect during inspection of agricultural commodities (CABI 2011).

It is likely that if Tarnished plant bug was to become established on a suitable host in Australia that it would spread to other susceptible hosts. The species is widespread throughout the United States and found on many hosts. As Australia shares similar environmental conditions to the USA it would be expected that *L. lineolaris* would readily spread across Australia. Natural barriers may limit the natural movement of the pest in certain regions. There have been numerous reports of *L. lineolaris* covering significant distances in a single flight including the capture of bugs up to 5 km out to sea.

However, it is more likely that dispersal between regions and over long distances would be assisted by the movement of infested commodities including nursery stock.

## 4.2 Affected hosts

### 4.2.1 Host range

Tarnished plant bugs have an extremely wide host range, being able to complete their life cycle on over 328 plant species in North America, of which 130 species are economically important (Young 1986). A partial host list includes: lucerne, apples, apricots, beans, beets, blackberries, carrots, celery, cherries, clover, commercially grown flowers, cotton, cucumbers, currants, lettuce, peaches, peas, pears, peppers, plums, potatoes, quince, raspberries, strawberries, tobacco, tomatoes and turnips. *L. lineolaris* is most attracted to flowering plants in the families' Asteraceae and Brassicaceae (CABI 2011). It has also been suggested that *L. lineolaris* has the broadest documented feeding niche of any arthropod.

A comprehensive list of hosts is provided in Appendix 1 (Table 12).

### 4.2.2 Current geographic distribution

*L. lineolaris* is the most widely distributed *Lygus* species in North America. It occurs in all Canadian provinces, all states of the United States and throughout most of Mexico and is found in all agricultural areas from low to relatively high elevations, from east central Alaska southeast to Newfoundland and south to southern Mexico (Kelton 1975; Young 1986; Schwartz and Footitt 1992). The Tarnished plant bug *L. lineolaris* is displaced by *L. hesperus*, the Western tarnished plant bug on lucerne and cotton in western North America (Day 1987; Layton 2000).

**Table 3.** Current worldwide distribution of the Tarnished plant bug

| Continent       | Countries                                         |
|-----------------|---------------------------------------------------|
| Asia            | Republic of Georgia                               |
| North America   | United States of America, Canada, Bermuda, Mexico |
| Central America | El Salvador, Guatemala, Honduras                  |

#### 4.2.2.1 POTENTIAL DISTRIBUTION IN AUSTRALIA

Plant bugs (*Lygus* spp.) are widely distributed throughout northern America. Three species *Lygus elisus* van Duzee, 1914 (pale legume bug or lucerne plant bug), *Lygus hesperus* Knight, 1941 (Western tarnished plant bug) and *Lygus lineolaris* Palisot de Beauvois, 1818 (Tarnished plant bug) have been grouped together because of their related biology and taxonomy and are predicted to pose a similar risk. None of these species are present in Australia (CABI 2011) and all are considered quarantine pests of national concern.

The potential distribution in Australia is based on information sourced from 'Import risk analysis report for fresh stone fruit from California, Idaho, Oregon and Washington' (Biosecurity Australia 2010) and 'Import risk analysis report for fresh apple fruit from the United States of America Pacific Northwest states' (Biosecurity Australia 2009). In each document it is considered highly unlikely that nymphal or adult plant bugs would remain associated with imported fruit but the principle risk is that eggs laid into the fruit would have the potential to enter Australia resulting in the establishment of exotic plant bugs in Australia. Plant bug eggs would also have the potential to survive on imported flowers.

It has been shown that eggs can survive 10°C temperatures for 15 days without an increase in mortality, however with prolonged exposure over 30 and 45 days egg mortality increases with fewer adults produced (Snodgrass and McWilliams 1992). Egg development could then continue after fruit has been removed from cool storage (Zalom *et al.* 2008).

Successful transfer to a suitable host would require the plant bug to locate a host. The Tarnished plant bug is polyphagous and known to feed on a wide selection of hosts, crops, commercially grown flowers, fruit trees, forest tree nurseries and weeds so is expected to disperse quickly (CABI 2011).

### 4.2.3 Symptoms

*Lygus lineolaris* can feed on all aerial parts of a plant but prefers to feed on reproductive plant structures namely, leaf and flower buds, flowers, fruits and seeds. Nymphs and adults feed by sucking juices from the plant. Yellowing and distortion of the plants' growing points result from the feeding on buds and new growth. With continued feeding, dwarfing, blackening or die-back of the shoots may also occur. Other symptoms include blemished or distortion of fruit. Examples of these symptoms are the dieback of shoots on asparagus (Grafius and Morrow 1982) and the resultant flower death, fruit deformity or apical seediness of strawberries (Handley 1991) and dimpling (or 'catfacing') around the feeding site in peaches and apples.

Tarnished plant bug affects many parts of its host. Table 4 is a summary outlining symptoms.

**Table 4.** Tarnished plant bug symptoms and plant part affected

| Plant part affected | Symptoms                                                                                                          |
|---------------------|-------------------------------------------------------------------------------------------------------------------|
| Fruit               | premature drop, lesions: on pods, discoloration, abnormal patterns, abnormal shape                                |
| Growing point       | Dieback, distortion, lesions                                                                                      |
| Inflorescence       | Fall or shedding, blight, necrosis, discoloration (non-graminaceous plants), distortion (non-graminaceous plants) |
| Leaves              | Abnormal colours                                                                                                  |
| Seeds               | Empty or shrivelled grains, lesions on seeds, distortion                                                          |
| Stems               | Discoloration of bark                                                                                             |
| Whole plant         | Dwarfing, distortion, resetting                                                                                   |

**Figure 7.** Damage to a daisy. Image courtesy of Whitney Cranshaw, Colorado State University, Bugwood.org.



**Figure 8.** "Dirty bloom" or damage to anthers of bloom. Image courtesy of Ronald Smith, Auburn University, Bugwood.org

### 4.3 Diagnostic information

There is no molecular test to distinguish different *Lygus* spp., however a field key is regularly used to distinguish *Lygus hesperus* from other common plant bugs in the United States. This key developed by Mueller *et al.* (2003) is called 'A field key to the most common *Lygus* species found in agronomic crops of the central San Joaquin Valley of California'. The key is used to distinguish between three species reportedly found in the Central San Joaquin Valley of California namely *L. hesperus* (Western tarnished plant bug), *L. elisus* (Pale green bug) from *L. lineolaris* (Tarnished plant bug).

The key features of *L. lineolaris* distinguishing it from the other species include the following and are found in Table 5 (Mueller *et al.* 2003; Kelton 1975).

For a list of diagnostic facilities and advisory services that can be utilised in the event of an incursion see Section 9.2 Appendix 2.



**Table 5.** Key features distinguishing *L. lineolaris* from other species

| Lygus lineolaris |                                                                                                                                                                                                                                                                  |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Male             | length 4.9-5.74 mm, width 2.38-2.8 mm                                                                                                                                                                                                                            |
| Head             | length 0.91 mm, width 1.12 mm. Yellowish brown, middle of clypeus, lorum, and jugum marked with reddish or black; line above head                                                                                                                                |
| Antennae         | antennal socket red or black; frons smooth, median line and submedian diagonal line red or black. I – 0.56 mm, reddish brown, black beneath; II – 1.40-1.82 mm, brown, base and apical third black; III – 0.88 mm, black; IV – 0.74 mm, black. 2.24-2.52 mm long |
| Pronotum         | 1.96-2.31 mm wide at base; yellowish brown to reddish brown; outer callus, two dots or rays behind, black; basal angle and often subbasal margin at base, black; anterior angles rounded; shallowly and widely punctate.                                         |
| Mesoscutum       | black, lateral margins reddish.                                                                                                                                                                                                                                  |
| Scutellum        | yellowish, two median and lateral lines, black or reddish.                                                                                                                                                                                                       |
| Hemelytron       | reddish brown; darker at apex of corium; cuneus pale green, basal and inner margins reddish, tip black; wing membrane fuscous, veins reddish; pubescence moderately long and dense, yellowish.                                                                   |
| Ventral surface  | reddish brown, sternum and middle of abdomen black; legs yellowish, usual markings on femora reddish brown.                                                                                                                                                      |
| Female           | length 5.25-5.95 mm, width 2.52-3.01 mm. Rostrum: 2.17-2.52 mm long. Much like male in colour, markings, and appearance, but more robust.                                                                                                                        |

The description above is for overwintered adults with summer adults similar in size but with colour varying from pale yellow with few black markings to reddish brown, and to almost completely black with few pale yellow markings. Nonetheless, the characteristic pattern on the head, and the reddish or pale lateral markings of the mesoscutum, and the rather long and dense pubescence readily distinguishes this species from its close relatives. Summer adults may appear as early as the end of April in the northern hemisphere and later at higher altitudes and as the season progresses northward (Mueller *et al.* 2003).

## 4.4 Pest risk ratings and potential impacts

A pest risk analysis has been carried out on this pest, taking into account the entry, establishment and spread potentials, together with the economic and environmental impact of establishment. A summary of these ratings are shown in Table 6. Based on this information, the Tarnished plant bug is considered a Medium overall risk to Australia.

**Table 6.** Pest risk ratings for the Tarnished plant bug as determined in the Nursery and Garden IBP (Plant Health Australia, 2008)

| Potential or impact     | Rating |
|-------------------------|--------|
| Entry potential         | Medium |
| Establishment potential | High   |
| Spread potential        | High   |
| Economic impact         | Medium |
| Overall risk            | Medium |

#### 4.4.1 Entry potential

##### **Rating: Medium**

As adults of *L. lineolaris* are very active insects and fly readily when disturbed, it is therefore unlikely that they would remain on imported produce or plants (eg fruit or cutflowers) or be included in commodity shipments. On the other hand nymphs are reclusive and hard to see and could potentially hide in certain commodities, such as flower crops. Eggs are very small and once inserted into plant tissues, detection would be unlikely during inspections of agricultural commodities.

Unless fruit damage or other symptoms are obvious, fruit containing eggs are not expected to be removed by grading and culling operations.

Even though *L. lineolaris* is a very common pest on a wide variety of commodities in northern America (United States, Canada and parts of Mexico) it has limited global distribution elsewhere and it would appear not to pose a large phytosanitary risk from imported materials other than plant material from northern America.

#### 4.4.2 Establishment potential

##### **Rating: High**

To establish a reproductive population a mated female or 'immatures' of both sexes would be necessary. Eggs would need to enter, hatch and develop to adulthood, locate each other and successfully mate. Female *Lygus* bugs attract males with pheromones (Wardle and Borden 2003) increasing the probability of mating. Climatic conditions in Australia are varied ranging from southern temperate regions to tropical and subtropical as well as Mediterranean climatic regions, each of which are similar to regions in the US, Canada and Mexico suggesting that climate would not be a restricting factor for establishment. The high reproductive rates and dispersal abilities of the *Lygus* spp. indicate that there would be few barriers to spread.

Tarnished plant bug is a polyphagous feeder and known to feed on a wide selection of hosts crops and fruit and commercially grown flowers, fruit trees, forest trees and weeds (CABI 2011) and evidence suggests that it may have the widest host range of any arthropod (Young 1986). Therefore there is sufficient availability of suitable hosts for the establishment of these pests in Australia.



#### 4.4.3 Spread potential

**Rating: High**

With similar environmental conditions to northern America, Australia would therefore be suitable for the spread of this pest. It has been shown that parasitoid wasps are effective against the Tarnished plant bug (Sohati *et al.* 1992) and other *Lygus* spp. (Broadbent *et al.* 2006) but it is not known what role if any, endemic parasitoids would play in Australia in biological control. Natural barriers like desert and mountain ranges may limit the natural movement between regions but *Lygus* spp. are well adapted colonisers that are capable of flying.

There is potential for movement of *Lygus* spp. between regions and over long distances by movement of infested commodities such as nursery stock. The movement of fruit is unlikely to be a significant factor in the spread of *Lygus* spp. between regions.

#### 4.4.4 Economic impact

**Rating: Medium**

Tarnished plant bug is highly polyphagous resulting in direct losses to many economically important crops and nursery stock including in cotton, canola, lucerne, asparagus, apple, peaches, strawberry, raspberries, poplars, celery, broad bean and seedling conifer trees in nurseries.

#### 4.4.5 Environmental, amenity and human health impact

*Lygus* spp. infest a large variety of plants with the potential to affect many amenity species in urban, suburban and rural areas. Hosts would include conifers and weed species. Other potential environmental effects would be the increased use of pesticides. Introduction of a pest to a new region can also lead to competition for resources with native plant bugs including mirids (Biosecurity Australia 2008).

## 5 Pest management

### 5.1 Response checklist

The following checklist (Table 7) provides a summary of generic requirements to be identified and implemented within a Response Plan.

**Table 7.** Checklist of requirements to be identified in a Response Plan

| Checklist item                                                    | Further information      |
|-------------------------------------------------------------------|--------------------------|
| Destruction methods for plant material, soil and disposable items | Sections 6.1.1 and 6.1.2 |
| Disposal procedures                                               | Section 6.1.5            |
| Quarantine restrictions and movement controls                     | Section 6.3              |
| Decontamination and property cleanup procedures                   | Section 6.5              |
| Diagnostic protocols and laboratories                             | Sections 4.3 and 9.2     |
| Trace back and trace forward procedures                           | Section 6.6              |
| Protocols for delimiting, intensive and ongoing surveillance      | Section 5.2              |
| Zoning                                                            | Section 6.4              |
| Reporting and communication strategy                              | See PLANTPLAN            |

For a range of specifically designed procedures for the emergency response to a pest incursion and a general communication strategy refer to PLANTPLAN (Plant Health Australia, 2010). Additional information is provided by Merriman and McKirdy (2005)<sup>5</sup> in the Technical Guidelines for Development of Pest Specific Response Plans.

### 5.2 Surveys and epidemiology studies

Information provided in Section 5.2.1 to 5.2.3 provides a framework for the development of early detection and delimiting surveys for Tarnished plant bug in Australia.

Where Tarnished plant bugs are found in a production nursery that is in close proximity to potential host plants (including weeds), periodically inspect nearby hosts for signs of Tarnished plant bug infestation by examining leaves closely and looking for resultant damage. Infested sources within a production nursery may provide an opportunity for Tarnished plant bugs to spread outside the production nursery.

As the adult plant bugs are very active they will readily disperse to new areas in search of suitable hosts (herbaceous weeds, vegetables and flowers). Plant bugs can also lay eggs and feed on weedy hosts. Control of weeds is encouraged to limit plant bug multiplication. The adult bugs may also over winter amongst weeds, leaves and bark.

<sup>5</sup> Available on the PHA website ([www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information](http://www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information))

As feeding by this pest (both nymphs and adults) causes damage to all aerial plant parts, it is important to check all parts of the plant for visible damage.

Agricultural inspectors and other production nursery visitors should avoid moving infested plant material between production nurseries. Shoes, tools and vehicle tyres should be thoroughly washed of soil and then sanitised with a registered disinfectant. Extra precaution should be taken when working in areas known to be infested, including disposable overboots that may be used and disposed of on-site.

### 5.2.1 Technical information for planning surveys

When developing surveys for Tarnished plant bug presence and/or distribution, the following characteristics of the pest provide the basic biological knowledge that impact on the survey strategy:

- Tarnished plant bugs have a wide host range and share a number of similarities with other native plant bugs (Fletcher 2007)
- Host species in Australia are likely to be numerous and widely dispersed.
- Movement of the pest can occur by flight or by human assistance through the transfer of nursery stock
- The risk of pest movement on machinery, equipment and personal effects is high
- Production nursery greenhouses and significant proportions of Australia have favourable climatic conditions for the spread and establishment of Tarnished plant bug
- As Tarnished plant bugs spread readily in a greenhouse or production nursery environment the tracing of plant material from one nursery to another needs to be taken into consideration

### 5.2.2 Surveys for early detection of an incursion in a production nursery

The success of an eradication response to a Tarnished plant bug incursion in a production nursery is more likely following early detection of the pest before the insect has had the opportunity to disperse to a wide area. It is therefore necessary to consider pathways and plan surveys accordingly. Important points to consider when developing early detection surveys in commercial production nurseries are:

- The adult Tarnished plant bug is a small flattened bug, about 6 mm in length. They are generally brown in colour with yellow and black markings
- A number of methods have been proposed for the monitoring of Tarnished plant bug including direct tree examinations, jarring or beating tray counts, sticky traps, orchard floor sweep sampling and fruit damage counts (Polk *et al.* 1995; Boivin *et al.* 1982). Points to note are:
  - Visual examination of trees is tedious and time consuming
  - Beating tray sampling can be used which comprises using a framed white sheet placed on the ground beneath the tree or with a hand held square canvas beating tray. Use a rubber mallet or heavy stick wrapped in rubber hose to beat one or two branches 3 to 4 times. Any insects landing will fly away if not counted quickly

- Sweep sampling can be used to indicate the insects present in the ground cover. This method will select nymphs and adults and could therefore be used as a method to predict population growth. Sampling should include taking 50 sweeps across a site and be biased towards the thicker ground cover and weeds that are blooming or have flowered
- In the USA, fruit damage is monitored by assessing 200 units of fruit per block. This type of sampling is done for management rather than eradication purposes
- White sticky boards have been used in apple orchards but not successfully in peach orchards. Traps should be placed in the outer one or two rows with the trap colour mimicking bloom colour. Traps should be placed approx. 0.5 m above ground on the tree or on stakes near weeds with the ground cover cleared around the traps. Traps should be monitored and replaced weekly, or cleaned weekly and when needed replace adhesive
- The preferred method for detection of plant bugs species is to beat the leaves with a small heavy trowel over a clean plastic surface or sweep nets to collect adults and nymphs
- For nurseries, depending on the size of the business, beating tray, sweep or white sticky board sampling methods would be most suited
- Targeted surveillance should be focussed on high-risk areas. These include commercial propagators and production nurseries involved with the import and export of cut flowers and other nursery produce

If an incursion of *L. lineolaris* is to be eradicated in a production nursery, it must be detected early, before the insect has had the opportunity to disperse over a large area. It is therefore necessary to consider pathways and plan surveys accordingly. Important points to consider when developing early detection surveys are:

- The greatest entry risk currently comes from importation of host plants or other goods. Ongoing surveys at importing production nurseries and ports are therefore recommended
- Awareness information should be targeted at people who are in regular close contact with potential hosts in high risk areas or movement vectors (e.g. production nursery operators)
- Systematic and careful inspection of production nursery crops and propagative plant material is essential to prevent introduction of Tarnished plant bug and limit its spread within, and from infested production nurseries. Early detection of the pest, while at very low levels, will provide the best chance of eradication
- An inspector must be trained to recognise the basic identification of all stages of Tarnished plant bug, including adults, eggs and larvae, as well as other endemic pests for comparison (see Section 4.3). A production nursery layout map that includes approximate locations of known host species will be required to develop a strategy for surveys. A survey map should include species and cultivar names, locations, approximate quantity and sources of targeted plants within the area. During the survey walkthrough, record the date, observations, and sampling information directly onto the survey map. The recorded information should be reviewed and used to develop the most efficient survey strategy each time the production nursery is inspected
- Begin the inspection with an overview of the area from the crop perimeter or with a quick walk-through. If suspicious symptoms or stages of Tarnished plant bug are apparent, immediately examine them more closely and collect samples if required. If no symptoms are

apparent from the overview inspection, start the complete inspection by walking a systematic path through the crop. A common survey technique is to move relatively quickly down a walkway and scan both sides of adjacent production beds/benches, back and forth. If suspicious symptoms are seen, inspect plants more closely. A good-quality 10x magnification hand lens can help identify many pest symptoms. If plants are found with suspicious symptoms or stages of Tarnished plant bug, a sample should be taken and the plant marked with plastic tape or a flag with the location noted on the survey map. Also, a few plants can be selected at random to closely inspect for Tarnished plant bug life stages or plant damage. Surveys can be prioritised to highest risk stock

- New stock or cuttings of hosts should be monitored closely. Note also outside sourced plants on survey maps for weekly examination

### 5.2.3 Delimiting surveys in the event of an incursion

- In the event of an incursion, information from delimiting surveys will be used in the decision-making process
- The size of the survey area will depend on the size of the known infested area and the severity of the infection, as well as prevailing winds and movement of plant material during the period prior to detection (Figure 9). Other considerations are for example, movement of people or plant material equipment as a result of trace-forward and trace-backs
- Tarnished plant bugs can readily fly and also can spread long distances by floating with the wind or being transported on infested plants
- Initial surveys should be carried out in a 1.5 km radius of the initial detection but as the Tarnished plant bug is an active flier the survey radius should be expanded to a 30 km radius as the delimitation progresses. It should be noted this will only take into account natural dispersal and survey range may need to be extended if human assisted dispersal is considered a factor
- All potential host species (refer to Section 4.2 and 9.1) should be surveyed including the species to which the pest was initially detected
- In addition to inspection of possible host plants, material should be collected for diagnostic purposes (refer Section 4.3)
- If the incursion is in a populated area, publication and distribution of information sheets and appeals for public assistance may be helpful

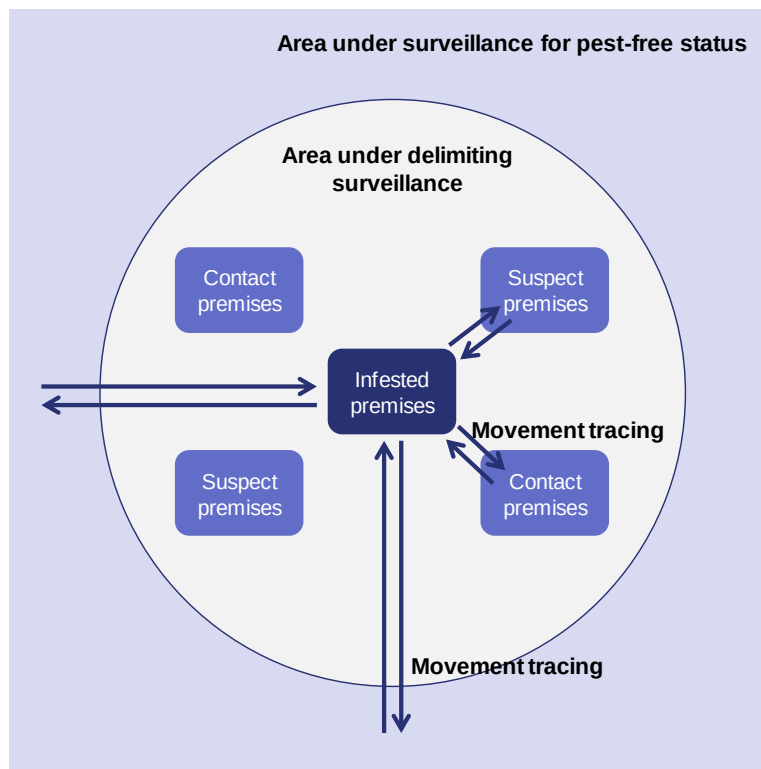


**Figure 9.** Diagram of a delimiting survey showing surveillance activities from the infected premises

## 5.2.4 Collection and treatment of samples

Protocols for the collection, transport and diagnosis of suspect Emergency Plant Pests (EPPs) must follow PLANTPLAN (Plant Health Australia, 2010). Any personnel collecting samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis.

### 5.2.4.1 COLLECTION OF SPECIMENS

#### **Sampling procedures**

Samples can be collected by hand using a sweep net or beat sheet, along with white sticky traps (see Section 5.2.2). All life stages are found on the plant material except for eggs (eggs are inserted into flowerets of blossoms) which are found within plant material.

#### **Number of specimens to be collected**

Where possible, collect multiple specimens representative of all life stages of the population available. Adult Tarnished plant bugs are preferred, as the adult life stage is the easiest with which to confirm identification.

Record the identity of the host plant where the plant bugs were collected. Record the location, preferably as GPS co-ordinates, or alternatively, a map reference or distance and direction from a suitable landmark. If the land is privately owned, record the owner's details including contact telephone numbers.

## ***How to collect and send plant samples with eggs, larvae or pupae***

Samples should be treated in a manner that allows them to arrive at the laboratory in a fresh, well preserved state. Leaf samples containing Tarnished plant bug nymphs and if possible adults are to be placed in a specimen container and placed in a portable fridge or insulated container with cool packs to prevent the insect and leaf samples from drying out.

Adults are the preferred stage for identification. However, if an adult is not available for collection, the pupae can be used for identification (should be packed between sheets of dry newspaper (for stem etc.) or moist paper (for leaves) and sealed in a plastic bag. Each sealed bag should be placed in a second bag along with additional paper to absorb excess moisture. Bagged samples should then be placed in a non-crushable container with paper, bubble or foam to fill the remaining space and protect samples during transit.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (Plant Health Australia, 2010; Appendix 3). Containers should then be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of plant species/parts affected, location of affected plant (where available include GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650.

## ***How to preserve insects***

Prior to beginning the identification process, place specimens in the freezer for at least 24 hours to kill them. Alternatively, they may be placed in ethyl alcohol to kill and preserve them. Specimens stored in alcohol for more than 3-5 days will become brittle (Mueller *et al.* 2003).

## ***How to transport insects***

Vials containing the samples in a preservative should be sealed to avoid leakage and packed in a manner to minimise shock to the vials (i.e. with cushioning material in a strong box). It is important to ensure that vials are completely filled with preservative so as to remove excess air which, through movement of the vial, will allow agitation of the preservative and quickly degrade the specimen.

Live insects should be packaged in a strong, sealed container.

A word of caution:

- Where a quarantine situation occurs, special authority will be needed to remove live exotic insects from the quarantine area
- Transport/airline regulations may preclude the transportation of ethanol. Contact the relevant transport authority or company for advice

## ***Precaution***

Overheating or desiccation of samples prior to despatch should be prevented. Samples may be stored in a fridge (4-10°C) for a few days if necessary.

## ***Receipt***

On receipt of the samples the diagnostic laboratory should follow strict quarantine and processing guidelines. In keeping with ISO 17025 refer to PLANTPLAN (Plant Health Australia, 2010).

### 5.2.5 Epidemiological study

The extent of infestation in a production nursery, on a property or within a region will depend on the initial population size and whether conditions have been favourable for the pest to spread from the initial location. Sampling should be based upon the origins of the initial suspect sample(s). Factors to consider will be:

- The proximity of other susceptible plants to the initial infestation source, including both current and previous crops. This will include crops in the production nursery or on the property with the initial detection and those on neighbouring properties
- Machinery or vehicles that have been into the infested area or in close proximity to the infestation source
- The extent of human movements into and around the infested area. A possible link to the recent importation of plant material from other regions should also be considered
- The source of any production nursery stock propagation material and whether any other crops have been propagated from the same source and/or distributed from the affected nurseries
- If any other crops have been propagated from the same source and/or distributed from the affected production nurseries
- Plant bugs are highly mobile and depending on the temperature and environmental conditions Tarnished plant bug can have multiple generations per year
- Tarnished plant bugs have an extremely wide host range feeding on agricultural crops, weeds and other herbaceous plants

### 5.2.6 Models of spread potential

No models of spread potential have been developed for Tarnished plant bug.

### 5.2.7 Pest Free Area guidelines

Determination of Pest Free Areas (PFAs) should be completed in accordance with the International Standards for Phytosanitary Measures (ISPMs) 8 and 10 (IPPC 1998a, 1999).

General points to consider are:

- Design of a statistical delimiting field survey for the presence of the insect on host plants (see Section 5.2 for points to consider in the design)
- Surveys should be completed as described in the BioSecure HACCP manual (Nursery and Garden Industry Australia, 2008), including monitoring processes (summarised in Table 8 and Table 9), indicator plants and weed monitoring
- Surveys should also consider alternative hosts (see Sections 4.2.1 and 9.1) and not be limited to the primary infested host
- Information (including absence of the pest) should be recorded



**Table 8.** Summary of monitoring processes for protected production areas as described in BioSecure HACCP Guidelines

|                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wear protective clothing when handling suspect samples                                                                                                                            |
| Walk at random through the area in a zigzag pattern                                                                                                                               |
| Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m <sup>2</sup> of production area                                                                          |
| Inspect the tops and bottoms or leaves, looking for any direct evidence of insects                                                                                                |
| Inspect the entire plant if it has less than six leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually |
| Inspect the length of all stems and branches for insects and symptoms                                                                                                             |
| During individual plant inspection, strike the foliage over a white sheet of paper, or a paper or plastic plate to dislodge small insects for easier viewing                      |
| If any plants show suspect symptoms or evidence of eggs or larvae (refer to Section 4.2.3) take a sample (refer to Section 5.2.4) to be formally diagnosed (refer to Section 4.3) |
| Check for a problem that have occurred regularly in the past, until you are certain it is not present                                                                             |
| Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest                                                                                                  |
| Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed                    |

Additional information is provided by the IPPC (1995) in Requirements for the Establishment of Pest Free Areas. This standard describes the requirements for the establishment and use of pest free areas as a risk management option for phytosanitary certification of plants and plant products. Establishment and maintenance of a PFA can vary according to the biology of the pest, pest survival potential, means of dispersal, availability of host plants, restrictions on movement of produce, as well as PFA characteristics (size, degree of isolation and ecological conditions).

**Table 9.** Summary of monitoring processes for field production areas as described in BioSecure HACCP Guidelines

|                                                                                                                                                                                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wear protective clothing when handling suspect samples                                                                                                                              |
| Pay particular attention to areas on the windward side, the sides bordering ditches, canals or other uncultivated areas and growing block centres                                   |
| Place a flag or other marker at the entrance to the block or sampling area at the beginning of each inspection                                                                      |
| Vary the entrance point in the sampling area (1 m to 3 m) for each subsequent sampling so that the same plants are not inspected each time                                          |
| Walk at random through the area in a zigzag pattern                                                                                                                                 |
| The scout should follow the same general pattern at each sampling                                                                                                                   |
| Make an effort to select those plants that appear less healthy for visual inspection                                                                                                |
| Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m <sup>2</sup> of production area                                                                            |
| Inspect the tops and bottoms of leaves, looking for any direct evidence of insects                                                                                                  |
| Inspect the entire plant if it has less than six leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually   |
| Inspect the length of all stems and branches for insects and symptoms                                                                                                               |
| During individual plant inspection, strike the foliage over a white sheet of paper, or a plastic or paper plate to dislodge small insects for easier viewing                        |
| If any plants show suspect symptoms or evidence of eggs or larvae (refer to Section 4.2.3) take a sample (refer to Section 5.2.4.1) to be formally diagnosed (refer to Section 4.3) |
| Check for a problem that has occurred regularly in the past, until you are certain it is not present                                                                                |
| Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest                                                                                                    |
| Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed                      |

## 5.3 Availability of control methods

### 5.3.1 General procedures for control

- Keep traffic out of affected areas and minimize movement in adjacent areas
- Adopt best-practice property hygiene procedures to retard the spread of the pest
- After surveys are completed, and permission has been obtained from the Chief Plant Health Manager or OCPPO, destruction of the infested plant material is an effective control
- On-going surveillance of infested areas is required to ensure the pest is eradicated
- Do not use any material from infested plants for propagation

### 5.3.2 Chemical control

Tarnished plant bug is controlled by a range of chemical products across a number of crop species overseas. While none of these chemicals are registered for Tarnished plant bug in Australia, several

of these products are available for the control of other insect pests across many crops in Australia (Listed in Table 10), and may be pursued for an Emergency Use Permit should Tarnished plant bug enter the country. In recent years *Lygus* populations in North America have developed resistance to insecticides (Grafton-Cardwell *et al.* 2000). Thus, use of a range of chemical groups may be necessary in an eradication effort and should Tarnished plant bug become established in Australia, rotation of insecticide groups will be essential in management of the pest.

**Table 10.** Chemical control options for Tarnished plant bug

| Active ingredient | Group | Reference                                                                                 |
|-------------------|-------|-------------------------------------------------------------------------------------------|
| Acephate          | 1B    | Bagwell <i>et al.</i> (2005)                                                              |
| Bifenthrin        | 3A    | Brust (2010)                                                                              |
| Deltamethrin      | 3A    | Kharboutli <i>et al.</i> (2000)                                                           |
| Dimethoate        | 1B    | Bagwell <i>et al.</i> (2005)                                                              |
| Endosulfan        | 2A    | Brust (2010)                                                                              |
| Fipronil          | 2B    | Kharboutli <i>et al.</i> (2000), Scott and Snodgrass (2000)                               |
| Imidacloprid      | 4A    | Bagwell <i>et al.</i> (2005), Kharboutli <i>et al.</i> (2000), Scott and Snodgrass (2000) |
| Indoxacarb        | 22A   | Kharboutli <i>et al.</i> (2000)                                                           |
| Oxamyl            | 1A    | Bagwell <i>et al.</i> (2005)                                                              |
| Thiamethoxam      | 4A    | Bagwell <i>et al.</i> (2005), Kharboutli <i>et al.</i> (2000)                             |

Any chemicals used for the eradication or control of Tarnished plant bug in Australia must be registered for use through the Australian Pesticides and Veterinary Medicines Authority (APVMA). For information regarding this process visit the APVMA website ([www.apvma.gov.au](http://www.apvma.gov.au)).

### 5.3.3 Biological control

Several parasitoids are known to be effective at parasitising *Lygus* spp., Hymenoptera including the egg parasite *Anaphis iole* (Girault) and the nymphal parasites *Leiophron uniformis* (Gahan), *Peristenus pallipes* (Curtis) and *P. pseudopallipes* (Loan), are thought to be relatively important for biological control. In the USA, native parasites are more effective at parasitising *Lygus* on weed hosts than on crops. Capinera (2001) showed that the parasitoid *Peristenus digoneutis* (Loan) decreased Tarnish plant bug abundance by 75% without affecting native parasitoid populations.

The braconid wasp *Peristenus pallipes* attacks nymphs, and the mymarid wasp *Anaphes oviventatus* attacks eggs. Big-eyed bugs, damsel bugs, assassin bugs and crab spiders are important natural enemies and can help control lygus bug nymphs on host plants outside orchards or in the cover crop (<http://jenny.tfrec.wsu.edu/opm/displaySpecies.php?pn=180>).

Parasitoids, mainly species of *Peristenus* originating from Europe, have been imported and released in Canada and the USA (Kelleher and Hulme, 1981; Day, 1987). Evidence suggests that the entomopathogen *Beauveria bassiana* also has promise as a biocontrol agent (Steinkraus and Tugwell, 1997).



**Figure 10.** A quarter-inch-long parasitic wasp, *Peristenus digoneutis*, prepares to lay an egg in a tarnished plant bug nymph, *Lygus lineolaris*. Image courtesy of Scott Bauer, USDA Agricultural Research Service, Bugwood.org

### 5.3.4 Physical and cultural control

Cultural practices may provide the best defence against Tarnished plant bugs. These practices include the removal of weeds and the elimination of trash that provide overwintering sites for the plant bugs. As a number of weeds and crops such as mustard play host to Tarnished plant bugs they have been used as trap crops to control *Lygus* numbers (CABI 2011).

## 5.4 Market access impacts

Within the AQIS PHYTO database ([www.aqis.gov.au/phyto](http://www.aqis.gov.au/phyto)), there is currently no additional phytosanitary statement required that declares Tarnished plant bug is not known to occur in Australia (as at April 2011). Should Tarnished plant bug be detected or become established in Australia, countries may require a specific declaration or supplementary measures upon export. Latest information can be found within PHYTO, using an Advanced search “Search all text” for *Lygus lineolaris*.

## 6 Course of action

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Additional information is provided by the IPPC (1998b) in Guidelines for Pest Eradication Programmes. This standard describes the components of a pest eradication programme which can lead to the establishment or re-establishment of pest absence in an area. A pest eradication programme may be developed as an emergency measure to prevent establishment and/or spread of a pest following its recent entry (re-establish a PFA) or a measure to eliminate an established pest (establish a PFA). The eradication process involves three main activities: surveillance, containment, and treatment and/or control measures.

### 6.1 Destruction strategy

#### 6.1.1 Destruction protocols

General protocols:

- No plant material should be removed from the infested area unless part of the disposal procedure
- Disposable equipment, infested plant material or growing media/soil should be disposed of by autoclaving, high temperature incineration or deep burial
- Any equipment removed from the site for disposal should be double-bagged
- Machinery used in destruction processes need to be thoroughly washed, preferably using a detergent or farm degreaser

#### 6.1.2 Decontamination protocols

Machinery, equipment and vehicles in contact with infested plant material or growing media/soil, or present within the Quarantine Area, should be washed to remove plant material and growing media/soil using high pressure water or scrubbing with products such as a degreaser or a bleach solution (1% available chlorine) in a designated wash down area. When using high pressure water, care should be taken not to spread plant material. High pressure water should be used in wash down areas which meet the following guidelines:

- Located away from crops or sensitive vegetation
- Readily accessible with clear signage
- Access to fresh water and power
- Mud free, including entry and exit points (e.g. gravel, concrete or rubber matting)
- Gently sloped to drain effluent away
- Effluent must not enter water courses or water bodies
- Allow adequate space to move larger vehicles
- Away from hazards such as power lines

- Waste water, growing media/soil or plant residues should be contained (see Appendix 18 of PLANTPLAN [Plant Health Australia, 2010])
- Disposable overalls and rubber boots should be worn when handling infested plant material or growing media/soil in the field. Boots, clothes and shoes in contact with infested plant material or growing media/soil should be disinfected at the site or double-bagged to remove for cleaning
- Skin and hair in contact with infested plant material or growing media/soil should be washed

Procedures for the sterilisation of plant containers and growing media are provided within the BioSecure HACCP Guidelines, however, in the event of a Tarnished plant bug incursion, additional or modified procedures may be required for the destruction of the pest. Any sterilisation procedure must be approved for use in the endorsed Response Plan.

### 6.1.3 Priorities

- Confirm the presence of the pest
- Limit movement of people and prevent movement of vehicles and equipment through affected areas
- Stop the movement of any plant material that may be infested with the pest
- Determine the strategy for the eradication/decontamination of the pest and infested host material
- Determine the extent of infestation through survey and plant material trace back and trace forward

### 6.1.4 Plants, by-products and waste processing

- Any growing media/soil or infested plant material removed from the site should be destroyed by (enclosed) high temperature incineration, autoclaving or deep burial
- As the pest can be mechanically transmitted, plant debris from the destruction zone must be carefully handled and transported for destruction
- Infested areas or production nursery yards should remain free of susceptible host plants until the area has been shown to be free from the pest

### 6.1.5 Disposal issues

- Particular care must be taken to minimize the transfer of infested plant material or insects from the area
- Host material, including leaf litter, should be collected and incinerated or double bagged and deep buried in an approved site

## 6.2 Containment strategies

For some exotic pest incursions where eradication is considered impractical, containment of the pest may be attempted to prevent or slow its spread and to limit its impact on other parts of the state or country. Containment is currently being considered for inclusion within the Emergency Plant Pest Response Deed (EPPRD). The decision on whether to eradicate or contain the pest will be made by the National Management Group, based on scientific and economic advice (see Section 3, page 8).

## 6.3 Quarantine and movement controls

Consult PLANTPLAN (Plant Health Australia, 2010) for administrative details and procedures.

### 6.3.1 Quarantine priorities

- Plant material and growing media/soil at the site of infestation to be subject to movement restrictions
- Machinery, equipment, vehicles and disposable equipment in contact with infested plant material or growing media/soil, or present in close proximity to the site of infestation to be subject to movement restrictions

### 6.3.2 Movement controls

Movement controls need to be put in place to minimise the potential for transport of the pest, and this will apply to all plant material, growing media and other items within the quarantined area.

Movement of people, vehicles, equipment and plant material, from and to affected properties or areas, must be controlled to ensure that the pest is not moved off-property. Movement controls can be achieved through the following, however specific measures must be endorsed in the Response Plan:

- Signage to indicate quarantine area and restricted movement into and within these zones
- Fenced, barricaded or locked entry to quarantine areas
- Movement of equipment, machinery, plant material or growing media/soil by permit only. Therefore, all non-essential operations in the area or on the property should cease
- Where no dwellings are located within these areas, strong movement controls should be enforced
- Where dwellings and places of business are included within the Restricted and Control Areas movement restrictions are more difficult to enforce, however limitation of contact with infested plants should be enforced
- If a production nursery is situated within the Restricted Area, all nursery trading must cease and no material may be removed without permission, due to the high likelihood of pest spread. Movement restrictions would be imposed on both host and non-host material
- Residents should be advised on measures to minimise the inadvertent transport of Tarnished plant bug from the infested area to unaffected areas

- Clothing and footwear worn at the infested site should either be double-bagged prior to removal for decontamination or should not leave the site until thoroughly disinfected, washed and cleaned
- Plant material or plant products must not be removed from the site unless part of an approved disposal procedure
- All machinery and equipment should be thoroughly cleaned down with a high pressure cleaner (see Section 6.1.2) or scrubbing with products such as a farm degreaser or a 1% bleach (available chlorine) solution, prior to leaving the affected area. Machinery should be inspected for the presence of insects and if found, treatment with insecticide may be required. The clean down procedure should be carried out on a hard surface, preferably a designated wash-down area, to avoid mud being re-collected from the affected site onto the machine. When using high pressure water, care should be taken to contain all plant material and mud dislodged during the cleaning process

## 6.4 Zoning

The size of each quarantine area will be determined by a number of factors, including the location of the incursion, biology of the pest, climatic conditions and the proximity of the infested property to other infested properties. This will be determined by the National Management Group during the production of the Response Plan. Further information on quarantine zones in an Emergency Plant Pest (EPP) incursion can be found in Appendix 10 of PLANTPLAN (Plant Health Australia, 2010). These zones are outlined below and in Figure 11.

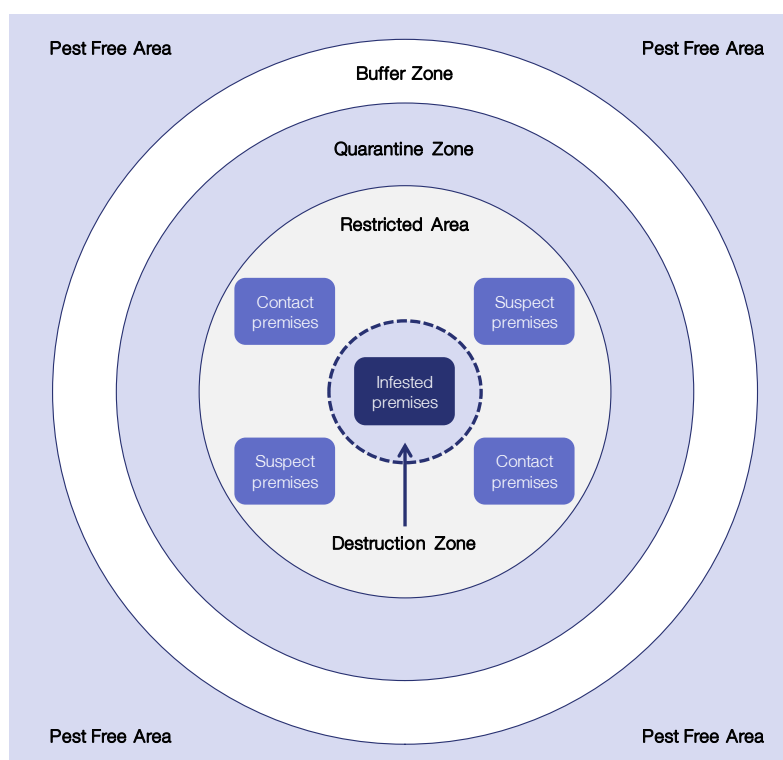


**Figure 11.** Schematic diagram of quarantine zones used during an EPP incursion (not drawn to scale)



### 6.4.1 Destruction Zone

The size of the destruction zone (i.e. zone in which the pest and all host material is destroyed) will depend on the ability of the pest to spread, distribution of the pest (as determined by delimiting surveys), time of season (and part of the pest life cycle being targeted) and factors which may contribute to the pest spreading.

All host plants should be destroyed after the level of infestation has been established. The delimiting survey will determine whether or not neighbouring plants are infested and need to be destroyed. Non-host plant material within this zone may be destroyed, based on recommendations in the Response Plan. The Destruction Zone may be defined as contiguous areas associated with the same management practices as, or in contact with, the infested area (i.e. the entire production nursery, property or area if spread could have occurred prior to the infection being identified).

Particular care needs to be taken to ensure that plant material (including non-hosts) is not moved into surrounding areas.

### 6.4.2 Restricted Area

The Restricted Area is defined as the zone immediately around the infested premises and suspected infested premises. The Restricted Area is established following initial surveys that confirm the presence of the pest. The Restricted Area will be subject to intense surveillance and movement control with movement out of the Restricted Area to be prohibited and movement into the Restricted Area to occur by permit only. Multiple Restricted Areas may be required within a Control Area.

### 6.4.3 Quarantine Zone

The Quarantine Zone is defined as the area where voluntary or compulsory restraints are in place for the affected property or properties. These restraints may include restrictions or movement control for removal of plants, people, growing media/soil or contaminated equipment from an infested property.

### 6.4.4 Buffer Zone

A Buffer Zone may or may not be required depending on the incident. It is defined as the area in which the pest does not occur but where movement controls or restrictions for removal of plants, people, soil or equipment from this area are still deemed necessary. The Buffer Zone may enclose an infested area (and is therefore part of the Control Area) or may be adjacent to an infested area.

### 6.4.5 Control Area

The Control Area is defined as all areas affected within the incursion. The Control Area comprises the Restricted Area, all infested premises and all suspected infested premises and will be defined as the minimum area necessary to prevent spread of the pest from the Quarantine Zone. The Control Area will also be used to regulate movement of all susceptible plant species to allow trace back, trace forward and epidemiological studies to be completed.

## 6.5 Decontamination and property clean up

Decontaminant practices are aimed at eliminating the pest thus preventing its spread to other areas.

### 6.5.1 Decontamination procedures

General guidelines for decontamination and clean up:

- Refer to PLANTPLAN (Plant Health Australia, 2010) for further information
- Keep traffic out of affected area and minimize it in adjacent areas
- Adopt best-practice property hygiene procedures to retard the spread of the pest between growing areas/fields and adjacent properties
- Machinery, equipment, vehicles in contact with infested plant material or growing media/soil present within the Quarantine Zone, should be washed to remove growing media/soil and plant material using high pressure water or scrubbing with products such as a degreaser or a bleach solution in a designated wash down area as described in Section 6.1.2
- Only recommended materials are to be used when conducting decontamination procedures, and should be applied according to the product label
- Infested plant material should be disposed of by autoclaving, high temperature (enclosed) incineration or deep burial

### 6.5.2 General safety precautions

For any chemicals used in the decontamination, follow all safety procedures listed within each MSDS.

## 6.6 Surveillance and tracing

### 6.6.1 Surveillance

Detection and delimiting surveys are required to delimit the extent of the outbreak, ensuring areas free of the pest retain market access and appropriate quarantine zones are established.

Initial surveillance priorities include the following:

- Surveying all host growing properties and businesses in the pest quarantine area
- Surveying all properties and businesses identified in trace-forward or trace-back analysis as being at risk
- Surveying all host growing properties and businesses that are reliant on trade with interstate or international markets which may be sensitive to Tarnished plant bug
- Surveying production nurseries selling at risk host plants
- Surveying other host growing properties and backyards

## 6.6.2 Survey regions

Establish survey regions around the surveillance priorities identified above. These regions will be generated based on the zoning requirements (see Section 6.4), and prioritised based on their potential likelihood to currently have or receive an incursion of this pest. Surveillance activities within these regions will either allow for the area to be declared pest free and maintain market access requirements or establish the impact and spread of the incursion to allow for effective control and containment measures to be carried out. Detailed information regarding surveys for Tarnished plant bug have been outlined elsewhere in this plan (refer to Section 5.2).

Steps outlined in Table 11 form a basis for a survey plan. Although categorised in stages, some stages may be undertaken concurrently based on available skill sets, resources and priorities.

**Table 11.** *Phases to be covered in a survey plan*

|         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Phase 1 | <ul style="list-style-type: none"> <li>Identify properties that fall within the buffer zone around the infested premise</li> <li>Complete preliminary surveillance to determine ownership, property details, production dynamics and tracings information (this may be an ongoing action)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Phase 2 | Preliminary survey of host crops in properties in buffer zone establishing points of pest detection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Phase 3 | Surveillance of an intensive nature, to support control and containment activities around points of pest detection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Phase 4 | <p>Surveillance of contact premises. A contact premise is a property containing susceptible host plants, which are known to have been in direct or indirect contact with an infested premises or the pest. Contact premises may be determined through tracking movement of materials from the property that may provide a viable pathway for spread of the pest. Pathways to be considered are:</p> <ul style="list-style-type: none"> <li>Items of equipment and machinery which have been shared between properties including bins, containers, irrigation lines, vehicles and equipment</li> <li>The producer and retailer of infested material if this is suspected to be the source of the outbreak</li> <li>Labour and other personnel that have moved from infested, contact and suspect premises to unaffected properties (other growers, tradesmen, visitors, salesmen, crop scouts, harvesters and possibly beekeepers)</li> <li>Movement of plant material and growing media/soil from controlled and restricted areas</li> </ul> |
| Phase 5 | Surveillance of production and retail nurseries, gardens and public land where plants known to be hosts of the pest are being grown                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Phase 6 | Agreed area freedom maintenance, post control and containment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

## 6.6.3 Post-eradication surveillance

The period of pest freedom sufficient to indicate that eradication of the pest has been achieved will be determined by a number of factors, including growth conditions, the previous level of infestation, the control measures applied and the pest biology.

Specific methods to confirm eradication of Tarnished plant bugs may include:

- Monitoring of sentinel plants that have been grown at the affected sites. Plants are to be grown *in situ* under quarantine conditions and monitored for symptoms or other indications of Tarnished plant bug presence

- If symptoms or suspect insects are detected, samples are to be collected and stored and plants destroyed
- Targeted surveys for Tarnished plant bug should be undertaken within the Quarantine Zone to demonstrate pest absence
- Alternate non-host crops should be grown on the site and any self-sown plants sprayed out with a selective herbicide

## 7 Technical debrief and analysis for stand down

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Refer to PLANTPLAN (Plant Health Australia, 2010) for further details

The emergency response is considered to be ended when either:

- Eradication has been deemed successful by the lead agency, with agreement by the Consultative Committee on Emergency Plant Pests and the Domestic Quarantine and Market Access Working Group
- Eradication has been deemed impractical and procedures for long-term management of the pest risk have been implemented

A final report should be completed by the lead agency and the handling of the incident reviewed.

Eradication will be deemed impractical if, at any stage, the results of the delimiting surveys lead to a decision to move to containment/control.

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## 8.1 Related Websites

CABI Compendium ([www.cabicompendium.org](http://www.cabicompendium.org))

Center of Invasive Species and Ecosystem Health – Bugwood Network ([www.bugwood.org](http://www.bugwood.org))

Pest and Disease Image Library (PADIL) ([www.padil.gov.au](http://www.padil.gov.au))

<http://www.virginiafruit.ento.vt.edu/tpb.html>

Washington State University, Tree Fruit Research & Extension Centre, Orchard Pest Management Online (<http://jenny.tfrec.wsu.edu/opm/displaySpecies.php?pn=180> )

Penn State University (<http://ento.psu.edu/extension/factsheets/tarnished-plant-bug>)

## 9 Appendices

### 9.1 Appendix 1: Genera of plants from which *Lygus lineolaris* has been recorded

**Table 12.** List of taxa known to be hosts of *Lygus lineolaris*. (CABI 2010)

| Species                                        | Common name       |
|------------------------------------------------|-------------------|
| <i>Amaranthus cruentus</i>                     | Redshank          |
| <i>Anethum graveolens</i>                      | Dill              |
| <i>Apium graveolens</i>                        | Celery            |
| <i>Apium graveolens</i> var. <i>dulce</i>      | Celery            |
| <i>Asparagus officinalis</i>                   | Asparagus         |
| <i>Aster</i>                                   |                   |
| <i>Aster pilosus</i>                           | White heath aster |
| <i>Bellis perennis</i>                         | Common daisy      |
| <i>Beta vulgaris</i>                           | Beetroot          |
| <i>Brassica napus</i> var. <i>napus</i> (rape) | Rape              |
| <i>Brassica oleracea</i> var. <i>botrytis</i>  | Cauliflower       |
| <i>Brassica oleracea</i> var. <i>capitata</i>  | Cabbage           |
| <i>Calendula officinalis</i>                   | Pot marigold      |



| Species                                               | Common name              |
|-------------------------------------------------------|--------------------------|
| <i>Cosmos</i>                                         |                          |
| <i>Cucumis sativus</i>                                | Cucumber                 |
| <i>Dahlia hybrids</i>                                 |                          |
| <i>Daucus carota</i>                                  | Carrot                   |
| <i>Erigeron</i>                                       | Fleabane                 |
| <i>Fragaria ananassa</i>                              | Strawberry               |
| <i>Gladiolus hybrids</i>                              | Sword lily               |
| <i>Glycine max</i>                                    | Soybean                  |
| <i>Gossypium hirsutum</i>                             | Bourbon cotton           |
| <i>Helianthus</i>                                     | Sunflower                |
| <i>Lespedeza cuneata</i> ( <i>Sericea lespedeza</i> ) |                          |
| <i>Malus</i>                                          | Ornamental species apple |
| <i>Medicago sativa</i>                                | Lucerne                  |
| <i>Papaver nudicaule</i>                              | Iceland poppy            |
| <i>Phaseolus lunatus</i>                              | Lima bean                |
| <i>Phaseolus vulgaris</i>                             | Common bean              |
| <i>Pinus echinata</i>                                 | Shortleaf pine           |
| <i>Polyphagous</i> ( <i>polyphagous</i> )             |                          |
| <i>Populus</i>                                        | Poplars                  |
| <i>Prunus persica</i>                                 | Peach                    |
| <i>Pyrus communis</i>                                 | European pear            |
| <i>Rubus</i>                                          | Blackberry, raspberry    |
| <i>Salvia officinalis</i>                             | Common sage              |
| <i>Sinapis alba</i>                                   | White mustard            |
| <i>Solanum tuberosum</i>                              | Potato                   |
| <i>Tragopogon porrifolius</i>                         | Oysterplant              |
| <i>Trifolium incarnatum</i>                           | Crimson clover           |
| <i>Verbena</i>                                        | Vervain                  |
| <i>Vicia sativa</i>                                   | Common vetch             |
| <i>Zea mays</i> subsp. <i>mays</i>                    | Sweet corn               |
| <i>Zinnia elegans</i>                                 | Zinnia                   |

## 9.2 Appendix 2: Resources and facilities

Table 13 provides a list of diagnostic facilities for use in professional diagnosis and advisory services in the case of an incursion.

**Table 13. Diagnostic service facilities in Australia**

| Facility                                                                             | State | Details                                                                                                    |
|--------------------------------------------------------------------------------------|-------|------------------------------------------------------------------------------------------------------------|
| DPI Victoria – Knoxfield Centre                                                      | Vic   | 621 Burwood Highway<br>Knoxfield VIC 3684<br>Ph: (03) 9210 9222; Fax: (03) 9800 3521                       |
| DPI Victoria – Horsham Centre                                                        | Vic   | 110 Natimuk Rd<br>Horsham VIC 3400<br>Ph: (03) 5362 2111; Fax: (03) 5362 2187                              |
| Industry and Investment New South Wales – Elizabeth Macarthur Agricultural Institute | NSW   | Woodbridge Road<br>Menangle NSW 2568<br>PMB 8 Camden NSW 2570<br>Ph: (02) 4640 6327; Fax: (02) 4640 6428   |
| I&I New South Wales – Tamworth Agricultural Institute                                | NSW   | 4 Marsden Park Road<br>Calala NSW 2340<br>Ph: (02) 6763 1100; Fax: (02) 6763 1222                          |
| I&I New South Wales – Wagga Wagga Agricultural Institute                             | NSW   | PMB Wagga Wagga<br>NSW 2650<br>Ph: (02) 6938 1999; Fax: (02) 6938 1809                                     |
| SARDI Plant Research Centre – Waite Main Building, Waite Research Precinct           | SA    | Hartley Grove<br>Urrbrae SA 5064<br>Ph: (08) 8303 9400; Fax: (08) 8303 9403                                |
| Grow Help Australia                                                                  | QLD   | Entomology Building<br>80 Meiers Road<br>Indooroopilly QLD 4068<br>Ph: (07) 3896 9668; Fax: (07) 3896 9446 |
| Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories    | WA    | 3 Baron-Hay Court<br>South Perth WA 6151<br>Ph: (08) 9368 3721; Fax: (08) 9474 2658                        |

# Appendix 7



Industrial Affiliates Program

## Cover Sheet

## Section 1: Personal details (student to complete)

|                        |            |
|------------------------|------------|
| Griffith student ID #: | S2619659   |
| Last name:             | McNamara   |
| First name:            | Andrew     |
| Mobile phone number:   | 0432364705 |

## Section 2: Course and Assessment details (student to complete)

|                       |                      |
|-----------------------|----------------------|
| Course code:          | 4001ENG              |
| Assessment item name: | Final Project Report |
| Assessment due date:  | 10/06/2011           |
| Campus:               | Nathan               |

## Section 3: Student declaration (student to complete)

Breaches of academic integrity (cheating, plagiarism, falsification of data, collusion) seriously compromise student learning, as well as the University's assessment of the effectiveness of that learning and the academic quality of the University's awards. All breaches of academic integrity are taken seriously and could result in penalties including failure in the course and exclusion from the University.

Students should be aware that the University uses text-matching software to safeguard the quality of student learning and that your assessment may be checked using this software. Examiners will only award marks for work within this assessment item that is your own original work.

I acknowledge and agree that the examiner of this assessment item may, for the purpose of marking this assessment item:

- Reproduce this assessment item and provide a copy to another Griffith staff member; and/
- Submit this assessment item to a text-matching service. This web-based service will retain a copy of this assessment item for checking the work of other students, but will not reproduce it in any form.

I hereby certify that:

- Except where I have indicated, this assessment item is my own work, based on my personal study and/or research.
- I have acknowledged all materials and sources used in the preparation of this assessment item whether they are books, articles, reports, lecture notes, or any other kind of document or personal communication.
- I have not collaborated with another student or person in planning, developing and writing this assessment item.
- This assessment item has not been submitted for assessment in any other course or at any other time in the same course.
- I have not copied in part or in whole or otherwise plagiarised the work of other students and/or persons.
- I haven't made this piece of work available to another student.
- All of the work covered in this assessment was undertaken during the IAP placement.
- The material/content in this assessment item does not breach the Non-disclosure and Assignment of Intellectual Property Deed I have with the industry partner.
- Providing this declaration falsely is considered a breach of academic integrity.

I have retained a copy of this assessment item for my own records.

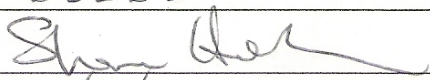
|                                                                                                                                    |                                                                                     |       |           |
|------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------|-----------|
| Acknowledged by:<br>(After above sections have been completed print and sign form. Ask the Industry Partner to complete section 4) |  | Date: | 1/06/2011 |
|                                                                                                                                    | (Signature)                                                                         |       |           |



**Section 4: Industry partner/supervisor release (Industry to complete)***(To be completed by the Industry partner/supervisor after the student has fully completed sections 1-3)*

The signature of the Industry Partner or Industry Supervisor gives approval for release of information in the assessment item for assessment purposes. It also confirms the assessment as a true representation of the student's work for the organisation.

I give approval for release of this assessment item for assessment purposes:

|                                        |                                                                                    |
|----------------------------------------|------------------------------------------------------------------------------------|
| Industry partner/supervisor name:      | Shane Holborn                                                                      |
| Organisation name:                     | DEEDI                                                                              |
| Industry partner/supervisor signature: |  |
| Date:                                  | 3/6/2011                                                                           |

## **EXTENDED JOURNAL ABSTRACT**

TARGET JOURNAL – “Environmental Science and Technology Journal”

### **Introduction**

The use of plastic within industries worldwide has vastly increased bringing with it a legacy of waste and pollution. The nursery industry plays a major role in the production of plastic waste with the majority of plants being grown and sold in plastic containers (Taylor et al, 2010). Because of the amount of plastics being used within the nursery industry there are serious concerns regarding the way the plastic is being handled and continuously discarded into overburdened landfills. Adding to this problem is the cost of the nursery industries need for plastic, which is steadily increasing as the price of oil goes up (Kenney, 2005). From estimates taken in Victoria it is believed that up to 7000 tonnes of plastic pots are being used yearly in that state alone, with the majority of these ending up as landfill (Australian Packaging Covenant, 2008). It has also been estimated by Williamson, as cited in Berney (2003, p.42), “that in Western Australia 100 million pots, equalling 8000 tonnes of plastic, are annually entering landfills.”

The beyond plastic project was created to perform a situation analysis of pot use and recycling in each state of Australia. This was completed in consultation with the national nursery research manager. The project identified possible pot recycling model schemes and examines current and emerging commercially available pot options for the nursery industry. These options were examined against an ideal pot criteria i.e. plastic benchmark, to provide performance and cost comparisons. The project’s aim was to identify future pot options for the Australian nursery and garden industry. This involves looking into and identifying the numerous recycling options for possible use in Australia and also a study into the biodegradable and compostable pot options. The need for this project is based upon the current unsustainable use of petrochemical-based plastic products within the industry. Plastic pots are unsustainable from both the manufacture and disposal ends of the pot supply chain. It is therefore the objective of this report to identify and provide possible alternatives to plastic use within the nursery industry. In doing this the project will provide a basis for future research and improvements within the industry and act as a pilot study.

## **Pot Recycling**

Currently one of the most economically and environmentally viable options for pot use in the nursery industry appears to be recycling. Common plastic pots found in the plant nurseries are generally made up of poly propylene (PP) plastic. The same material that is often used in common food containers such as ice cream tubs and yogurt containers (Australian Packaging Covenant, 2008). This common plastic material has become a standardised polymer used in Australia and according to Garden City Plastics (2009); “it gives plastic pots the ability to be infinitely 100% recyclable.” With this possibility of 100% recyclability the need for land filling would be completely dissolved therefore saving the industry money in disposal costs and also helping to reduce carbon footprint.

From research conducted on the various recycling methods being used and trialled around the world it is obvious that there is a growing trend towards plastic waste recycling. With a large amount of plastic being used and disposed of by the plant industry it is important that Australia, along with the rest of the world, begin to conceive or expand upon viable recycling options. The methods available for recycling plastic pots range from simplistic methods of collection, and reselling to the more complex scenarios where the plastic is being processed into a kind of fuel source. From research completed in the project the methods which seemed the most feasible for use throughout Australia were the ones that after collection and sorting phases used specialised equipment to breakdown the pots into chips. These chips could then be remoulded back into pots or the likes of plastic lumber. If methods of recycling such as those currently occurring in Western Australia and Victoria can be incorporated into use throughout Australia, the Australian nursery industry could profit both environmentally and economically.

## **Biodegradable Pot Use**

Around the world different options for pot materials are becoming more available for use in the nursery industry. Due to the use of these alternate materials, it is becoming more and more common to see plastic pots being replaced with biodegradable ones. Throughout the nursery industry it is common knowledge that “biodegradable plastics made with plant-based materials have been available for many years. Their high cost, however, has meant they have never replaced traditional non-degradable plastics in the mass market” (Australian Academy of Science, 2002).

For the report a total of 11 different types of biodegradable and compostable bio-pots were examined and compared with a standard plastic pot. Results from testing carried out in the US, showing pot performance characteristics, allowed for some generalised comments to be made about the different pots. Strength wise (Figure 1) plastic, Rice hull and Paper pots showed the best Characteristics. Water usage tests (Figure 2) showed that the plastic and compostable pot types such as OP47 and Rice hull pots had the best water retention characteristics due to there water retardant nature. Decomposition tests (Figure 3) showed that after plastic, the compostable pots degraded the slowest along with Zein (corn starch) pots. This information helped to show which pots had the characteristics which most suited the grower's needs.

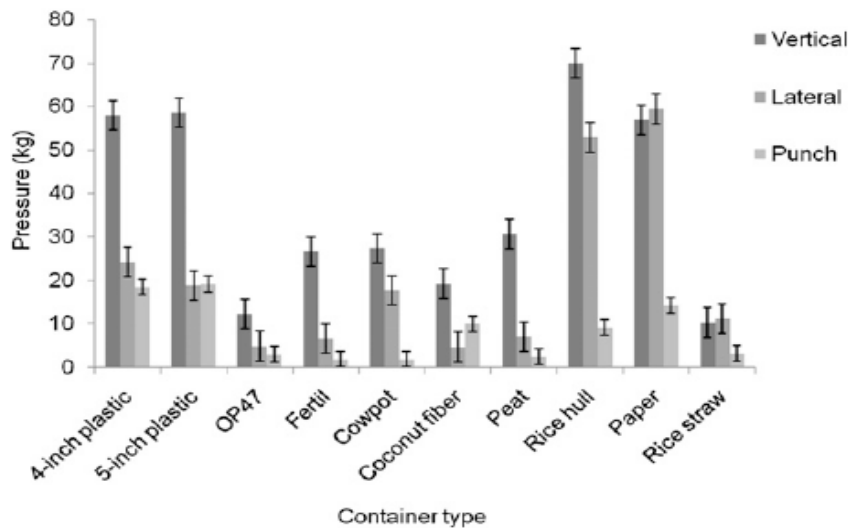


**Figure 1: Dry vertical, lateral and punch strength of containers. (Source: Evans et al, 2010, p552)**



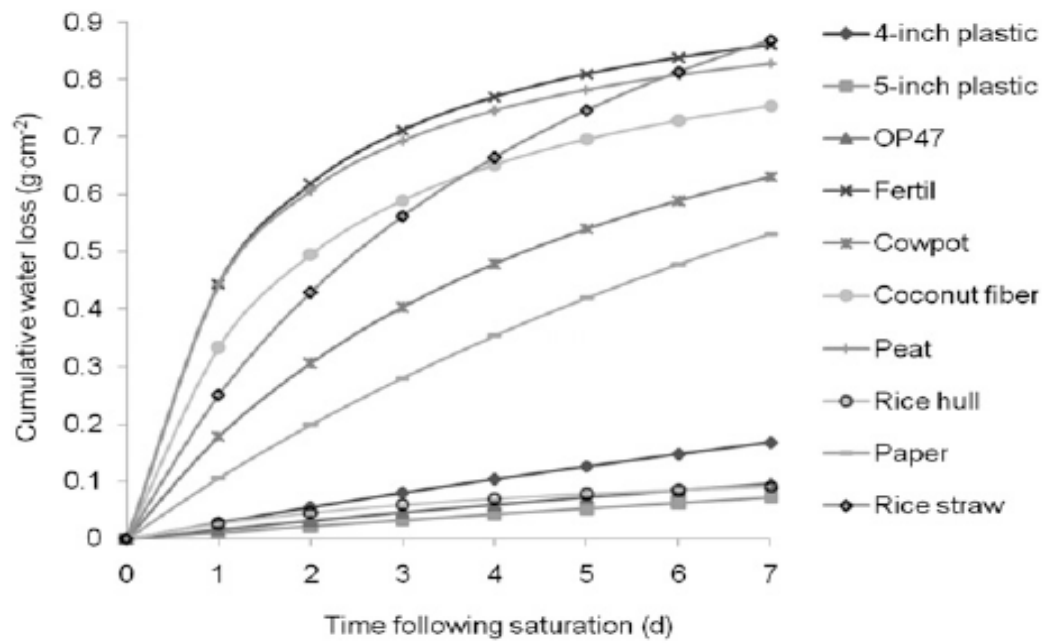


Figure 2: Cumulative water loss (Source: Evans et al, 2010, p554)

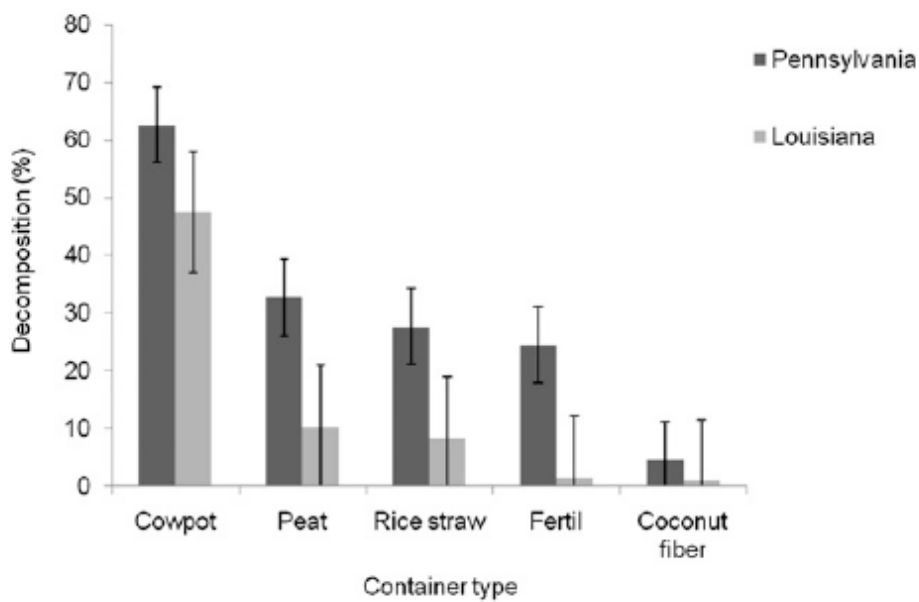


Figure3: Pot Decomposition over 8 week period (Source: Evans et al, 2010, p 555)

## **Conclusion**

The report finds that there are a number of different recycling initiatives occurring around the world and in Australia. There are also numerous bio-containers which have the possibility of replacing and reducing the use of the common plastic containers.

The recycling of plastic pots through organised collection and reprocessing at recycling plants appears to be one of the most economically and environmentally viable options for the nursery industry. Through this method Garden City Plastics in Victoria have found that pots made from poly propylene (PP) plastic are infinitely 100% recyclable (Garden City Plastics, 2011). With this possibility of 100% recyclability the need for land filling would be completely dissolved therefore saving the industry money in disposal costs and also helping to reduce carbon footprint.

The use of biodegradable and compostable containers is gradually gaining popularity, particularly as their prices get closer to the price of plastic pots. Based on performance the choice of bio-pot was found to be dependant upon a number of issues. These issues included; specific location, crop grown, cultural conditions and post pot handling (Taylor et al, 2010). It was therefore found that no one bio-pot was suitable as a complete alternative to plastic pots. The different options need to be considered so that the right pot can be chosen for the right climate and the right plant. The current pots available can be made up of many different organic materials such as coconut fibre, chicken feathers or even cow manure. By examining the features and performances of the different biodegradable pots and comparing them, it is hoped that an ideal biodegradable pot or pots can be identified.

The issue is in which recycling concept or biodegradable material would work best to possibly supersede the currently popular plastic market.

**Griffith School of Environment  
Griffith University  
3001ENV – Industrial Affiliates Program**

# **Domestic Outdoor Water Use Pilot Study**

**Morgan Walker s2680592**

*10<sup>th</sup> June 2011, Semester 1*

**Department of Employment, Economic Development and Innovation  
Dr Rachel Poulter  
Dr Andrew Chan**

*A report submitted in partial fulfilment of the degree of Environmental Management*

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## **EXECUTIVE SUMMARY**

In the last decade, South-East Queensland (SEQ) has encountered various natural disasters, including the worst drought in recorded history (QWC, 2010a). The need for water security in SEQ has since been highly acknowledged and undisputed, resulting in the publication of the SEQ Water Strategy in 2010. The SEQ Water Strategy's *Target 200* includes an allowance of 90L/p/d for outdoor use, 45% of the targeted total household water use (QWC, 2010b: 2). This set allocation is based on outdoor water use habits and attitudes pre-dating the Millennium drought, which is now known to have changed the beliefs and attitudes of the SEQ community.

This pilot study acknowledged the need for a representative domestic outdoor water use study in SEQ, aiming to prove that the current outdoor water use statistic of 45% is inaccurate. To substantiate these claims the Domestic Outdoor Water Use Pilot Study had two main components: the collection of actual water use data from participating households through a field study and a review of literature, involving both quantitative and qualitative data, respectively. The field study element involved the identification of five trial sites, installation of ten outdoor water meters (two at each site), periodic data collection (including surveys and climate data) and analysis. The literature review concentrated on national and international water use studies, which not only measured residential household water use but partitioned it into both indoor and outdoor consumption.

The field study resulted in an average outdoor water use percentage of 2.39% of the total household water use, supporting the review of national and international water use studies which highlighted the difference in water use statistics cited in government documents and actual outdoor water use. Therefore it was evident that the 45% allocation for outdoor water is unrepresentative of the SEQ region.

The SEQ Water Strategy 2010 governs the whole SEQ region, and as such is an important and significant Queensland government document, yet it has been shown here to encourage inequitable allocation and inefficient use of water. The importance of the document should be reflected in the accuracy of its policies. And as such it has been proposed that this document be amended to reflect current water use practices.

# Energy Saving Trees

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412-659 Research Project

**Yan Yang Zhang      374398**

**Department of Civil and Environmental Engineering**

**The University of Melbourne**

**November 2010**



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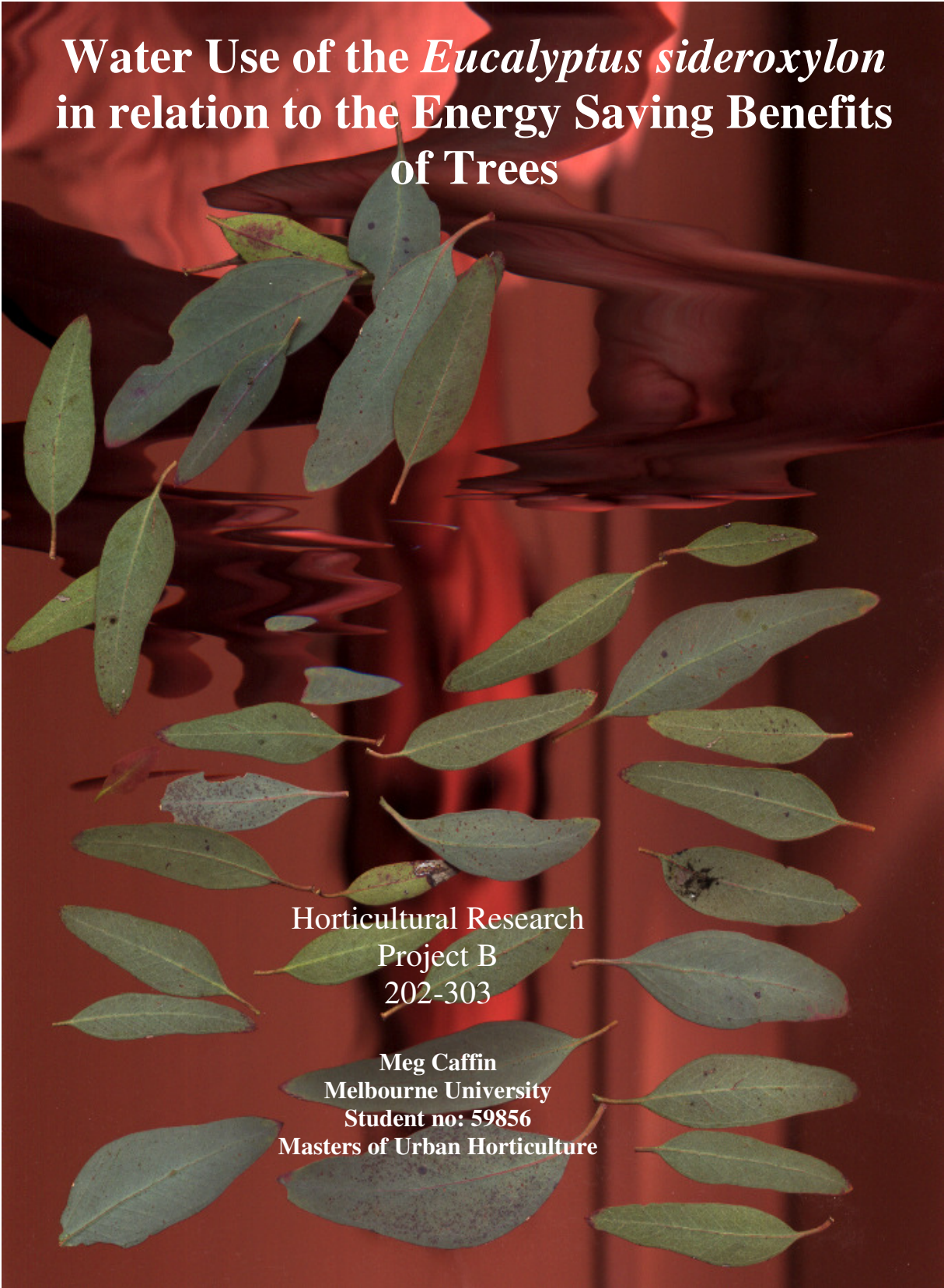
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## Abstract

Trees are said to be energy savers in urban area. It is known that the trees can reduce cooling energy usage by shading and evapotranspiration. A field experiment is conducted at Burnley Campus, The University of Melbourne where three test buildings were installed with heat flux sensors, infrared sensors, heat pumps and watts-up meters. One buildings has been shaded by evergreen and another one shaded by deciduous trees. Detailed thermal performance and energy consumption data are collected continuously with a data logger. It was found from the measured data that heat loss in buildings with shaded trees are greater than the baseline building. This may be attributed from the cooling effect of the trees and differences in the condition of the buildings.

In effort to verify the field measurement data, computer simulation using TRNSYS was conducted as well. Models were built in accordance with field experiment input data. Results were compared with the field measurement data to evaluate the models developed. Field measured data indicated no significant differences in energy consumption for three buildings. This may be due to the slow growth rate of trees. The models seem to underestimate the actual energy usage. However, computer simulation indicates that substantial potential cooling energy savings can be achieved by trees.



# Water Use of the *Eucalyptus sideroxylon* in relation to the Energy Saving Benefits of Trees

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Project B  
202-303

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Masters of Urban Horticulture



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## Introduction

The importance of urban trees in cities is becoming better understood through greater research about their many benefits including aesthetics, increasing value of properties, increasing biodiversity, air pollution and storm water amelioration, urban heat island mitigation and general health and community well-being benefits (McPherson, Nowak et al. 1997; Akbari, Pomerantz et al. 2001; Mansfield, Pattanayak et al. 2005; Georgi and Dimitriou 2010). Studies in the USA, UK and Europe have, over time generated enough evidence to suggest that trees have the capacity to modulate temperatures of buildings in urban environments through shading and evapotranspiration.(Akbari, Kurn et al. 1997; Simpson 2002; McPherson and Simpson 2003; Wang 2006). This shading also influences the amount of heat absorbed by impervious surfaces within cities, maintaining that tree canopy cover can decrease urban heat island effects (Gober, Brazel et al. 2010). This statement assumes that vegetation, including trees, is efficiently transpiring, meaning they are healthy and well watered. These concepts are important in formulating urban planning and development policies, especially when considering the need to build sustainable, resilient and climate proof cities.

The importance of vegetation, particularly trees, in cities belies an array of factors as mentioned above. One of the emerging fields of research relates to the environmental benefits of urban trees in their capacity to perform ecosystem functions within a dynamic and complex environment. Whilst qualifying these environmental benefits is proven (Sequest 1998; Akbari 2002; Wang 2006; Georgi and Dimitriou 2010; Leuzinger, Vogt et al. 2010), the ability to quantify them, particularly in dollar terms has been no easy task. Studies undertaken primarily by the Department of Forestry in the United States have seen dollar figures attributed to such benefits as storm water amelioration, carbon storage and sequestration, air pollution amelioration and energy saving benefits in their UFORE and STRATUM tools. Only a handful of studies delve further into the water requirements of these trees to ensure their maximum capacity to produce such benefits (McCarthy and Pataki 2010). One such study found that irrigation is frequently in excess of estimated plant demand (White, Havlak et al. 2007) and another attempted to incorporate water use of urban trees in models of cost and benefits (Wang, Endreny et al. 2008). In order then to provide a holistic cost benefit analysis for increasing tree cover in cities to provide broad reaching environmental benefits it is necessary to seek out the water costs of ensuring such vegetation is healthy.

These environmental benefits studies however have been conducted in climates relatively different to those within Australia. Melbourne, Australia, the focus for this research has undergone sixteen consecutive years of drought. Water shortages across the state called for community water restrictions to a level of 3A. This restriction saw municipal councils stop the supply of irrigated water to many street and park trees in an effort to reduce water use and it also encouraged residents to find alternative water uses for their gardens. Irrigation levels fell as the community worked hard to achieve the State Government's benchmarked 155 litres of water used per person per day. Private trees then also suffered from lack of water as soil moisture levels were rarely replenished. Finally, the Spring of

2010 has brought much needed rains, improving soil moisture levels however the damage to many of the urban trees is unremedied. The debate rages as to whether this drought is/was cyclical or a precursor to a changing climate, however the fact remains that due to the drought and the associated water restrictions, the urban trees suffered. In turn, their environmental benefits diminished, particularly reducing their cooling capacity. Hence, a spotlight is drawn not only on the potential benefits of urban trees in reducing energy use in buildings but also to the fact that the trees must be healthy and well watered in order to provide the maximum cooling benefits.

Studies within Australia on this topic are lacking. Brisbane City Council commissioned a consultants report in 2002 to model the effects of their urban canopy on 3 story buildings in the city, finding that there was a potential for up to 50% energy savings (Plant 2005). This study though was only a desktop study, modelling the effect of the urban forest on the built form and a field study was not undertaken. However, this study was influential enough for council decision makers to implement the Brisbane City Councils 2 million trees program, which aims to extrapolate the benefits of street trees across the entire city. The City of Sydney and the City of Adelaide, both municipal councils have installed weather stations around their streets to quantify the microclimatic conditions in and around urban trees (City of Sydney, 2010). These projects verify the effects of evapotranspiration in cooling the surrounding climate, however they will be unable to measure the water use of the trees, nor quantify the economic effect of reduced energy use in surrounding buildings. This quantum of data from various projects however will form an important base from which to begin to quantify the direct benefits of trees in urban fabric and bridge the knowledge gap on Australia's urban trees.

In order to provide a proof of concept to the vast array of industries involved in designing, building and managing cities in Australia, a pilot project is currently being conducted to definitively quantify the energy saving benefits of trees in an urban environment under Australian climatic conditions in Melbourne Australia. Given the long-term nature of the data collection to secure a relationship between the surrounding trees and the energy use of the buildings, this paper is unable to comment on the energy saving benefits of trees in Melbourne at this point in time. Instead, a subsidiary project has been conducted to quantify the particular water use of the trees in the project to gain a better understanding of the water requirements and economic cost of irrigating urban trees in Melbourne. This will be imperative given Australia's history of prolonged droughts and the effects of lower annual rainfall predicted under climate change modeling coupled with the notion that many urban trees are situated in areas of high imperviousness. The data from this project will aim to feed into the end results of the larger project to estimate the holistic cost-benefit ratio of urban trees effecting energy use in buildings and to aid in calculating the optimal irrigation regimes to ensure healthy benefit producing trees. The project is the first of its kind in Australia and will draw on methods used in similar studies conducted internationally to draw conclusions in an Australian context.

# Appendix 8



# Prioritisation of potential interstate quarantine treatments for nursery stock

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## EXECUTIVE SUMMARY

Movement of plants across state borders often requires that they be certified as free from pests and diseases. Typically, this involves spraying the plants with a particular pesticide or showing that the plants were free of pests for a certain length of time prior to shipment. With pesticide resistance and the deregistration of chemical products, there is a need for sustainable quarantine treatments to facilitate interstate movement of plants. To this end, a number of non-standard pesticide treatments were examined, with particular attention given to treatments that could be certified as organic.

A total of twelve treatments were summarised for their suitability as quarantine treatments that could potentially be used to facilitate interstate trade in Australia (Table 1). Half of the

treatments are unsuitable, the other half may be suitable with further research. Vacuum + heat and controlled atmosphere + heat treatments were ranked as having the highest potential as an organic alternative to standard pesticides based on their ability to disinfest pest species and not harm living plants, among other considerations (Table 1). However, both of these options are extremely host/pest specific and require further investigative studies to determine optimum rates, exposure times etc. Phosphine and ethyl formate also have very high potential for development into a relatively broad-spectrum treatment, however it would be expected for some plant species to show unacceptable levels of phytotoxic effects.

Developing any of the treatments into a commercial option will be associated with a significant financial investment, over a substantial period of time (probably over 1-3 years), with phosphine as the only possible exception. Susceptibility of all pest species to be treated must be conducted individually and all host plant species on which pests are found will need to be tested for phytotoxicity. For this reason it seems unlikely that their use will be feasible as a broad-spectrum pest cure-all for most, or even a significant portion, of plant species traded interstate in Australia. It seems more realistic that a treatment could be developed to facilitate trade for specific pests on specific commodities, e.g. in place of dimethoate or bifenthrin to facilitate trade to Western Australia (ICA-35), or to disinfest plant material with western flower thrips to facilitate trade to Tasmania (currently properties must have certified property freedom). Other potential uses probably exist, however identifying pests and commodities traded interstate that are in need of an alternative treatment requires further research. Individual nurseries may develop their own protocols with relevant state organisations to facilitate trade without publication. It seems reasonable, however, that a treatment that is worth the significant cost of investment associated with its development would probably come to the attention of the relevant state nursery peak body or NGIA.

Development of new chemical pesticides would be cheaper and simpler to implement than the fumigants described here, that require sealed facilities. As such, it seems unlikely that they would be worth developing into a treatment for interstate trade of nursery plants while standard chemical pesticide options remain viable. The only possible exception is phosphine (see section on phosphine for details). One must ask the question, however, what is the difference between using phosphine and a standard pesticide chemical? Phosphine is not organic and has significant human health concerns (even if the risks are mitigatable). The main advantage could be that phosphine may result in a higher level of confidence in successful treatment of plants, perhaps even facilitating international markets.

Table 1. Summary of advantages and disadvantages of treatments discussed in this document. Ranks have been calculated using two methods. Feasibility and organic refers to the likelihood that a treatment could be successfully researched and that the resulting method would be organic (or relatively natural). This ranking disregarded the cost of developing such a treatment and the cost to growers implementing such a method. Rank weighted by cost looked at the cheapest method to research and implement that would likely result in a successful method. This method disregarded the desire to have a natural or organic product.

| Treatment type                      | Advantages                                                                                                                                                                                                                                                                                                                                                   | Disadvantages                                                                                                                                                                                                               | Qualitative assessment of cost of research | Rank weighted by feasibility and organic | Rank weighted by cost |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------------------------------------|-----------------------|
| Vacuum and heat                     | <ol style="list-style-type: none"> <li>1. Organic</li> <li>2. Low risk of insect resistance</li> <li>3. Low phytotoxicity</li> <li>4. Low human health risks</li> <li>5. No Registration requirements (unless combined with a fumigant that requires registration)</li> <li>6. Higher efficacy than CAs, particularly if combined with a fumigant</li> </ol> | <ol style="list-style-type: none"> <li>1. Pest specific</li> <li>2. Somewhat complex dosimetry</li> <li>3. Moderately difficult to research and implement commercially</li> <li>4. Extremely expensive equipment</li> </ol> | Very high                                  | 1                                        | 5                     |
| Controlled atmosphere (CA) and heat | <ol style="list-style-type: none"> <li>1. Organic</li> <li>2. Low risk of insect resistance</li> <li>3. Low phytotoxicity</li> <li>4. Low human health risks</li> <li>5. No Registration requirements</li> </ol>                                                                                                                                             | <ol style="list-style-type: none"> <li>1. Pest specific</li> <li>2. Very complicated dosimetry</li> <li>3. Very difficult to research and implement commercially</li> <li>4. Expensive equipment</li> </ol>                 | High                                       | 2                                        | 4                     |
| Phosphine                           | <ol style="list-style-type: none"> <li>1. Broad-spectrum</li> <li>2. Low-moderate phytotoxicity</li> <li>3. Registered in Australia (in another crop)</li> <li>4. Low cost</li> </ol>                                                                                                                                                                        | <ol style="list-style-type: none"> <li>1. Moderate treatment durations</li> <li>2. Low-moderate phytotoxicity</li> <li>3. High human health risk, mitigatable</li> </ol>                                                    | Low                                        | 5                                        | 1                     |
| Ethyl formate                       | <ol style="list-style-type: none"> <li>1. Broad spectrum against external pests</li> <li>2. Short treatment duration</li> <li>3. Registered in Australia (in another crop)</li> <li>4. Potential for organic labelling</li> <li>5. Low to moderate cost</li> </ol>                                                                                           | <ol style="list-style-type: none"> <li>1. Moderate phytotoxicity</li> <li>2. Low-moderate human health risks</li> </ol>                                                                                                     | Low to moderate                            | 3                                        | 2                     |
| Ozone                               | <ol style="list-style-type: none"> <li>1. Broad spectrum</li> <li>2. Organic, may not require registration</li> </ol>                                                                                                                                                                                                                                        | <ol style="list-style-type: none"> <li>1. Moderate human health risk</li> <li>2. Moderate phytotoxicity</li> <li>3. Moderate cost of equipment</li> </ol>                                                                   | Moderate                                   | 4                                        | 3                     |
| Carbonyl sulphide                   | <ol style="list-style-type: none"> <li>1. Broad spectrum</li> <li>2. Low-moderate phytotoxicity</li> </ol>                                                                                                                                                                                                                                                   | <ol style="list-style-type: none"> <li>1. Not registered</li> <li>2. Moderate treatment times</li> </ol>                                                                                                                    | Not assessed                               |                                          | NA                    |
| Heat and cold only                  | <ol style="list-style-type: none"> <li>1. Organic</li> <li>2. Low risk of insect resistance</li> <li>3. Low human health risks</li> <li>4. No Registration requirements</li> </ol>                                                                                                                                                                           | <ol style="list-style-type: none"> <li>1. Heat- high phytotoxicity at temperatures required</li> <li>2. Cold - very long treatment times at very low temperatures</li> </ol>                                                | NA                                         |                                          | NA                    |

|                    |                                                    |                                                                                      |    |  |    |
|--------------------|----------------------------------------------------|--------------------------------------------------------------------------------------|----|--|----|
|                    |                                                    |                                                                                      |    |  |    |
| Sulphuryl fluoride | 1. Broad-spectrum<br>2. Highly penetrating         | 1. High human health risk<br>2. Not registered in Australia<br>3. High phytotoxicity | NA |  | NA |
| Propylene oxide    | 1. Broad spectrum                                  | 1. Very high human health risk                                                       | NA |  | NA |
| Hydrogen cyanide   | 1. Broad spectrum<br>2. Low-moderate phytotoxicity | 1. Very high human health risk                                                       | NA |  | NA |
| Carbon disulphide  | 1. Broad spectrum                                  | 1. Very high human health risk<br>2. Very high phytotoxicity                         | NA |  | NA |
| Methyl iodide      | 1. Broad spectrum<br>2. Low-moderate phytotoxicity | 1. Very high human health risk                                                       | NA |  | NA |

## INTRODUCTION

Nursery producers grow a huge number of plant species in a variety of different sized containers (from small propagated plants to large trees). Movement of live plants has the potential to carry pests and diseases into areas otherwise free from these threats. Such an introduction could adversely impact on nursery, horticulture production, cropping systems, pastures and the environment in general. Currently, most treatments of living, whole plants rely on a pesticide application which may not consistently eliminate pests. Furthermore, pesticides used to facilitate interstate movement of plants, i.e. as part of interstate certification assurance (ICA), are often used throughout the growing season to control pests. Consequently, pesticide resistance is likely to increase and cause a breakdown in the use of that chemical as part of an interstate quarantine treatment.

There is a need for alternative, environmentally friendly and sustainable treatment methods that eliminate pests. The nursery industry would like to investigate non-standard chemical treatments that are economically viable. This report will summarise a number of such treatment options and discuss the feasibility of their implementation for the nursery industry. For the purposes of this report, pests refer to insects and mites, and pesticides as products that cause the death of insects and mites.

There are a number of different types of disinfestation treatments that could be used as an alternative to standard pesticides to facilitate interstate movement of nursery stock. These include: (i) physical (hot and cold) treatments, (ii) fumigants (e.g. phosphine, ethyl formate and modified atmosphere treatments), and (iii) a combination of the two (e.g. high carbon dioxide environment and high temperature). Fumigant and other non-chemical techniques for pest disinfestation are generally becoming more widely researched because methyl bromide is no longer widely available.

Post harvest disinfestation research has largely focused on fruit (including dried fruit), vegetables and grain, with a relatively small amount devoted to cut flowers and virtually no research devoted to living plants. Research has indicated non-pesticide disinfestation treatments have not been developed to facilitate movement of living plants across state/territory or international borders. Disinfestation treatments for living plants must overcome a number of challenges that

are not incurred by fruit and vegetable produce. Firstly, the product must be able to grow and flourish after treatment precluding treatments that results in sterility. Secondly, the treatment must be relatively quick, unlike treatments on certain fruit and vegetable products that can last weeks. A long treatment introduces practical constraints including the requirement of automated irrigation and light (sun) requirements. Thirdly, living plants are not as robust as fruit and vegetables owing to the physiological nature of leaves and the plant as a whole. A leaf is the substrate over which photosynthesis, respiration and transpiration occurs. Leaves also produce hormones that regulate various plant functions and have relatively high enzyme activity. Treatments are more likely to be phytotoxic to living plants than fruit or vegetables owing to this physiological activity which is required to continue after treatment; fruit and vegetables are not required to grow after they are treated; in fact, lack of growth after treatment can be beneficial in cases of some products, e.g. onions, potatoes etc. Plants are unlikely to survive after being dipped for long periods in water at temperatures greater than 50°C. Similarly, few tropical plants will remain in a saleable condition for long, continuous periods at temperatures below 5°C. Grain has an even greater advantage as they are seeds with a protective covering which shields the product from phytotoxic effects. As such, the requirements for non-chemical disinfestation of living plants are higher than most fruit, vegetables and stored products, being more akin to lettuce or leek.

Practical considerations also hinder the successful development of a treatment for living plants. If the treatment is too long, plants must be irrigated and have suitable lighting. Potted plants require special trays to allow them to be stacked and different sized pots have slightly different stacking requirements. Fruit and vegetables can be packed into pallets relatively easily and forklifted into place. All of the treatments discussed below require plants to be placed in a sealed container or storage device. This introduces additional demands on growers, including the cost of the new container and its maintenance. Current treatments are often completed in the position in which plants were grown; treatments discussed here would require plants to be moved at least twice (once into the treatment chamber and once into the transport vehicle).

Currently, chemical treatments are relatively inexpensive and nursery staff only require basic training for its application, e.g. Chemcert training. For example, to fulfill ICA 29 to send plants to Western Australia it may cost about \$4 of product (one application of 100L for each of imidacloprid, bifenthrin and mancozeb, based on bulk purchase of products).

Nevertheless, there are parallels between traditional post harvest research and that required for nursery plants. This document will summarise treatments currently available or being experimentally tested for the disinfestation of insect and mite pests in fruit, vegetable and stored product industries. As will be seen below, available information indicates that a high level of refinement is required for treatments to deliver 100% mortality for any particular pest. Normally, the changes to a treatment required to kill one pest precludes its efficacy against other pests. In addition, some species are more or less resistant to certain levels of any given treatment. Therefore, a broad spectrum treatment that causes 100% mortality, without producing unacceptable phytotoxic effects to a wide range of nursery stock, is unlikely to be achievable at this time. As such, in this report, a practical approach has been taken to prioritise treatments using the following criteria:

- 1) registration of the treatment in Australia,
- 2) range of pests likely to be affected,

- 3) practical feasibility of use for commercial nursery producers, including cost, and
- 4) likelihood of phytotoxic effects.

Using these criteria the treatments have been separated into high and low priority treatments. In general, those treatments that are already in use in Australia for the disinfestation of other agricultural products were placed as a high priority for testing with nursery stock. Furthermore, greater research effort was placed on high priority treatments rather than low priority treatments.

### *Market access research*

Researching new plant pest disinfestation treatments to facilitate market access is rigorous and time consuming. First, research must be conducted to demonstrate which stage of each pest species is the most tolerant to the treatment. Next, tests are conducted on the most tolerant stage to find the most efficacious treatment method; generally these tests are small scale trials to reduce costs. This could involve a large number of tests varying treatment concentrations, temperature and or treatment durations. The more variables there are, the more time consuming the research. In addition, the treatments must be shown to not cause unacceptable phytotoxic effects.

Once a method has been determined under relatively small scale conditions, tests must be conducted on a commercial scale. This requires large numbers of the pest in question to accurately demonstrate very high mortality. To illustrate, tests that demonstrates 99.5%, 99.99% and 99.9968% ('probit 9') mortality, requires about 600, 30 000 and 100 000 pest individuals to all be killed, respectively (Couey and Chew, 1986; Heather and Hallman, 2008). At this stage, tests resulting in even one survivor could invalidate a method. Therefore, tests must ensure that treatment and control cages are not cross-contaminated.

Tests must also be conducted on the range of products that are expected to be treated by the method to rule out possible interactions that may cause treatment failure (Heather and Hallman, 2008). For the nursery industry, this would probably involve testing each pest species on each plant species that would undergo the treatment and perhaps the same plant species at different phenotypic stages (e.g. propagation material and relatively large plants).

Since these experiments are complex and time consuming, such research normally takes a long period of time, dependent upon the number of pests being examined, the number of hosts and the number of treatment types being evaluated. Often such research may take a number of years.

## **METHODS**

Literature used to form this report was obtained from searches on Thomas Reuters Web of Knowledge. Searches were completed on post harvest pest disinfestation methods in general and on each of the methods described below. A Google search was also completed on each treatment to gain more general information. The Australian Pesticides and Veterinary Medicines Authority (APVMA) website was also searched to determine current registrations and registration requirements for each treatment in Australia. In addition, experts on various treatments were consulted including: Peter Leach (DEEDI, fruit and vegetable expert), Pat Collins (DEEDI, grain

disinfestation expert), Andrew Jessup (NSW DPI – general post harvest expert), Victoria Haritos (CSIRO), Swami Thalavaisundaram (BOC) and Robert Ryan (private consultant) – ethyl formate experts, Jed and Dick Bothel (Vivafresh – vacuum facility developers), Justin Tumambing (Cytec Australia Holdings) and Phillip Burrill (DEEDI) – Phosphine experts, David Hiscock (Oxyzone Pty Ltd) and Mel Biggs (Zox Ozonators) – ozone generator suppliers. In addition, many state/territory government agencies were contacted regarding licensing arrangements in their jurisdiction. Many businesses were contacted to ascertain costs of equipment.

## **FUMIGATION CHAMBERS**

All of the treatments considered below are gaseous fumigants and therefore require a well sealed chamber to be reliable, efficacious and cost effective. A leaky chamber reduces the capacity to maintain a constant concentration and increases the likelihood that pockets of the treatment chamber receive a sub-lethal dose. This increases the chance that a shipment will be rejected due to presence of living pests. Furthermore, loss of fumigant from the chamber necessitates a top up of the fumigant, thereby using more product than otherwise would be required and increasing the cost of each treatment. For grain stored in silos, a well-sealed silo is considered sufficiently sealed if it takes more than 3 or 5 minutes to reduce the pressure by half in a full or empty silo, respectively (Annis, 2003).

Treatment chambers can be any sealed structure, be it a glasshouse, shipping container, custom built room or purpose built plastic bags. Typically, standard glasshouses and shipping containers require a significant amount of sealing and often remain somewhat ‘leaky’, however refrigerated containers (without the refrigerator unit) are often better (Justin Tumambing, personal communication). Sealing a glasshouse adds the capacity to treat plants during their growth (i.e. not just before being shipped) but is likely to be costly owing to large volumes of air in the glasshouse and relatively small volumes of plants. Therefore, it seems unlikely that glasshouses would be a cost effective treatment chamber for nursery producers.

Shipping containers have a high capacity to be modified for a wide variety of purposes and come in a range of standard sizes, including 10, 20 and 40 ft long. The size of the container is important as the same amount of gas is required regardless of the number of plants placed into the container. For the purposes of this report, 20 ft (6 metre) containers were used for costings because it is large enough to contain a large number of nursery plants but remains only 33 m<sup>3</sup> in volume. Smaller containers might be more feasible for growers shipping smaller volumes of plants. Second hand containers are commonly available and are adequate for serving as a treatment chamber. Non-refrigerated units cost about \$2 500 and \$4 000 used and new, respectively. Refrigerated units are insulated and have improved seals to reduce energy costs. Because the life of refrigerated shipping containers is limited, i.e. the refrigerator unit breaks down, non-operational units are often available through container companies, e.g. Royal Wolf or Port Container Services. Such units cost around \$4 000, as opposed to new, operational units which are often over \$30 000. Sometimes non-operational 20 ft containers cost more if they have been modified to have lighting or a side door; this can double the cost of the unit. Refrigerated, non-operational units are ideal because they are insulated and therefore temperatures will be easier to regulate, regardless of outside temperature. The size of the container modifies the cost marginally, for example, a 40 ft, refrigerated, non-operational unit is about \$6 500 - \$7 000.



These figures will vary with availability, supplier and brand; shipping containers are commonly available on Ebay.

It is always possible to seal an existing shipping container, similar to grain silos. Such an operation could cost \$3 000 (rough estimate from Silo Sealing and Waterproofing Pty Ltd).

Another fumigation chamber option is to use sealable, reusable Pali Store bags, either within a shipping container or protected structure. A frame is placed within the bags to maintain structure. Unfortunately, businesses that supply the bags have been unable to provide quotes at this time.

## FUMIGATOR LICENSING

Regulations surrounding the use of certain fumigants requires that the operator be licensed as a fumigator. Licensing requirements are different in each state, as are licensing fees (Table 2). It seems that the APVMA is trying to get fumigation accreditation and licensing to be standardised at a national level, however this may not eventuate for some time. Fumigation legislation, licensing fees and training fees are subject to change, therefore check with your licensing body before undertaking a particular training course to ensure that all prerequisite training is achieved.

Table 2. List of training courses available in each state and costs associated with licensing.

| State              | Prerequisite courses                                                                                            | Cost of courses                     | Course length                    | Licensing body                                    | Cost of license                                                                    |
|--------------------|-----------------------------------------------------------------------------------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------|
| Northern Territory | None available in NT                                                                                            | NA                                  | NA                               | NT Dept of Health <sup>1</sup>                    | \$20, valid for 1 year                                                             |
| NSW                | TAFE NSW 7219 <sup>2</sup> and TAFE NSW 9016 or equivalent                                                      | \$705 and \$345                     | 90 hrs and 2 days                | WorkCover Authority of NSW <sup>3</sup>           | \$40, valid for 5 years                                                            |
| Queensland         | PRMPM11B Conduct fumigation and fumigation manual and TAFE Open Learning Queensland assessment fee <sup>4</sup> | \$1 084<br><br>\$46<br><br>\$223.30 | 4 full days                      | Queensland Health <sup>5</sup>                    | \$225.50, for 1 year;<br>\$717.50, for 5 years                                     |
| South Australia    | Pest and weed unit - Steve Collins – 08 8372 6814                                                               | Not known                           | Not known                        | South Australia Department of Health <sup>6</sup> | Not required, although training may be required to purchase fumigants <sup>7</sup> |
| Tasmania           | Not available in Tasmania                                                                                       | NA                                  | NA                               | Tas DPIW <sup>8</sup>                             | \$27.20, valid for 1 year                                                          |
| Victoria           | Ag vet chemical user course <sup>9</sup>                                                                        | \$290                               | 2 days                           | DPI Victoria <sup>10</sup>                        | \$464.35, valid for 3 years                                                        |
| Western Australia  | Durack Institute of Technology <sup>11</sup><br>Or<br>Pest education services and training <sup>12</sup>        | \$1 500<br><br>\$2 500              | 3 day course<br><br>5 day course | WA Dept of Health <sup>13</sup>                   | \$140, valid for 1 year                                                            |

<sup>1</sup> [http://www.health.nt.gov.au/Environmental\\_Health/Poisons\\_Control/Pest\\_Control\\_Operators/index.aspx](http://www.health.nt.gov.au/Environmental_Health/Poisons_Control/Pest_Control_Operators/index.aspx)

<sup>2</sup> [www.tafensw.edu.au/](http://www.tafensw.edu.au/)

<sup>3</sup> <http://www.workcover.nsw.gov.au/licensing/Licencesandcertificates/Pestmanagementfumigations/Pages/default.aspx>

<sup>4</sup> <http://www.pestc.com.au/13.html>

<sup>5</sup> [http://www.health.qld.gov.au/industry/poisons\\_pest/default.asp#pmlicensing](http://www.health.qld.gov.au/industry/poisons_pest/default.asp#pmlicensing)

<sup>6</sup> <http://www.dh.sa.gov.au/pehs/drugs-poisons-licences.htm>

<sup>7</sup> [http://www.austlii.edu.au/au/legis/sa/consol\\_reg/csr2003450/index.html#s6](http://www.austlii.edu.au/au/legis/sa/consol_reg/csr2003450/index.html#s6)

<sup>8</sup> <http://www.dpiw.tas.gov.au/inter.nsf/WebPages/EGIL-52RV9Z?open>; <http://www.dpiw.tas.gov.au/inter.nsf/webpages/egil-52q2ya?open>

<sup>9</sup> <http://new.dpi.vic.gov.au/agriculture/education-training/agtrain/agtrain-registered-training-courses/agvet-chemical-user-course>

<sup>10</sup> <http://new.dpi.vic.gov.au/agriculture/farming-management/chemical-use/agricultural-chemical-use/licenses-permits/commercial-operator-licence>

<sup>11</sup> Geraldton Campus, Glenn Brennan 08 9964 2133 or 0418 939 640

<sup>12</sup> <http://www.pesteducation.com.au/>

<sup>13</sup> [http://www.public.health.wa.gov.au/3/1137/2/pesticide\\_licenses.pm](http://www.public.health.wa.gov.au/3/1137/2/pesticide_licenses.pm); <http://www.public.health.wa.gov.au/cproot/3773/2/Guide%20to%20Obtaining%20a%20Pest%20Management%20Technician%20Licence.pdf>

## HIGH PRIORITY TREATMENTS

### Controlled atmosphere (CA) and heat

#### *Registration*

Not required for carbon dioxide, oxygen or nitrogen, temperature and humidity (Anon., 2002).

#### *Background*

Controlled atmosphere (CA) treatments are those that change the gaseous components of the treatment chamber from air to a relatively extreme concentration of O<sub>2</sub>, CO<sub>2</sub> or nitrogen. Typically this involves increasing the amount of CO<sub>2</sub> and or decreasing the amount of O<sub>2</sub>. Nitrogen is usually used to make up the remainder. The exact mode of action of low O<sub>2</sub> and high carbon dioxide environments that causes death of insects and mites is not fully understood.

Low O<sub>2</sub> environments tend to cause insects to go into metabolic arrest. Metabolism decreases, reducing pressure to initiate anaerobic metabolism; anaerobic metabolism leads to rapid exhaustion of carbohydrate reserves and the accumulation of toxic end products (Mitcham et al., 2003). It seems that low O<sub>2</sub> environments which are sufficient to be insecticidal are those below the point in which anaerobic respiration is triggered (Mitcham et al., 2003).

High CO<sub>2</sub> concentrations (i.e. significantly higher than 0.04% CO<sub>2</sub>, which is the normal atmospheric CO<sub>2</sub> concentration) appears to have a similar overall effect as low O<sub>2</sub> environments. However, high CO<sub>2</sub> environments appear to inhibit respiratory enzymes which reduce the generation of ATP, as opposed to not having O<sub>2</sub> to produce ATP in the first place. Eventually, it is believed that this causes a failure of cell membrane function, with membranes becoming relatively permeable and the crash of cell function completely (Mitcham et al., 2003). High CO<sub>2</sub> concentrations also cause insects to open spiracles immediately and results in continuous respiration. This may also lead to uncontrolled water loss and dehydration (Alonso et al., 2005). The combined effect of low O<sub>2</sub> and high CO<sub>2</sub> is sometimes synergistic and sometimes not. Lack of synergistic effects was mostly associated with more extreme combinations, e.g. >40% CO<sub>2</sub> and less than 0.5% O<sub>2</sub> were not synergistic but combinations of 5-15% CO<sub>2</sub> and 2% O<sub>2</sub> were more likely to be synergistic (Mitcham et al., 2003).

Temperatures greater than about 30-35°C tends to affect all insect systems. Metabolism is altered, enzymes may bind to substrates in a different fashion and alter the efficacy of catalytic reactions. Different nerve chords respond to heat in different ways including, increased firing rate, altered firing pattern, unresponsiveness or may not be affected at all (Neven, 2000). Heat can cause abnormalities in the endocrine system by causing defects or delays in development with heat. Respiration generally increases with temperature to a critical upper limit, after which respiration decreases. Death generally occurs soon after respiration rates begin to drop, even if the individual is returned to normal thermal conditions. Sufficient oxygen is essential for insects to survive heat, perhaps because oxygen is essential for the production of ATP, which is used to

withstand the heat (Neven, 2000). Regardless of the exact cause of death, at any given atmospheric condition, relatively high temperatures are associated with shorter treatment durations and higher levels of mortality than cooler temperatures (Heather and Hallman, 2008). The main factor affecting the upper temperature that can be applied to a consignment is product tolerance; increasing temperature increases the risk of unacceptable phytotoxic effects, although risk may be lowered with CA treatments (see below).

CA treatments have also been successfully conducted at very low temperatures (<1-2°C), however such treatments are normally associated with a long exposure time, i.e. greater than 10 days. Such treatments are feasible when conducted during long transport times, i.e. international trade of fruit and vegetables, but are not feasible for nursery trade within Australia. For this reason, this section focuses on CA with higher temperatures, which are more suited to the needs of the nursery industry.

There is a large body of literature demonstrating that CA treatments can be effective to facilitate market access of horticultural crops. Yet commercial adoption of CA treatments has been limited, mainly due to inexpensive broad spectrum fumigant alternatives; CA is more expensive and far more specific. In addition, difficulties maintaining and supplying the CA conditions required during transport has also limited its adoption (the last of which is not relevant to nursery industry) (Mitcham et al., 2003). In general, treatment regimes have been developed for specific insect pests (or a small number of insect pests) to meet specific market access requirements; CA treatments are unlikely to ever result in a broad spectrum method for disinfestation.

### *Efficacy*

Controlled atmosphere treatments have been associated with 99 or 100% mortality of a wide variety of target pests including fruit flies, moth larvae, beetles, the green peach aphid, book lice, thrips, a cricket species, spider mites and an armoured scale (Appendix 1). The exact CA and treatment duration to achieve such mortality was highly variable, modified by target species and lifestage within a species; no one treatment was equally effective for all species. It is usual for one lifestage of each species to be more resistant than all others, although this may vary at different CAs (Heather and Hallman, 2008). In fact, a highly efficacious treatment for one species may cause very little mortality for another. Therefore, research must first be conducted to determine the most resistant stage of each species in question and then to develop a protocol to disinfest that stage *for each pest species that requires disinfestation* (Heather and Hallman, 2008). Testing is then required to confirm disinfestation for all lifestages that could be present in a commercial scenario. Thus, there is a large gap in knowledge for most Australian nursery pest species.

To make matters more difficult, reactions to increasing carbon dioxide levels may not follow a typical dose-response curve. Mortality rate is not linear with increasing carbon dioxide concentration but appears to have a species specific threshold, above which, mortality does not increase greatly (Heather and Hallman, 2008). Since there is a large body of research using CA and temperature as a pest disinfestation technique (Appendix 1, but it is not exhaustive by any means), the following examples are used to illustrate the above principles.

As stated above, the relationship between CO<sub>2</sub> concentration and mortality is often non-linear. Mortality of the green peach aphid, *Myzus persicae*, was investigated at 15 CO<sub>2</sub> treatment concentrations, ranging from 0% to 95%, all with 5% O<sub>2</sub> at 12°C for 40 hours (van Epenhuijsen et al., 2002). For treatments above 5% CO<sub>2</sub> some aphids became moribund for a number of days. Moribund aphids always died within 12 days after treatment. The percentage of moribund aphids was highest two days after treatment in treatments with 30-40% CO<sub>2</sub>, dropping significantly both above and below these concentrations. However, the overall percentage mortality (12 days after treatment) was always greater than 90% in treatments with CO<sub>2</sub> concentrations greater than 40%. Similarly, mortality of two psocid species (*Liposcelis* spp.) did not increase above about 85% for CO<sub>2</sub> concentrations greater than 45% at a fixed exposure period of 4 hours (Leong and Ho, 1995); 100% mortality was achieved by increasing the exposure time at various concentrations of CO<sub>2</sub>. In general, the number of days required for complete egg mortality decreased with increasing CO<sub>2</sub> concentration, however, was about twice as many days for one species as the other.

Mortality at various CAs for adult New Zealand flower thrips was investigated at 40 and 60% carbon dioxide, each at a number of O<sub>2</sub> concentrations (20, 12, 8, 2, 0.25 and 0% - although not all concentrations were always tested for 40 and 60% CO<sub>2</sub> for a given treatment duration), plus normal air controls, each at 0, 12, 24, 36 and 48°C each for a number of treatment durations (1, 2, 4 and 24 hours) (Carpenter et al., 1996). In addition, a 100% nitrogen treatment was conducted at each duration and temperature. At 48°C for 1 hour, all adults died in all treatments except in air (98.9% mortality). At 0°C and 12°C, mortality only reached 100% for one treatment, 60% carbon dioxide and 0% oxygen at 12°C for 24 hours (mortality was 94% at the same atmospheric conditions for 24 hours at 0°C). There were four treatments that reached 100% mortality at 24°C, all for 24 hour exposure time; 40% CO<sub>2</sub> and 2% O<sub>2</sub>, 60% CO<sub>2</sub> and each of 20%, 8% and 0% O<sub>2</sub>. Mortality for all other treatments at 24°C for 24 hours were very high (>95%) versus control mortality (about 28%). This indicates that more extreme atmospheres may not always produce greater mortality. At 36°C similar results were recorded. Generally, 60% CO<sub>2</sub> produced higher mortality than 40% at a given O<sub>2</sub> concentration, but not always, and lower O<sub>2</sub> concentration generally produced greater mortality at a given CO<sub>2</sub> concentration, but not always (Carpenter et al., 1996); sometimes mortality decreased at more extreme atmospheres. Similarly, the LT<sub>99</sub> (LT<sub>99</sub> is the time taken to achieve 99% mortality with a particular treatment) of the black field cricket was about 63 and 32 hours at 18% and 57% CO<sub>2</sub> (both at 20% O<sub>2</sub>, and all at 20°C), but the LT<sub>99</sub> increased to about 42 hours at 57% CO<sub>2</sub> and 12% O<sub>2</sub> (Stevenson and Hurst, 1995). Thus, dosimetry is extremely complex and interactions are normal.

Different developmental stages of any particular species insect are more or less resistant than other stages; most often, one stage is more resistant than all others for that species. For example, fourth instar larvae of three caterpillar species were all the most resistant stage, although different species were more or less resistant than each other (Neven, 2008; Johnson and Neven, 2010). By contrast, for an armoured scales, *Hemiberlasia* spp., adult insects were most resistant stage, taking an estimated 109 days to reach LT<sub>99,9968</sub> under controlled atmosphere cold storage (2% O<sub>2</sub>, 5% CO<sub>2</sub> at 0°C) on kiwi fruit.

Another complicating factor is that the most resistant stage can sometimes differ with specific controlled atmospheres. For example, third instar *Ctenopseustis obliquana* was most tolerant in 1.2% O<sub>2</sub>, but fifth instar was most tolerant in 4.2% O<sub>2</sub> (both at 40°C and 5% CO<sub>2</sub>) (Whiting et al., 1995). In addition, the most resistant stage may differ with host plant. For example, the most

resistant stages for codling moth (*Cydia pomonella*) and oriental fruit moth were the white-ring egg stage and third instar larvae on apples, respectively (Neven and Rehfield-Ray, 2006), but on peaches and nectarines, black-head egg stage and white-ring egg stage were most tolerant, respectively (according to estimated  $LT_{99}$  values with the same atmospheric conditions) (Neven et al., 2006).

CA can produce significant phytotoxic effects for some fruit and vegetables. For example, most pome and stone fruit do not tolerate less than 2%  $O_2$  or greater than 5%  $CO_2$  and lettuce is normally intolerant of even small amounts of  $CO_2$  (Heather and Hallman, 2008). A number of cut flowers have been tested in high  $CO_2$  atmospheres at 1°C for long term storage of stems and foliage. For example, a number of geraldton wax cultivars, red kangaroo paw and banksia were tested under various atmospheres and in general, long term storage in  $CO_2$  at 1°C decreased flower and foliage vase life significantly. At 15%  $CO_2$ , vase lives were comparable with controls stored in air. At 80%  $CO_2$ , vase lives were reduced to zero after 3.5 days (Seaton and Joyce, 1993). The results are not directly comparable to potted nursery plants but do illustrate that phytotoxic effects may be expected for some plant species under some extreme atmospheric conditions.

### *Implementation*

CA treatments are reliant on a well sealed fumigation chamber and maintenance of the concentration of each gas being applied. There are two options for delivering a known atmosphere, bottled gas or gas generators. Bottled gas is more feasible for research purposes in smaller treatment chambers, as relatively large bottles typically only store 5 m<sup>3</sup> and can cost \$40 or more. However, this would not be economically feasible in a shipping container that is greater than 30 m<sup>3</sup>. Therefore, generating and monitoring gas concentrations is more likely to be feasible for commercial implementation. At this time, businesses that supply equipment that could be used for commercial applications of CA have not returned quotes.

Heat can be maintained using a digital temperature controller (about \$900 for a controller accurate to  $\pm 1^\circ C$ ) linked to a domestic space heater.

### *Summary*

CA treatments have high potential as a quarantine treatment which is sustainable and unlikely to cause insect resistance. The major drawbacks include the species specific nature of CA treatments so that broad spectrum treatments are unlikely to be feasible. The treatment chamber must also be quite sophisticated, being able to seal extremely well (otherwise it is more difficult to maintain the required CA), add the correct amount of each gas and monitor the concentration of each gas within the chamber continuously. In addition, further research is required to develop a commercially viable method. Controlled atmosphere treatments are considered to be one of the most difficult to research and implement on a commercial scale and, for this reason, there is only one instance of commercial use worldwide (Heather and Hallman, 2008). There is also evidence that some phytotoxic effects could occur at extreme atmospheric conditions.

Although these challenges are significant, assuming that a successful method were developed, growers could have a treatment facility on site. Risks associated with CA (asphyxiation) are

relatively low and can be mitigated with appropriate actions, e.g. not entering the treatment chamber while it is in use and ensuring high ventilation after treatment.

## Phosphine

### *Registration*

Phosphine is registered in Australia under various trade names and formulations for insects in buildings and stored products and cut flowers. There are two gas products, ECO<sub>2</sub>FUME<sup>®</sup> and VAPORPH<sub>3</sub>OS<sup>®</sup> held by Cytec Australia Holdings Pty Ltd, and many solid tablet formulations. ECO<sub>2</sub>FUME<sup>®</sup> is a non-flammable cylinderised formulation of 2% phosphine and 98% CO<sub>2</sub> by weight, VAPORPH<sub>3</sub>OS<sup>®</sup> is 99.3% pure phosphine. ECO<sub>2</sub>FUME<sup>®</sup> is currently registered for adult and larval stages of aphids, thrips, light brown apple moth and other leaf rolling moths, earwigs, psocids and two spotted mites at a dose rate of 700 ppm for 15 hours at 15°C. Cytec have indicated that fumigation of eggs requires 2 days.

### *Background*

Phosphine fumigation is generally used in seeds, grains and stored products. Traditionally, phosphine fumigation has been conducted using solid formulations, but is now available in gaseous form either with CO<sub>2</sub> (a number of products are available) or nitrogen FRISIN<sup>®</sup> (Navarro, 2006) (the latter of which is not registered in Australia). Solid formulations can leave behind nuisance by-products (e.g. aluminium or magnesium powder residue) and must be inserted into the treatment chamber by probe (Heather and Hallman, 2008), however are much less expensive than gaseous treatments. Gaseous formulations have the advantage that they can be pumped directly into the treatment chamber and do not leave any residue.

Phosphine is extremely volatile and acts on two main enzymes, cytochrome oxidase and catalase. These enzymes regulate respiration, specifically oxygen entering mitochondria (Ducom, 2005). Thus, phosphine stops oxygen from entering the cell and leads to formation of super oxides which actually causes mortality (Ducom, 2005).

Treatment chambers must be extremely well sealed to prevent its escape, a concern from a human health perspective as it can kill if inhaled at sufficient dose. An air concentration of 0.3 parts per million (ppm) is considered safe in work areas over a 40 hour week (Bond, 1984) and detector tubes are commercially available in Australia. In addition, a leaky structure requires more phosphine to deliver the required dose. Phosphine also corrodes copper and copper alloy components. Therefore sensitive electrical and electronic equipment must be sufficiently protected or not contain copper.

Use of phosphine fumigation to disinfest stored product pests has typically required an extended exposure time, often 24-48 hours but sometimes up to 7 days at doses between 0.3 and 5 g m<sup>-3</sup>. Research with cut flower pests only required 4 to 6 hours, depending upon the pest species being tested.

Phosphine is currently used in Australia's grain industry, with about 80% of of cereal grains being treated with phosphine fumigation to meet market requirements for insect free grain. Resistance has become a major problem for many of the major grain insect pests, mostly as a result of poor management practices. In grain storages, phosphine is usually applied as a solid



tablet which can take up to four days to diffuse through the entire silo. Resistance has occurred through the widespread practice of fumigation in unsealed silos and storage structures. As a result, insect populations were often exposed to sub-lethal doses, allowing the rare individuals with some resistance genes to survive, leading to a greater proportion of the population to be resistant. Repeat fumigations also increased resistance as the susceptible insects died, allowing resistant individuals to dominate the population. In sealed silos, by contrast, all individuals, including those with resistance genes, are killed because they receive the appropriate dose for the entire dosage period<sup>1</sup>. The highest level of phosphine resistance has been recorded for the lesser grain borer (*Rhyzopertha dominica*), but has also occurred in other insects including the red flour beetle (*Tribolium castaneum*), sawtoothed grain beetle (*Oryzaephilus surinamensis*) and *Liposcelis bostrychophila* (Nayak and Collins, 2008; Pimentel et al., 2010).

### *Efficacy*

In stored products in large silos, 100% mortality of grain pests normally takes 10 days (7 days treatment, 1 day airing with fans and 2 days withholding period). However it can take up to up to 27 days (20 days of exposure and 7 days withholding), if the temperature is less than 25°C or airing is done without fans and volumes larger than 300 tonnes are being treated. The long exposure time is mostly due to constricted air flow and diffusion of phosphine in silos filled with grain. Also, long treatment times with a relatively low concentration can greater efficacy than short times with a high concentration (Bell, 1992). From a nursery perspective, the treatment time would likely be much shorter because plants take up less volume than grain (which is filled to a level). There are very limited tests of efficacy of phosphine on plant tissues, although there is some information available on the treatment of fruit.

A study investigating phosphine for disinfestation of cut flowers (Williams and Muhunthan, 1998) has shown promising results against an aphid, two species of caterpillars and non-egg stages of two spotted mite (Table 2). The results indicate that a number of common horticultural pests are susceptible to phosphine fumigation, with the notable exception of eggs of two spotted mite (TSM). Phosphine was shown to sometimes cause unacceptable phytotoxic effects (Williams and Muhunthan, 1998); of 19 cut flower varieties tested, four exhibited phytotoxicity. Carnations showed varying degrees of wilting and browning of the edges of their petals above 0.4 g m<sup>-3</sup> and leaves of *Protea neriifolia*, *P. longifolia* and *P. 'Pink Ice'* turned brown within 7 days post fumigation. Leaves of *Leucadendron* had some browning after 7 days with concentrations 0.9 g m<sup>-3</sup> and above. However, 15 varieties of glasshouse plants were reported as tolerant to phosphine fumigation at rates that achieved 100% mortality of *Plannococcus citri* mealybug (Monro and Upitis 1967, unpublished data reported in Bond, 1984). Furthermore, of 12 varieties of cut flowers fumigated with phosphine at (0.25 g m<sup>-3</sup> for 5 hours), only very minor phytotoxic effects were observed (Weller and Graver, 1998). On Protea 'Pink Ice', phosphine at 1 or 2 g m<sup>-3</sup> for 5 hours did not result in significant phytotoxic effects, but when treated for 15 both treatments caused stems were almost unmarketable (Weller and Graver, 1998).

Large scale fumigation tests have been conducted on *Tetranychus kanzawai*, TSM and *Eotetranychus sexmanulatus*. All stages of all three mite species were completely controlled at 1.5 g m<sup>-3</sup> for 24 hours at 15°C (Souma et al., 2002). No fruit injury or changes to fruit quality were observed. Grapefruit infested with Caribbean fruit fly, *Anastrepha suspensa* (Loew) was fumigated with phosphine at a range of doses and durations (Hatton et al., 1982). In general,

insects survived fumigation when treatment times were either too short or when dose rates were too low. However, when treatments caused 100% mortality, injury to grapefruit was severe including scalding, rind breakdown (including aging and pitting) and fruit with visible injury started to decay once held at room temperature (Hatton et al., 1982).

Table 2. Summary of phosphine disinfestation as reported in Williams and Muhunthan (1998).

| Pest species                                                            | Dose                                           | Exposure time (h) | Stage                                               | Mortality                   | Other effects                                                       |
|-------------------------------------------------------------------------|------------------------------------------------|-------------------|-----------------------------------------------------|-----------------------------|---------------------------------------------------------------------|
| Green peach aphid ( <i>Myzus persicae</i> (Sulzer))                     | 0.3 g m <sup>-3</sup>                          | 4.5               | Larvae<br>Adults                                    | 100%<br>100%                |                                                                     |
| Light brown apple moth ( <i>Epiphyas postvittana</i> (Walker))          | 0.3 g m <sup>-3</sup>                          | 4.5               | Larvae (5 <sup>th</sup> and 6 <sup>th</sup> instar) | 100%, but see other effects | 11 larvae (33%) survived for up to 8 days before they died.         |
| A leaf rolling tortricid moth ( <i>Strepsicrates ejactana</i> (Walker)) | 0.3 g m <sup>-3</sup><br>1.4 g m <sup>-3</sup> | 4.5<br>6          | Larvae<br>Pupae and larvae                          | Some (not reported)<br>100  | 8 larvae survived for up to 7 days before they died.                |
| Two spotted mite ( <i>Tetranychus urticae</i> Koch)                     | 1.4 g m <sup>-3</sup>                          | 6                 | Eggs<br>Adults and immatures                        | 28<br>100                   | Eggs that were not killed during fumigation survived to adult stage |

## Implementation

Cytec Australia Holdings suggest that ECO<sub>2</sub>FUME<sup>®</sup> up to 1.4 g m<sup>-3</sup> (935 ppm) does not cause any phytotoxic affects. A cylinder of ECO<sub>2</sub>FUME<sup>®</sup> costs \$373, plus GST, and contains 620 grams of phosphine. If a 6 metre shipping container were used as a fumigation chamber (about 33 m<sup>3</sup>), one cylinder could make 13 applications (a cost of about \$30/application). The change in weight of the cylinder is used to monitor how much product is applied to the treatment chamber, therefore 100kg scales accurate to 0.01 Kg are required (cost of less than \$300<sup>2</sup>). Other one-off costs include the treatment chamber itself (discussed above), ECO<sub>2</sub>FUME<sup>®</sup> delivery system and phosphine monitoring system (around \$2 500).

Cytec have suggested that they could collaborate to provide proof of concept during the early stages of research. In addition, research supporting shorter treatment times at higher temperatures for control of most resistant stages could then be registered for nursery plants. ECO<sub>2</sub>FUME<sup>®</sup> is only available through Cytec.

In addition, current registrations for use of gaseous phosphine require operators to be licensed (refer to licensing section above for costs in each state). Grain producers commonly hold such licenses to fumigate their product.

Use of phosphine in tablet form is far less expensive and does not require monitoring or delivery systems. To fumigate a 20 ft shipping container at  $1.4 \text{ g m}^{-3}$  would require about 50 tablets of phosphine, at a cost of about \$8. Grain producers mitigate risk associated with residue from tablets by drenching powder in detergent solution post-treatment (Philip Burrill, personal communication). In addition, phosphine tablets (e.g. Fumitoxin) are available from most agricultural suppliers and does not require a fumigation license. A personal safety phosphine monitor also can be worn and placed near the operators face (\$995 from Graitec Scientific). The monitor has an alarm at 0.3 ppm (can safely work at or below 0.3 ppm for 8 hours – equivalent to  $0.45 \text{ mg m}^{-3}$ ) and 0.6 ppm (should evacuate for at least 1 hour) and is useful to mitigate risk associated with the use of the product.

Phosphine in tablet form would be relatively inexpensive to research as there are devoted facilities and experts available (both at DEEDI) who are willing to collaborate in the development of a treatment for nursery plants.

### *Summary*

Phosphine is effective against a large variety of insect and mite groups when administered correctly. Under such situations, resistance in nursery production scenarios is unlikely to occur as it would only be administered once per consignment. Major drawbacks include phytotoxic effects to at least some plant species and poor efficacy on eggs, however ECO<sub>2</sub>FUME<sup>®</sup> formulation may reduce some of the phytotoxic effects because it is combined with CO<sub>2</sub>. However, ECO<sub>2</sub>FUME<sup>®</sup> is relatively expensive compared to tablet forms. It may be possible to develop a method that is not associated with phytotoxic effects using phosphine tablets. The extent of phytotoxic effects are unknown without specific test. In stored product situations, phosphine requires lengthy treatment durations, however it is likely that even large, well sealed containers with nursery stock would only require treatments in the order of hours, not days, as indicated by the 15 hour treatment of cut flowers at 15°C.

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<sup>1</sup> [http://www.dpi.qld.gov.au/26\\_4801.htm#Phosphine\\_resistance](http://www.dpi.qld.gov.au/26_4801.htm#Phosphine_resistance)

<sup>2</sup> [http://www.geckooptical.com/100kg\\_bench\\_scales\\_large.htm](http://www.geckooptical.com/100kg_bench_scales_large.htm);  
<http://discountscales.com.au/100kg-bench-scales-small>

## Ethyl formate

### Registration

There are currently three registrations in Australia under the names ORICA ERANOL<sup>®</sup> and VAPORFAZE eMate, for disinfecting packaged dry fruits, and VAPORMATE<sup>™</sup> for cereal grains, oilseeds, horticultural produce (post harvest only)-fruit, vegetables and flowers in sealed storage. VAPORMATE<sup>™</sup> is registered for a number of pest species including a spider mite (*Tetranychus pacificus*), western flower thrips (*Frankliniella occidentalis*), a leafroller, aphids and mealybugs with a 4 hour exposure time. ORICA ERANOL<sup>®</sup> is an old name, but is now sold as ethyl formate from Bronson and Jacobs Pty Ltd. VAPORFAZE eMate, although registered, is likely to become available in 2012 following appropriate experimental research.

### Background

Ethyl formate (EF) in liquid form has been used in a number of industries as a solvent for various substances including oils and greases and as a substitute for acetone. As a fumigant it has been used to disinfest a number of stored product pests, mostly grain pests. Fumigations with VAPORMATE<sup>™</sup> cannot be compared directly to fumigations with straight ethyl formate (EF) because the addition of CO<sub>2</sub> in VAPORMATE<sup>™</sup> changes pest mortality and plant phytotoxicity (van Epenhuijsen et al., 2007). VAPORMATE<sup>™</sup> uses liquid CO<sub>2</sub> as a solvent and propellant (marketed by BOC). This formulation is beneficial as it eliminates flammability (which was problematic in its pure form) and enhances the efficacy as an insecticide chemical (Ryan and Bishop, 2003).

Ethyl formate is a naturally occurring substance, found in fruits and vegetables and breaks down into naturally occurring levels of formic acid and ethanol found in food within hours after fumigation (Ryan and Bishop, 2003; Keenes et al., 2005). It is actually the formic acid which causes any phytotoxic effects, with biologically active areas being relatively susceptible (V. Haritos, CSIRO, personal communication). There are no withholding periods and it has a potential 'organic' status (Ryan and Bishop, 2003). There have been some phytotoxicity tests which have shown grapes, 'Bartlett' pears, strawberries and cherries are not sensitive to ethyl formate (Ryan and Bishop, 2003).

VAPORMATE<sup>™</sup> must be applied by certified person in Australia, the level of certification apparently differs across different states (V. Haritos, personal communication), and may allow for grower application with relevant training in a stored container (Lawrence, 2005).

### Efficacy

In a recent study, complete control of adult and immature onion thrips (*Thrips tabaci*) was achieved at very low concentrations (2.7 g m<sup>-3</sup>) after 2 hours on onions and leeks, however, eggs were not affected (van Epenhuijsen et al., 2007). Ethyl formate (EF) is generally considered to be an external pesticide and thrips generally lay eggs inside leaf tissue (although see below). No phytotoxic effects were found on onions or leeks up to 324 g m<sup>-3</sup>; rates above 324 g m<sup>-3</sup> for 6

hours on leeks had severe phytotoxic effects, turning leeks greyish-white (van Epenhuijsen et al., 2007).

Treatments on stored grain in silos is challenging because of relatively limited penetration ability of EF, although VAPORMATE™ formulation with CO<sub>2</sub> and forced flow techniques can improve uniform delivery in grain storages. Very high mortality (greater than 99.5%) was achieved against the red flour beetle and phosphine resistant lesser grain borer at 25°C for 3 and 24 hours with rates of 145 and 83 g/tonne, respectively (Damcevski et al., 2004). The rice weevil, *Sitophilus oryzae* required 207 g/tonne for 72 to achieve greater than 99.5% mortality (Damcevski et al., 2004). Tests using 34 g m<sup>-3</sup> EF and with 40-50% CO<sub>2</sub> (VAPORMATE™ has 11% CO<sub>2</sub> by volume) achieved 100% mortality of the confused flour beetle (*Tribolium confusum*), sawtoothed grain beetle and the Indian meal moth (*Plodia interpunctella*) over 48 hours at an average of about 20°C (Tarri et al., 2004). Similar results have also been achieved by Dojchinov et al. (2010) in stored wheat.

In Israel, VAPORMATE™ has been registered for use in the date industry. VAPORMATE™ was used to disinfect nitidulid beetles (*Carpophilus* spp.) from inside dates. Mortality reached 100% at 420 g m<sup>-3</sup> at 30°C, with large numbers being killed after emigration from dates caused by the fumigation (Finkelman et al., 2010). Tests on bananas have shown that VAPORMATE™ achieves 100% mortality of spider mites, mealybugs and soft scale insects and its eggs at about 150 g m<sup>-3</sup>, 80 g m<sup>-3</sup> and 24 g m<sup>-3</sup>, respectively, during a 10 day transport (the exact fumigation exposure time was not specified) (Krishna et al., 2005). However, EF at 20 g m<sup>-3</sup>, four of 12 cut flower varieties were shown to have unacceptable phytotoxic effects, but six were shown to have only very slight or no phytotoxic effects, although the exact type of damage was not specified (Weller and Graver, 1998).

### Implementation

Ethyl formate is commercially available in Australia in two forms, as a gas premixed with CO<sub>2</sub> (VAPORMATE™) and in liquid form. Ethyl formate in liquid form costs about \$15/kg (in 180kg drums). It would take about 4 kg to gain a concentration of 100 g m<sup>-3</sup> in a 20 ft shipping container, amounting to about \$60 of product. Bulk purchases, i.e. more than 4 tonnes, would reduce the cost to about \$11/kg. A bottle of VAPORMATE™ is 22kg with 166.7 g/kg of ethyl formate. It would take 21kg of VAPORMATE™ to gain a concentration of 100 g m<sup>-3</sup> in a 20 ft shipping container. In addition, the monitoring and delivery system for VAPORMATE™ costs about \$10 000. VAPORMATE™ is still under development but the cost has been estimated at about \$220 per bottle. Liquid ethyl formate does not require a fumigation license to apply, VAPORMATE™ does.

### Summary

Ethyl formate has high potential as a quarantine disinfestation treatment. Critical requirements remain testing all plants proposed to be included in treatments for phytotoxicity at rates/durations that cause 100% mortality of the pest/s in question. Fumigations must be conducted in a well sealed chamber to reduce loss of product. It is likely that ethyl formate could be adapted to produce a successful disinfestation method assuming that concentrations were relatively low, to reduce cost and phytotoxicity problems. It is also relatively natural and does not leave any

residue. Ethyl formate in liquid form would avoid fumigation licensing requirements and would be much cheaper than VAPORMATE<sup>TM</sup>.

## Vacuum and heat and or other fumigant

### Registration

Not required for vacuum alone, only required if combined with a fumigant which requires registration.

### Background

Low pressure (hypobaric) treatments have the same mode of action as low oxygen environments (Mbata et al., 2004), as discussed in the controlled atmosphere section above. Vacuum treatments are ideal for situations when other fumigation treatments are not suitable, e.g. resulting from unacceptable phytotoxic effects (Heather and Hallman, 2008). The use of vacuum to control insects dates back to Robert Boyle, about 350 years ago, where he studied the effects of low pressure on various organisms, although more robust tests in commercial situations did not occur until the early 1900s (Back and Cotton, 1925). Since then, considerable research has been undertaken showing that it can be used successfully in a number of scenarios, including pest control, storage of fruits and vegetables and lengthening the vase life of cut flowers. Low pressure (hypobaric) treatments have also been combined with fumigants, e.g. phosphine, CO<sub>2</sub> or other fumigant, to achieve a faster treatment at lower concentrations than would otherwise be required.

### Efficacy

Hypobaric treatments are similar to controlled atmosphere treatments in that there is species and stage specific susceptibility/tolerance. Of four grain pests tested at a range of pressures and temperatures, the lesser grain borer (*R. dominica*) was the most tolerant to vacuum at nearly all temperatures, and red flour beetle (*T. castaneum*) the most susceptible (Mbata et al., 2004). For the red flour beetle (*T. castaneum*), lesser grain borer (*R. dominica*) and Indian meal moth (*P. interpunctella*), eggs were found to be more resistant than larvae or pupae (however, pupae were significantly more resistant than larvae). The LT<sub>99</sub> for lesser grain borer eggs, pupae and larvae at 25°C were 176, 98 and 84 hours, respectively. At 40°C LT<sub>99</sub> was significantly reduced to 11, 8 and 6 hours, respectively. For the red flour beetle and Indian meal moth the LT<sub>99</sub> followed similar trends with the shortest treatment times between 2-4 hours at 40°C, all at 32.5 mm Hg (Mbata and Phillips, 2001). However, even within the egg stage there were developmental stages that were more or less tolerant to vacuum treatments; 24-hour old eggs were more tolerant to vacuum treatments than were eggs aged 3, 6, 12, 48, 72 and 96 hours for all species tested (Mbata et al., 2004). Also, like controlled atmosphere treatments, increasing temperature under vacuum tends to reduce the exposure time required to achieve 100% mortality (Locatelli and Daolio, 1993).

The host plant on which a pest is treated also influences mortality to any given treatment. A study of *Callosobruchus maculatus* indicated that shorter exposure times were required when

larvae of the beetle was reared on varieties of cowpea more susceptible to the pest; likewise, longer exposure times were required on more resistant varieties (Mbata et al., 2009). This means that care needs to be taken to test species on a number of different host plants to ensure that all scenarios are tested and cause the required level of mortality. In this case, the point was somewhat moot as eggs were the most resistant stage and required much longer exposure times than any larvae on even the most resistant host plant tested, and egg mortality was not influenced by host plant (Mbata et al., 2009).

Perhaps one of the most useful aspects of using low pressure treatments is when combined with a fumigant, e.g. CO<sub>2</sub>. For example, LD<sub>99</sub> (the dosage required to gain 99% mortality) of *T. castaneum* using propylene oxide (discussed below) were significantly reduced by about eight times when conducted under low pressure (100mm Hg) or in combination with 92% CO<sub>2</sub> (Navarro et al., 2004). For the lesser grain borer, vacuum alone at 37.5°C required between 54 and 59 hours (at 200 and 300 mm Hg, respectively) to achieve 99% mortality (Mbata et al., 2004). At a similar pressure (about 35 kPa or 263 mm Hg), with 98% CO<sub>2</sub> at 35°C, only 12 hours was required to achieve 100% mortality (Locatelli and Daolio, 1993). A similar reduction in exposure time was also achieved for *P. interpunctella* with the addition of 98% CO<sub>2</sub> at similar temperatures and pressures (Locatelli and Daolio, 1993; Mbata et al., 2004).

Vacuum (all at 37 mm Hg for the below study) and controlled atmosphere were investigated to control two aphid species (the currant lettuce aphid, *Nasonovia ribisnigri*, and the potato aphid, *Macrosiphum euphorbiae*) and a leaf mining fly on lettuce. The results indicate that 100% mortality was achieved for *N. ribisnigri* with vacuum, 6% CO<sub>2</sub>, at 5°C after 3 days, and after only 1 day at 10°C with CO<sub>2</sub> and vacuum. Complete mortality was also achieved after 1 day with vacuum and 100% nitrogen at 10°C (Liu, 2003). The potato aphid was not studied in as much detail, however, 100% mortality was achieved using 6% CO<sub>2</sub> alone, vacuum and CO<sub>2</sub> and vacuum with 100% nitrogen in a fixed duration of 4 days at 5° and 10°C (Liu, 2003). Incomplete mortality was achieved against the pupae of the leafmining fly (*Liriomyza langei*), which are the most resistant stage, under similar conditions and treatments as described above. The highest mortality was about 60% after 4 days at 10°C under vacuum and 6% CO<sub>2</sub> (Liu, 2003). Perhaps pupae being inside lettuce leaves produced some level of resistance. Use of vacuum, high CO<sub>2</sub> and ethanol vapour was ineffective at controlling various fruit flies when they were inside papaya; but treatments were highly lethal in petri dishes (Arevalo-Galarza and Follett, 2011).

### Implementation

Vacuum treatments chambers must be extremely well sealed. Therefore, purpose built facilities are required (modified shipping containers will not be sufficient). Such facilities include the ability to apply a variety of treatments, e.g. controlled atmosphere or some other fumigant simultaneous to vacuum and temperature. Because they are very specialised, they are expensive. At this time, a quote was only able to be obtained for a research facility (internal chamber 0.158 m<sup>3</sup>). A pair of the chambers cost about \$45 000USD from Vivafresh Pty Ltd. A quote for a vacuum system used to disinfest paper documents and insect collections was obtained from a European company, EXPM. Their system was slightly larger but would have to be modified to allow all of required treatment conditions (i.e. their facility could only control O<sub>2</sub> concentration, relative humidity and temperature) and cost 113 700€ (internal volume is about 4m<sup>3</sup>). It seems



likely that a commercial sized vacuum treatment chamber would be prohibitively expensive at this time.

### *Summary*

Low pressure (generally 300 mm Hg and below) at relatively high temperatures (e.g. 30°C) have great potential as a quarantine treatment to facilitate interstate trade, particularly for external pests. Like all treatments described in this report, individual pest species and stages of each species would require testing, as would product tolerance. Addition of CO<sub>2</sub> (or other fumigant) may help decrease lethal dose times required and or decrease required concentration of insecticidal fumigant, e.g. ethyl formate or ozone. However, these benefits may be outweighed by very expensive equipment required to conduct such treatments.

## **LOW PRIORITY TREATMENTS**

### **Heat or cold only**

#### *Registration*

Not required.

#### *Background and Summary*

Heat and cold treatments have been used as quarantine treatments for over 100 years (Heather and Hallman, 2008), particularly for stored products, fruit and vegetables. A great deal of research has been conducted in these systems and they are successfully used to facilitate international trade of a variety of produce. Only an extremely brief summary is provided here, beyond that described in the CA section above, because the feasibility of using heat and cold treatments in nursery stock is unlikely due to the reasons outlined earlier.

Cold treatments are generally completed at less than 3°C, although sometimes tests are conducted at 5 or 10°C. They are almost always associated with very long treatment times to produce 100% mortality of the pest in question, sometimes up to several weeks (Heather and Hallman, 2008). For this reason, they are not considered to be suitable for the nursery industry.

Heat treatments, by contrast, are generally very short, sometimes only hours, however temperatures almost always exceed 45-50°C (Heather and Hallman, 2008). There are a variety of methods of transferring heat to the commodity, the most common of which are vapor heat, water dipping and dry heat. In all cases, produce must be very durable to withstand the process. For this reason, heat treatments alone are not considered to be suitable for the nursery industry.

As described in other sections, modifying temperature is a powerful tool when combined with other treatments at more moderate temperature, i.e. not greater than 35-38°C, for nursery stock.

## Sulfuryl fluoride (also sulfuryl difluoride) (SF)

### *Registration*

Registered for control of insects in buildings and other structures including those used for storage of cereal grains, dried fruits and nuts under by Dow AgroSciences under the name ProFume<sup>®</sup> since 2007. However, the APVMA has recently announced that it will be phased out from Australia by an unspecified date<sup>3</sup> following the US EPA decision to phase out the product. The main cause for concern is that the use of SF, which breaks down into fluoride increases the level of fluoride exposure above that which is deemed safe.

### *Background*

SF has been used as a fumigant of buildings to control insects and rodents since the 1950s. Normally, it is used to control drywood termites (registration in Australia prohibits use of SF above 128 g m<sup>-3</sup>) where local measures are not feasible. It is highly efficient because of its extremely high penetrating ability. In fact, there are no known filters that can remove sulfuryl fluoride, thus controllers that enter a building being fumigated must use compressed air (Adler, 2006). More recently, SF has been used as a fumigant of stored food products, mainly cereal crops, dried fruit and nuts. One limiting factor is that it leaves a residue of fluoride in or on fumigated products, which is why it is being phased in the USA and Australia.

Formal tests of phytotoxicity on living plants are not widespread, although some websites claim that it is injurious to green plants, vegetables, fruits and tubers<sup>4</sup>, others sources say that it unlikely to be harmful to animals, plants or to the environment (APVMA, 2007), despite tests on animals to the contrary being reported in the same document. There is only one published scientific report that suggests rates at which buildings are fumigated causes injury to plants (Bond, 1984).

### *Efficacy*

SF has mainly been tested against beetles and moths, for which it is effective against all stages. For most species tested the egg stage is most resistant. Dose required for 100% mortality is highly dependent on temperature and length of exposure (Bell, 2006); 25–30 degrees being most effective (Bell, 2006; Heather and Hallman, 2008). Relatively low doses are possible if the length of exposure is relatively long, e.g. 2–4 days, which may be required for species that are most resistant to SF, e.g. the beetle *Ahasverus advena* (Coleoptera: Silvanidae) (Bell, 2006). Snails have also been shown to be controlled by SF (Mack and Barak, 2006), and it is approved for disinfestation of ticks on non-food items in the USA (Heather and Hallman, 2008). Studies of phytotoxicity of SF to lemons show that even low doses (10 mg/L) cause a low level of phytotoxicity and levels shown to cause 100% mortality of California red scale (*Aonidiella aurantiii*) cause unacceptable phytotoxicity.

### *Summary*

While SF is highly effective against a wide range of invertebrate species, it is likely to cause unacceptable phytotoxicity to nursery plants at necessary doses. The proposed requirement for only professional fumigators to conduct fumigating will also hinder the commercial viability of any method successfully developed using SF.

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<sup>3</sup> [http://www.apvma.gov.au/news\\_media/our\\_view/2011/2011-01-13\\_sulfuryl\\_fluoride\\_fumigant.php](http://www.apvma.gov.au/news_media/our_view/2011/2011-01-13_sulfuryl_fluoride_fumigant.php)

<sup>4</sup> <http://www.fluoridealert.org/pesticides/sulfuryl.f.vikane.epa.htm>; <http://npic.orst.edu/factsheets/sfgen.pdf>

## Propylene oxide

### *Registration*

Yes, for the control of microbiological spoilage caused by fungi, yeasts, moulds and bacteria in tree nuts.

### *Background and summary*

Propylene oxide (PPO) is a chemical used in the production of plastics and various substances including, polyether polyols, propylene glycol and propylene glycol ethers. It is also used to reduce bacteria, mould and yeast contamination in the production of spices, cocoa and some processed nutmeats. It boils at 35°C and is flammable as a gas, therefore it should be applied under low pressure in a CO<sub>2</sub>-enriched atmosphere.

In a recent study by Isikber et al. (2004), the LD<sub>99</sub> of Indian meal moth, *P. interpunctella*, eggs (the most resistant stage) using PPO was 15.3 mg l<sup>-1</sup>. However, a large portion of the fumigant was absorbed into nuts tested with the insect. Furthermore, it is considered to be a possible human carcinogen that can alter genetic material and cause impaired fertility (Lyondell, 1996).

No information is available on phytotoxicity. However, the hazards involved with using this fumigant, at this time, appear too great to warrant research into developing a potential disinfestation method for nursery plants.

## Carbonyl sulphide (COS)

### *Registration*

COS is not currently registered in Australia. Application for registration for control of certain stored product insect pests has been made by BOC.

### *Background and Efficacy*

The only commercial use of carbonyl sulphide (COS) is as an intermediate in the production of thiocarbamate herbicides. It is an organic compound which is released by deciduous and coniferous trees, as well as volcanoes, salt marshes and soil<sup>5</sup>. The fumigant was patented by CSIRO in 1992 and showed promise as a replacement for methyl bromide for use on grains and other stored products and durable agricultural commodities (Wright, 2000). While little research has been conducted, California red scale and codling moth egg mortality reached 87% with a relatively high dose (80 mg L<sup>-1</sup>) of COS for only 2 hours on lemons and nectarines (Aung et al., 2001). The colour of nectarine peeling was intensified and delayed fruit softening but did not change the quality of fruit, lemons were not adversely affected by COS fumigation. Efficacy tests of COS to control Mediterranean fruit fly in lemons showed that lemons tolerate between 12 to 16 hours exposure duration at a relatively high dose (70 mg/L) (Obenland et al., 1998). Complete control of Mediterranean fruit fly could be achieved with 60 mg/L for 6 hours. Long exposure times at high concentrations resulted in a strong objectionable odour for a number of days. Such an odour is very negative for food products but is unlikely to be a problem for nursery plants. All lifestages of the granary weevil (*Sitophilus granarius*) were controlled with 25 mg/L for 72 hours (EPA, 1997). Lower doses seem to be more feasible with longer exposure times (e.g. 8 mg/L for 48 hours) (EPA, 1997). A study of five stored product pests (moths and beetles) found that the confused flower beetle was most resistant, the most resistant stages (pupae and eggs) had an LT<sub>99.9</sub> of 24 hours with 750mg/L/H (Zettler et al., 1997). Furthermore, of 12 cut flower varieties tested with COS (15 g/m<sup>3</sup> for 5 hours), only 2 were damaged enough to become unmarketable; the remainder had extremely low phytotoxic effects (Weller and Graver, 1998).

### *Summary*

A limiting factor for use of COS in Australia is that it requires registration for use with nursery plants. Research to support such registration would provide the backbone for further work to facilitate interstate trade. The effect of COS on plants is not well-known. It seems likely that high concentrations (>100mg/L) for extended periods (days) are likely to cause unacceptable phytotoxic effects. However, there is reasonable evidence that shorter durations and lower concentrations may be effective.

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<sup>5</sup> [http://www.epa.gov/chemfact/s\\_carbns.txt](http://www.epa.gov/chemfact/s_carbns.txt)

## Hydrogen cyanide

### *Registration*

No registration in Australia.

### *Background, efficacy and summary*

Hydrogen cyanide (HCN) is one of the first fumigants that was heavily used under modern industrialisation for treating trees under tents (Bond, 1984). It was also used for cut flowers, dormant nursery stock and dried plant products but was superseded by methyl bromide. However, with restrictions on the use of methyl bromide, HCN has been reconsidered (Heather and Hallman, 2008). HCN is one of the most toxic insect fumigants and is very soluble in water, producing a dilute acid in water. Nursery stock treated with HCN must be very dry or be rinsed with water immediately to prevent burning by the acid and should be kept away from sunlight for several hours after treatment (Bond, 1984).

Hydrogen cyanide is a very fast acting and toxic poison, inducing asphyxiation if inhaled; it renders tissues unable to absorb oxygen (Bond, 1984). As such, it poses a very high health risk to people.

Preliminary research using HCN to disinfest oranges resulted in very high disinfestation rates of three pests and acceptable changes in fruit quality (Park et al., 2006). Tests on a range of cut flowers indicate that HCN produced significantly more phytotoxic effects than phosphine (HCN, 1.8 g/m<sup>3</sup>, 30 minutes; phosphine 0.25 g m<sup>3</sup>, 5 h) (Weller and Graver, 1998), although only 3 of the 12 flowers tested were considered unmarketable. Another study indicated that doses up to about 3 g/m<sup>3</sup> were safe for all but 2 of 17 cut flowers tested (Hansen et al., 1991). Standardisation across these studies, however, is questionable as conflicting results were reported on closely related varieties, e.g. protea 'Pink Ice' was considered unmarketable with 1.8 g/m<sup>3</sup> (Weller and Graver, 1998), but protea 'Pink Mink' was considered marketable with a dose of 5.3 g/m<sup>3</sup> (Hansen et al., 1991). It may be that species and varietal differences in tolerance to HCN is highly variable.

Fumigation with HCN poses numerous difficulties. From preparing a product for HCN fumigation (i.e. reducing water in the product) to post fumigation treatment of plants (i.e. keeping product out of sun and rinsing product). Treatments are likely to cause some phytotoxic effects. Furthermore, given the current climate of human health concerns surrounding application of deadly fumigants, it seems unlikely that HCN would make a viable treatment.

## **Carbon disulphide (CD)**

### *Registration*

Yes, as a bait for feral pigs.

### *Background and summary*

CD is an old fumigant dating back to the 1800s as a soil injection to control grapevine phylloxera (Bond, 1984). It can be used successfully against a variety of grain pests particularly when combined with CO<sub>2</sub> (Heather and Hallman, 2008). It is extremely explosive at relatively low temperatures and ignites readily from static electricity, electric motors etc; even the vapour contacting a steam pipe or an electric light bulb may be enough to cause ignition (Bond, 1984). In addition, fumigation of nursery plants is associated with severe injury or their death (Bond, 1984) and, therefore, it is not recommended in nursery situations

## **Methyl iodide**

### *Registration*

No, but it is used in Japan for treatment of timber (Heather and Hallman, 2008).

### *Background and summary*

Methyl iodide (MeI – also called iodomethane) is toxic to pests and has been considered as a replacement of methyl bromide. They are both in the same family of chemicals, however MeI is rapidly destroyed by UV light and therefore may not be associated with stratospheric ozone depletion (Ohr et al., 1996). It has mostly been researched as a soil fumigant of plant diseases where it has been shown to have equal or better control of fungi, nematodes and weeds (Ibekwe et al., 2010). MeI is also effective at achieving 100% mortality of a number of insect plant pests including aphids, red scale and moth species (Waggoner et al., 2000; Aung et al., 2001). MeI is sometimes associated with phytotoxic effects on lemons, but not nectarines, at doses required to cause 100% mortality of red scale (Aung et al., 2001). However, forced aeration of lemons for 24 hours post treatment dramatically reduced fruit phytotoxicity (Aung et al., 2004). Wheat treated with MeI caused unacceptable phytotoxic effects at relatively high concentrations (Waggoner et al., 2000).

Despite the notion that MeI could potentially be developed as a successful treatment for nursery plants, the fumigant is currently under scrutiny, worldwide, but particularly in the USA. It had been approved for fumigation of strawberries in the USA in 2007 but has now been put on hold due to human health risks associated with exposure to MeI. MeI is considered to be a human carcinogen, and can cause psychological disturbances, vertigo and weakness and may be mutagenic (WHO, 1999). As such, MeI is not considered to be a high potential fumigant for the nursery industry.



## Ozone

### Registration

No. However, it is designated as GRAS (Generally Considered As Safe) which may exempt it from registration requirements (Schneider et al., 2003).

### Background

Ozone is a powerful oxidant. It has been used longest in food processing as a water treatment to disinfect and eliminate odours, taste and colour. It can be generated by UV-light and electrical discharges in air. Ozone generation by electrical discharge is more cost effective and successful. Ozone generators spontaneously generate ozone and therefore there are no stores of toxic chemicals. It also rapidly breaks down leaving no residue on product or for disposal. It is also possible to neutralise ozone through techniques such as thermal activated charcoal and catalytic and chemical abatement (Mason et al., 2006). Ozone is very unstable and rapidly decays releasing one O<sub>2</sub> and a single oxygen atom which reacts with organic molecules, disrupting normal cellular activity and is why it is a potential fumigant and inhibits or eliminates fungal spores (Maier et al., 2006). It is such a powerful oxidiser it is sometimes associated with commodity injury and damages metals (which therefore requires special fumigation equipment) (Schneider et al., 2003; Heather and Hallman, 2008). It also has poor penetrating ability and is best employed as a surface sterilant.

### Efficacy

There has been considerable research into ozone as a fumigant of stored product pests (Table 3). These data indicate that 100% mortality of a range of pest insects can be achieved using relatively low doses of ozone, at least when exposure time is relatively long (2-4 days). None of the studies summarised in Table 3 observed unacceptable phytotoxic effects. In addition, there is an indication that sub-lethal doses of ozone can produce absolute sterility or significantly reduced adult emergence (Mason et al., 2006).

Only one study was found directly related to ornamental plants. Ozone in combination with CO<sub>2</sub>, high temperature and low pressure were tested against western flower thrips (WFT; *F. occidentalis*) and long tailed mealy bug (*Pseudococcus longispinus*) (Hollingsworth and Armstrong, 2005). High temperature (37.8°C), ozone concentration and low oxygen were found to be the most important factors; low pressure was not associated with significant increases in mortality for a given concentration of ozone, although the lowest pressure tested was only 440 mm Hg (Hollingsworth and Armstrong, 2005). Adult male WFT were most resistant to ozone (eggs not tested); ozone concentration of about 4000 ppm was required to achieve 100% mortality of all stages, except males – 98% mortality, in 60 minute trials at 37.8°C. When CO<sub>2</sub> was added (concentrations not known), 100% mortality of female WFT was achieved using 0 and 200 ppm of ozone. Near 100% mortality of female WFT was also reported with 37.8°C for

Table 3. The maximum mortality achieved using ozone with various treatment parameters against a number of stored product pests.

| Pest species                                                 | Ozone (ppm)                               | Duration                                                                                                        | Maximum % Mortality   | Stage                                | Exposure media                                | Reference                 |
|--------------------------------------------------------------|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------------------|--------------------------------------|-----------------------------------------------|---------------------------|
| <i>Oryzaephilus surinamensis</i>                             | 5                                         | 3 days                                                                                                          | 100                   | Adult                                | Small tubes                                   | (Mason et al., 2006)      |
|                                                              | 70                                        | 4 days                                                                                                          | 95<br>75              | Adult<br>Egg                         | Buried in wheat to 1-3m in depth              | (Bonjour et al., 2010)    |
| <i>P. interpunctella</i>                                     | 10<br>50                                  | 9 days<br>3 days                                                                                                | 100                   | Larvae                               | Small tubes buried in flour                   | (Mason et al., 2006)      |
|                                                              | 70                                        | 4 days                                                                                                          | 97<br>33              | Pupae<br>Egg                         | Buried in wheat to 1-3m in depth              | (Bonjour et al., 2010)    |
| <i>O. surinamensis</i> and <i>P. interpunctella</i> combined | 2 000<br>2 000<br>4 000<br>4 000<br>4 000 | 2 hours<br>2 hours<br>1 hour<br>1 hour<br>3 hours (1 hour of 100% CO <sub>2</sub> followed by 2 hours of ozone) | 100<br><br><br><br>75 | Adult and larval<br><br><br><br>Eggs | On or in dates<br><br><br><br>Petri dish      | (Niakousari et al., 2010) |
| <i>T. confusum</i>                                           | 5                                         | 5 days                                                                                                          | 100                   | Adult                                | Small tubes                                   | (Mason et al., 2006)      |
|                                                              | 10<br>50                                  | 12 days<br>4 days                                                                                               |                       |                                      | Small tubes buried in flour                   |                           |
| <i>T. castaneum</i>                                          | 10<br>50                                  | 9 days<br>6 days                                                                                                | 100                   | Adult                                | Small tubes buried in flour                   | (Mason et al., 2006)      |
|                                                              | 50<br>70                                  | 4 days<br>2 days                                                                                                | 100<br>100            | Adult<br>Egg                         | Buried in wheat to 1-3m in depth              | (Bonjour et al., 2010)    |
|                                                              | 47 800                                    | About 5-6 minutes (3 passes through system)                                                                     | 100                   | Adult                                | In nylon mesh bag among corn on conveyor belt | (McDonough et al., 2011)  |
|                                                              |                                           |                                                                                                                 |                       |                                      |                                               |                           |
| <i>Sitophilus zeamais</i>                                    | 10<br>50                                  | 4 days<br>3 days                                                                                                | 100                   | Adult                                | Small tubes buried in flour                   | (Mason et al., 2006)      |
|                                                              | 47 800                                    | About 5-6 minutes (3 passes through system)                                                                     | 100                   | Adult                                | In nylon mesh bag among corn on conveyor belt | (McDonough et al., 2011)  |
| <i>S. oryzae</i>                                             | 25<br>50<br>70                            | 4 days<br>2 days<br>4 days                                                                                      | 100<br>100<br>90      | Adult<br><br>Egg                     | Buried in wheat to 1-3m in depth              | (Bonjour et al., 2010)    |
|                                                              |                                           |                                                                                                                 |                       |                                      |                                               |                           |
|                                                              |                                           |                                                                                                                 |                       |                                      |                                               |                           |
| <i>R. dominica</i>                                           | 70                                        | 4 days                                                                                                          | 95<br>90              | Adult<br>Egg                         | Buried in wheat to 1-3m in depth              | (Bonjour et al., 2010)    |

| Pest species                                           | Ozone (ppm)                      | Duration | Maximum % Mortality     | Stage                           | Exposure media                                 | Reference                           |
|--------------------------------------------------------|----------------------------------|----------|-------------------------|---------------------------------|------------------------------------------------|-------------------------------------|
| <i>C. ferrugineus</i>                                  | 70                               | 4 days   | 85<br>73                | Adult<br>Egg                    | Buried in wheat to 1-3m in depth               | (Bonjour et al., 2010)              |
| <i>Liposcelis bostrychophila</i>                       | 70                               | 1 days   | 100<br>90               | Adult<br>Egg                    | Petri dish on top of grain in a small cylinder | (Bonjour et al., 2010)              |
| <i>L. paeta</i>                                        | 70                               | 1 days   | 100<br>96               | Adult<br>Egg                    | Petri dish on top of grain in a small cylinder | (Bonjour et al., 2010)              |
| <i>Hypothenemus hampei</i> , coffee berry borer        | 10 000 (under 300 mm Hg at 13°C) | 6 hours  | 100                     | All stages                      | 'Industry conditions'                          | (Armstrong et al., 2003)            |
| <i>Ephestia kuehniella</i> (Lepidoptera)               | 300                              | 2 hour   | 100<br>100<br>100<br>85 | Adult<br>Pupal<br>Larval<br>Egg | Small glass jar                                | (Isikber et al., 2007)              |
| WFT                                                    | 500<br>1 100<br>2 000            | 1 hour   | 76.6<br>94.8<br>100     | Pupae                           | Petri dishes                                   | (Hollingsworth and Armstrong, 2005) |
| <i>Pseudococcus longispinus</i> (long-tailed mealybug) | 100<br>200                       | 2 hours  | 96.7<br>99.5            | All stages                      |                                                |                                     |

60 minutes under 100% nitrogen and no ozone; humidity greater than about 45% reduced mortality rates significantly. Long tailed mealy bug was more resistant to all treatments, no treatment reaching 100% mortality. Greater than 95% mortality of long tailed mealy bug was achieved with 200 ppm ozone for 90 and 120 minutes and 400 ppm ozone for 60 minutes, both at 37.8°C with CO<sub>2</sub>. Third and fourth instar mealy bug nymphs were the most resistant stage tested (eggs were tested). The study is valuable but did not include treatment times greater than 2 hours nor lower than 440 mm Hg. Therefore, it is possible that a more successful combination could be achieved at lower pressure and or for a longer duration, e.g. 6 hours.

A number of potted plants, cut flower and foliage were also tested for phytotoxicity from treatment with ozone (Hollingsworth and Armstrong, 2005), including *Anthurium* hybrid cut flowers, *Cordyline terminalis* cut foliage, Croton (*Codiaeum variegatum*) cut foliage, various orchid cut flowers and potted plants, *Guzmania* hybrid potted plants and red ginger (*Alipnia purpurata*) cut foliage and flowers. All plants tested had at least slight, unacceptable phytotoxic effects at doses tested (minimum of 200 ppm of ozone), including pitting and browning of leaves, sunken black spots, burning of root tips and water-soaked streaks in leaves. Phytotoxic effects sometimes were not apparent until 6-7 days after treatment. Concentrations between 200 and 400 ppm were relatively slight compared to higher doses. Waxy parts of plants tended to be free from damage, e.g. inflorescences of red ginger and orchid flowers (Hollingsworth and Armstrong, 2005).

It is possible that insect behaviour could be altered as a by-product of ozone fumigation. Studies have been conducted on insect preference, performance and reproduction on plants fumigated with very low ozone concentrations (to simulate levels of atmospheric ozone pollution), i.e. between 0.2 ppm and 75 ppb. The number of eggs laid by two beetle species decreased when they were fed leaves from increasing ozone concentrations (Coleman and Jones, 1988; Barger et al., 1992). Caterpillars showed extended larval development when fed ozone fumigated leaves from one of three plants tested (however the same pupal weight was attained) (Jondrup et al., 2002). Chrysomelid beetle leaf consumption was reduced when fed ozone fumigated leaves, but no significant result was obtained from parameters measured on two aphids in the same system (Whittaker et al., 1989). No one has investigated insect parameters from foliage that has been fumigated with relatively high levels of ozone.

### *Implementation*

Ozone is typically generated using corona discharge (electricity) or UV waves. The UV method is less expensive but produces concentrations which are too low for pest disinfection purposes. Ozone generators using corona discharge must be connected to an oxygen source to gain relatively high levels of ozone (i.e. 10-20 g/hr of ozone). Such a system might cost \$6 300 for the ozone generator, \$1 800 for the oxygen generator and at least \$3 000 for an ozone monitoring system (quote from Oxyzone).

### *Summary*

Commercialisation of ozone treatments may be limited due to 1) its reactivity with metals; special fumigation chambers are required and 2) the tendency for ozone fumigation to produce unacceptable phytotoxic effects at concentrations required to achieve 100% mortality. Ozone has potential as a phytosanitary treatment at very low concentrations if it is used as one component of the treatment, e.g. in combination with CO<sub>2</sub> and perhaps low pressure treatments. Given the costs associated with the system it seems unlikely that ozone will be a feasible disinfection treatment.

## **Low-Dose Gamma Irradiation**

### *Registration*

Not required, but irradiation can only be administered at three locations in Australia; Brisbane, Sydney and Melbourne by Steritech Pty Ltd.

### *Background and Summary*

A great deal of research has been conducted on the use of low dose gamma irradiation to disinfest fruit, vegetable and stored product pests and there is growing support for a generic 400 Gray (Gy) dose to eliminate all arthropod pests except Lepidoptera pupae and adults (Follett, 2009). Lower doses are sufficient for certain pest groups on certain types of fruit (e.g. various fruit flies between 70-100 Gy, sweet potato weevil at 150 Gy and mango seed weevil 300 Gy, but see Follett (2009) for a complete list); the exact dose that kills or sterilizes a particular group of pest and does not adversely effect the commodity is the subject of a great deal of research (Karnkowski, 2004; Arvanitoyannis et al., 2009; Follett, 2009). In general, the method is gaining considerable support as a quarantine treatment of fruits in Australia and around the world (Follett, 2009).

Use of low dose irradiation in cut flowers has also had some success as a quarantine treatment. For example, flowers of certain orchid species would tolerate doses of up to 750 Gy, well above that required to sterilize or kill arthropod pests. However, doses of 300 Gy caused flowers of other species of orchids to drop from stems or would inhibit bud opening (Kikuchi, 2000). There are limited published data on irradiation of whole plants, although what little there is indicates that unacceptable phytotoxicity may occur (Hara et al., 2002). Extensive test of the effect of two doses of irradiation (300 and 650 Gy) on 20 nursery plant species commonly shipped interstate has recently been completed (Manners and Ashford, unpublished data). Severe phytotoxic effects were observed on almost all plant species for both levels of irradiation. The most common symptoms included leaf chlorosis, leaf and flower abscission, leaf death, death of stems and plant death. Irradiated individuals that were in a saleable condition at the end of the study period were not able to reshoot when pruned at ground level (controls reshot vigorously). As such, gamma irradiation of  $\geq 300$  Gy can not be considered as a viable quarantine treatment to facilitate interstate or international movement of living potted plants. It may be possible to develop a method using irradiation of plants at lower doses. However, the practical and economic costs associated with using such a method, once developed, are probably too high to be worth investigating at this time in Australia.

## CONCLUSION

The treatments discussed above certainly indicate that a method can be researched as an alternative to standard chemicals to facilitate market access within Australia. Phosphine and ethyl formate are the cheapest options, in terms of the cost of the product and equipment required to carry out fumigations. However, phosphine is basically a gaseous chemical which is synthetically produced. This begs the question, why use phosphine when standard chemicals exist that are cheaper and easier to apply? Ethyl formate is similar, being a synthesised product, but breaks down into natural products. It probably could not be classified as organic because it is synthesised, but is much closer than phosphine. Both of these products would be relatively easy to research as there are current programs researching their use in Australia. The critical questions are:

- 1) Is there a need for such products?
- 2) Would growers actually use such products?

Methods that are truly organic, e.g. vacuum and controlled atmosphere, are costly to research and implement on a commercial scale. It seems likely that research of such methods will only occur when it becomes clear that standard pesticides are not sufficient to gain market access or when there is a very large demand for 100% organic products.

If research is to be conducted into any of the methods discussed in this report, it must first be established under what scenarios growers would switch to the new method. Otherwise we risk researching a method for which no growers will use because it costs more than methods currently available. If financial constraints were no object, controlled atmosphere and/or vacuum technologies represent a powerful, low risk, organic method of disinfesting plants which could be very valuable to have completed before standard chemical failure (be it from deregistration or insecticide resistance).

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## APPENDIX 1

### Summary of studies that used controlled atmosphere treatments to disinfest horticultural or stored product pests.

| Method category                        | Method details                                                                                                                                                                                                                         | Pest                                                                                                  | Host                         | Efficacy                                                                                                                                                                                                        | Phytotoxic effects                                                                                                                                      | Other comments (feasibility with living plants?)                                                                                                                                                                                                                                                                     | Reference                                          |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| High CO <sub>2</sub> and constant temp | Perspex cabinets on fruit. 95% CO <sub>2</sub> with pretreatments of 25, 20 and then going to 1.5°C.                                                                                                                                   | <i>Ceratitis capitata</i> Wiedemann (Diptera: Tephritidae) Third instar larvae.                       | Citrus – ‘Fortune’ mandarins | At 1.5° took 10 days to have complete mortality. With 25 and 20° pretreatment , it took 5 and 4 days less to 100% mortality.                                                                                    | Marginal changes occurred to maturity index, colour, juice yield and other fruit characters.                                                            | CO <sub>2</sub> acts directly on insect’s spiracles in 2-3% to open spiracles immediately and results in continuous respiration. Sustained opening can lead to uncontrolled water loss and dehydration. May be a threshold of a optimal temperature and CO <sub>2</sub> percentage to cause best quickest mortality. | (Alonso et al., 2005)                              |
| High N <sub>2</sub> and high temp      | Tests conducted in small chambers and in fruit with air at 47°, with 99% N <sub>2</sub> and O <sub>2</sub> at 1kPa or, air for the first 55 minutes and then N <sub>2</sub> and O <sub>2</sub> as above.                               | Mexican fruit fly. <i>Anastrepha ludens</i> (Loew) (Diptera: Tephritidae). Third instar larvae        | Grapefruit.                  | The relationship between time and delay of modified atmosphere and estimated time to 99% mortality was not linear; 157, 127 and 141 minutes respectively.                                                       | Not described.                                                                                                                                          | Delay of modified atmosphere may have greater benefit against pests entirely exposed to ambient atmospheres, i.e. not in fruit                                                                                                                                                                                       | (Hallman, 2010)                                    |
| High CO <sub>2</sub> and temp          | Each stage of insect placed in individual compartments at two rates of increasing temperature (above water bath) 12° and 24°C increase/hr to a max of 47°. Ran tests under air and CO <sub>2</sub> . Test ran for a maximum of 2.5 hrs | <i>Thaumotobia leucotreta</i> (Meyrick) (Lepidoptera: Tortricidae)                                    | None                         | CO <sub>2</sub> environment increased mortality significantly. Different stages were more or less resistant to heat and CO <sub>2</sub> treatment                                                               | NA                                                                                                                                                      | <i>T. leucotreta</i> more resistant than other moths studied by the authors.                                                                                                                                                                                                                                         | (Johnson and Neven, 2010)                          |
| High CO <sub>2</sub> and temp          | Tested different stages of two moths. Compared CO <sub>2</sub> to air environment heating from 23 to 45.5°C over 1 hour.                                                                                                               | Codling moth, <i>Cydia pomonella</i> (L.), and oriental fruit moth, <i>Grapholita molesta</i> (Busck) | None                         | Heat only treatment wasn’t effective. CO <sub>2</sub> treatment: Against codling moth it was 100% effective. Fourth instar oriental fruit moth were most resistant 97% mortality, other instars 100% mortality. | Fine for fruit. No comment for other horticultural crops                                                                                                | Comparisons to fruit infested with various stages may differ from data recorded here probably because larvae have the option to seek out a ‘safer’ place in the fruit.                                                                                                                                               | (Neven, 2008)                                      |
| High CO <sub>2</sub> and temp          | Tested various stages of two moths on infested apples. Small scale and commercial trials to a maximum of 46°C and 15% CO <sub>2</sub> , 1% O <sub>2</sub> .                                                                            | Codling moth and oriental fruit moth                                                                  | Apple, peach and nectarines  | Fourth instar was found to be most resistant for both species. However, heat and CO <sub>2</sub> treatment in commercial trial was found to be 100% effective in about 3 hrs                                    | Fruit were more firm in heat plus CO <sub>2</sub> environment compared to heat alone. There were some differences in fruit parameters across varieties. | None.                                                                                                                                                                                                                                                                                                                | (Neven and Rehfield-Ray, 2006; Neven et al., 2006) |
| High and                               | See right                                                                                                                                                                                                                              |                                                                                                       | Various                      | For bioassay insects, 14 days storage at 1 °                                                                                                                                                                    | Vase life of red kangaroo paw                                                                                                                           |                                                                                                                                                                                                                                                                                                                      | (Seaton and Joyce,                                 |

| Method category               | Method details                                                                                                                                                       | Pest                                                                                                                                      | Host                             | Efficacy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Phytotoxic effects                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Other comments (feasibility with living plants?)        | Reference                      |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|--------------------------------|
| low temp, various CO2         |                                                                                                                                                                      |                                                                                                                                           |                                  | C was required for 100% kill of adult flour beetles ( <i>Tribolium confusum</i> Koch.), and 10 days at 1 ° C killed 100% of Mediterranean fruit fly larvae ( <i>C. ccapitata</i> ). A CO2 enriched atmosphere of between 45% and 60% (11% and 8% O2, respectively) reduced the time required to achieve 100% mortality of these bioassay insects to 7 days at 1 °C. Increasing the CO2 content of the atmosphere to 80% (4% O2) did not further reduce the time to achieve 100% mortality. | (Anigozanthos rufus) was reduced below that of the unstored control after just 3.5 days at 1 ° C. Geraldton wax ( <i>Chamelaucium uncinatum</i> ) cultivar 'Newmarracarra' was similarly affected after 14 days, and acorn banksia ( <i>Banksia prionotes</i> ) after 28 days. Vase lives of Geraldton wax cultivar 'Newmarracarra' and of red kangaroo paw were not reduced following 7 days storage at 1 °C in 15% CO2, compared with controls stored in air. However, Geraldton wax and red kangaroo paw vase lives were shortened and flower colour was altered after storage for 7 days in 30% CO2 (15% O2). Geraldton wax and red kangaroo paw had no vase lives following storage in 80% CO2 (4% O2) at 1 °C for 3.5 days. Heat treatments of hot water dips (46°C for 30 min or 56°C for 10 min) and vapour heat (66°C for 10 min) killed 100% of adult flour beetles and Mediterranean fruit fly larvae, but damaged and shortened the vase lives of Geraldton wax and banksia. |                                                         | 1993)                          |
| High temp and CO2             | 41°C, 1% O2, 12%CO2 for 16h.                                                                                                                                         | fig moth ( <i>Ephesia cautella</i> ), Indian meal moth ( <i>Plodia interpunctella</i> ), and dried fruit beetle <i>Carpophilus</i> spp.). | Fig fruit                        | All insects were dead after first assessment, 6 hours after the end of the experiment.                                                                                                                                                                                                                                                                                                                                                                                                     | Some changes in quality, some neutral some positive, compared to MB treatment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Insects often left fruit during the heat/CO2 treatment. | (Sen et al.)                   |
| High temp and CO2, various O2 | Fruit treated at 44°C in 1% O2 and air with 20% CO2                                                                                                                  | Mexican fruit fly, <i>Citms paradise</i> Macf.                                                                                            | Grapefruit                       | Mortality of third instar larvae was highest at 44°C in 1% oxygen, compared to the same temperature in air or in air enriched with 20% CO2. Reducing to 1% oxygen reduced exposure time to achieve 100% larval mortality from 5 to 3.5 hours.                                                                                                                                                                                                                                              | Inconsistent fruit quality.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | None                                                    | (Shellie et al., 1997)         |
| High CO2 and temperature      | Tested varying temperatures between 39-45°C and 60% and 95% humidities in air 0.5% oxygen in nitrogen, 10% carbon dioxide in nitrogen and 98% carbon dioxide in air. | Diapausing larval coddling moth <i>Cydia pomonella</i> (L.)                                                                               | None, but collected from walnuts | Increasing temperature reduced the time required to LT <sub>95</sub> for all treatments. 98% carbon dioxide was the most effective treatment at all temperatures, followed by the other two modified atmospheres (not significantly different from each other) and air. Relatively low humidity caused greater mortalities than high humidities.                                                                                                                                           | NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | NA                                                      | (Soderstrom et al., 1996)      |
| High carbon dioxide at 12°C   | Tested various levels of carbon dioxide between 9% and 95%, with 5% oxygen at 12°C for 40 hours.                                                                     | Green peach aphids, <i>Myzus persicae</i> (Sulzer)                                                                                        | None, but reared on rape plants  | Concentrations of carbon dioxide between 20-60% caused 30% of treated aphids to be moribund after 2 days. Above 40% carbon dioxide, mortality neared 100% 12 days after treatment. However, moribund aphids had limited responses to stimuli, even                                                                                                                                                                                                                                         | NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | NA                                                      | (van Epenhuijsen et al., 2002) |

| Method category                                 | Method details                                                                                                                                                   | Pest                                                                                                                                                | Host                                   | Efficacy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Phytotoxic effects                                                                                                                       | Other comments (feasibility with living plants?)                                                                                                                                                                                                                                                                                                                                | Reference                  |
|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
|                                                 |                                                                                                                                                                  |                                                                                                                                                     |                                        | though death was immanent.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                 |                            |
| CO2 and various temperatures                    | Tested various carbon dioxide concentrations on eggs. Discusses other literature relating to the pests                                                           | Book lice. <i>Liposcelis entomophila</i> (Enderlein) and <i>L. bostrychophila</i> Badonnel (Psocoptera: Liposcelididae)                             | None                                   | Eggs were found to be the most resistant stage of these pests. Four hour treatments did not produce an increase in mortality for concentrations greater than 45% carbon dioxide. It was predicted to take 4 days at 90% carbon dioxide to achieve complete egg mortality. With 24 hour treatment times, there was no reduction in egg hatch, however, adult emergence was reduced inversely proportional to carbon dioxide concentration. Carbon dioxide concentrations between 60-80% were more effective in controlling the pests than higher concentrations without oxygen. Increased exposure time was more effective in control of adult book lice than increased carbon dioxide concentration. <i>L. entomophila</i> eggs were more than twice as susceptible to CO2 treatment than <i>L. bostrychophila</i> | NA                                                                                                                                       | At concentrations less than 30% CO2, complete mortality was not achieved even after 72 hours. At 40% CO2 the time to control <i>L. bostrychophila</i> was more than 8 d at 10°C and 12 days at 15°C. Other results indicate that higher temperatures reduced mortality at a given concentration of CO2. However, complete kill of adults could be achieved in 1 day at 90% CO2. | (Leong and Ho, 1995)       |
| Various heat treatments and high carbon dioxide | Tested various methods of heating fruit (hot water, vapour saturated air and vapour pressure deficit air on fruit fly mortality on four types of fruit.          | Mexican fruit fly, <i>A. ludens</i>                                                                                                                 | Mango, papaya, grapefruit and orange   | 100% mortality could not be achieved in infested fruit with hot air treatments. Hot water and control atmosphere treatments were able to achieve 100% mortality after 4.5 hours.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Commodity tolerance was enhanced when a water vapour pressure deficit was maintained in the heating medium; i.e. the fruit remained dry. | NA                                                                                                                                                                                                                                                                                                                                                                              | (Shellie and Mangan, 2000) |
| High CO2 and temp                               | 40 or 60% CO2, Air and Nitrogen atmospheres with varying oxygen concentrations at a range of temperatures between 0°C and 48°C for 1, 2, 4 and 24 hours duration | New Zealand flower thrips, <i>Thrips obscuratus</i> (Crawford)                                                                                      | None                                   | A variety of temperatures, durations and atmospheres caused 100% mortality. There was 100% mortality for all treatments at 48°C (even 1 hour). At 24°C, 100% mortality was only achieved after 24 hours in a variety of controlled atmosphere conditions (40% CO2 and 2% O2; 60% CO2 and 20%, 8% or 0% O2). At 36°C 100% mortality was achieved with many treatments and there was little consistency, however 0% oxygen often produced 100% mortality at 36°C.                                                                                                                                                                                                                                                                                                                                                    | NA                                                                                                                                       | No clear pattern of variation in how insects respond to variation in levels of CO2 and O2                                                                                                                                                                                                                                                                                       | (Carpenter et al., 1996)   |
| Low temp and high CO2                           | 45% CO2 and either .5% O2 or 11.5% O2 or air over varying lengths                                                                                                | <i>Platynota stultana</i> Walsingham (Lepidoptera: Tortricidae), <i>Tetranychus pacificus</i> McGregor (Pacific spider mites), <i>Frankliniella</i> | Table grapes pests – but no host used. | 0°C was more effective than 5°C in virtually every case. There was variation in efficacy across species and stages within a species. 11.5% O2 was more effective for <i>P. stultana</i> gaining 100% mortality after 4-6 days; 11.5% O2 was more effective for <i>T. pacificus</i> , sometimes achieving 100% mortality after 6-8 days; 11.5% O2 more                                                                                                                                                                                                                                                                                                                                                                                                                                                              | NA                                                                                                                                       | Different species and stages responded differentially to different temps and atmospheric conditions.                                                                                                                                                                                                                                                                            | (Mitcham et al., 1997)     |



| Method category                                                                       | Method details                                                                                                                                                          | Pest                                                                                              | Host           | Efficacy                                                                                                                                                                                                                                                                                                                                                                                                                        | Phytotoxic effects                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Other comments (feasibility with living plants?)                                     | Reference                   |
|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------|
|                                                                                       |                                                                                                                                                                         | <i>occidentalis</i> Pergande – western flower thrips                                              |                | effective WFT – 100% mortality after 4-6 days.                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                      |                             |
| Various concentrations of CO <sub>2</sub> and O <sub>2</sub> for differing durations. | 5, 9, 18, 30 and 57% CO <sub>2</sub> with 20% O <sub>2</sub> . 57% CO <sub>2</sub> with 12% O <sub>2</sub> . For 2 to 48 hours.                                         | <i>Teleogryllus commodus</i> Walker (Orthoptera: Gryllidae)                                       | NA             | Exposure time and CA significantly affected mortality. Estimated exposure time required to achieve 99% mortality was 62.8 hours for 18%CO <sub>2</sub> and 20% O <sub>2</sub> , 31.7 hours for 57% CO <sub>2</sub> and 20% O <sub>2</sub> and 42.4 with 57% CO <sub>2</sub> and 12%O <sub>2</sub> . More crickets were rendered comatose in 18% or 30% CO <sub>2</sub> than in lower concentrations with 20% O <sub>2</sub> .   | NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Crickets react differently to each of a range of CO <sub>2</sub> concentrations.     | (Stevenson and Hurst, 1995) |
| Carbon dioxide                                                                        | Warehouse treatments ranging from 35-70% CO <sub>2</sub> for 14 days.                                                                                                   | <i>Sitophilus zeamais</i> , <i>R. dominica</i> and <i>T. castaneum</i> and unidentified book lice | Wheat          | 100% mortality to all species tested, including phosphine resistant insect strains.                                                                                                                                                                                                                                                                                                                                             | No negative effects on grain, sometimes quality was better after treatment.                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Has notes on method of sealing warehouses and CO <sub>2</sub> atmosphere monitoring. | (Daolin et al., 2006)       |
| Ozone                                                                                 | 50 ppm for 3 days                                                                                                                                                       | Maize weevil, red flour beetle (species name not provided)                                        | Popcorn, maize | Essentially 100% mortality after three days however ozone exposure was required to sterilize the grain mass initially.                                                                                                                                                                                                                                                                                                          | No negative effects to grain. Ozone inhibits or eliminates fungal spores. Decays within 20-50 minutes. Therefore a special ozone air delivery and return system design is required for an ozonation treatment of a storage facility. Ozone can be generated at treatment site and has no residue on treated product. Ozone reacts with the cell structures of mold spores, insects, bacteria and other biological matter attached to grain mass. The more biological matter, the longer it takes to complete initial sterilization. |                                                                                      | (Maier et al., 2006)        |
| High Co <sub>2</sub> and high pressure                                                | 50% or 90% CO <sub>2</sub> and 3% O <sub>2</sub> , remainder N <sub>2</sub> under normal pressure. Also tested CO <sub>2</sub> under 15 and 20 atmospheres of pressure. | 11 stored grain pests                                                                             | NA             | 50% CO <sub>2</sub> for 4 days caused 99% mortality for only 2 pest for all life stages, but 90% CO <sub>2</sub> for 4 days caused 99% mortality for 4 pests and >80% mortality for all pests and life stages. 15 atmospheres for 15 minutes with 100% CO <sub>2</sub> was not particularly effective, only 1 pest had 99% mortality. 20 atm for 15 min was more effective (4 pests 99% mortality), but not as effective as 90% | NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Provide details of some of he equipment they used.                                   | (Riudavets et al., 2006)    |

| Method category         | Method details                             | Pest                                      | Host | Efficacy                                                                                                                                                                           | Phytotoxic effects | Other comments (feasibility with living plants?) | Reference       |
|-------------------------|--------------------------------------------|-------------------------------------------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------------------------------------|-----------------|
|                         |                                            |                                           |      | CO2 and 3% O2 for 4 days.                                                                                                                                                          |                    |                                                  |                 |
| Cold and low O2 and CO2 | 0°C with either air or CA (2% O2, 5% CO2). | Armoured scales, <i>Hemiberlasia</i> spp. | Kiwi | Mature scales were more resistant than immature scales. Time to 99% mortality for mature scales was estimated to take about 80 and 90 days for air and CA treatments, respectively | NA                 |                                                  | (Whiting, 2003) |

# Appendix 9



**Australian Government**  
**Australian Pesticides and  
Veterinary Medicines Authority**

**PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT**

**FOR CONTROL OF WHITEFLIES AND FUNGUS GNATS ON NURSERY STOCK  
(NON-FOOD) AND FRUIT TREES (NON-BEARING)**

**PERMIT NUMBER - PER12659**

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

**THIS PERMIT IS IN FORCE FROM 29 JUNE 2011 to 31 MAY 2016.**

**Permit Holder:**

NURSERY & GARDEN INDUSTRY AUSTRALIA  
c/- AGAWARE CONSULTING PTY LTD  
21 Rosella Avenue  
STRATHFIELDSAYE VIC 3551

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

Persons generally

## CONDITIONS OF USE

### Product to be used:

ADMIRAL INSECT GROWTH REGULATOR INSECTICIDE

Containing: 100 g/L PYRIPROXYFEN as their only active constituent.

### Directions for Use:

| Crop                                                                                                                                                                | Insect Pest  | R ate                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------------------|
| Nursery stock (non-food):<br>Including seedlings and plugs,<br>potted colour trees and shrubs,<br>foliage plants, palms, grasses,<br>and fruit trees (non-bearing). | WHITEFLIES   | 50 mL/100 L or 500 mL/ha |
|                                                                                                                                                                     | FUNGUS GNATS | 15 mL/100 L              |

### Critical Use Comments:

#### Whiteflies:

- ❑ Apply pyriproxyfen 7 - 10 days after initial appearance of adult whitefly on the leaves or monitor populations and apply based on the number of nymphs observed or when whitefly numbers reach the spray threshold level.
- ❑ Apply in accordance with SLWF Resistance Management Strategy. Importantly, *Admiral IGR* must be rotated with compounds from different chemical groups.

#### Fungus gnats:

- ❑ Use as a drench to pots saturating the top 2 - 4 cm of soil.
- ❑ Apply 25 mL of solution to soil surface of 15 cm pot.
- ❑ Adjust volume accordingly for smaller or larger pots.
- ❑ DO NOT drench plants more than one time per crop cycle.

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

### Jurisdiction:

ALL States - except Vic

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

### Additional Conditions:

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

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

### TO AVOID CROP DAMAGE:

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

Issued by

Delegated Officer



**PERMIT TO ALLOW EMERGENCY USE  
OF A REGISTERED AGVET CHEMICAL PRODUCT  
FOR THE CONTROL OF AUSTRALIAN PLAGUE LOCUST  
IN NURSERY SITUATIONS**

**PERMIT NUMBER – PER12445**

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

**THIS PERMIT IS IN FORCE FROM 7 JANUARY 2011 TO 31 AUGUST 2011.**

**Permit Holder:**

HORTICULTURE AUSTRALIA LTD  
c/- AGAWARE CONSULTING PTY LTD  
21 Rosella Avenue  
STRATHFIELDSAYE VIC 3551

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

Persons generally.

## CONDITIONS OF USE

### Products to be used:

DOMINEX DUO INSECTICIDE plus other registered products

Containing: 100 g/L ALPHA-CYPERMETHRIN as their only active constituent.

GOOGLY ALPHA-DUO 250SC INSECTICIDE plus other registered products

Containing: 250 g/L ALPHA-CYPERMETHRIN as their only active constituent.

REGENT 200SC INSECTICIDE plus other registered products

Containing: 200 g/L FIPRONIL as their only active constituent.

IMTRADE REGAL 800 WG INSECTICIDE plus other registered products

Containing: 800 g/kg FIPRONIL as their only active constituent.

### Directions for Use:

DO NOT apply using misters or aerial application

DO NOT reapply treatment for 7 days (alpha-cypermethrin) or 14 days (fipronil).

DO NOT spray near beehives or if bees are foraging on flowering plants.

| Crops/Situation                                                                                                                                                  | Pest                                                                           | Product & Rate                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Nursery stock (non-food)</b><br>including: seedlings & plugs, potted colour, trees & shrubs, foliage plants, palms, grasses and fruiting trees (non-bearing). | <b>AUSTRALIAN<br/>PLAGUE<br/>LOCUST</b><br>( <i>Chortoicetes terminifera</i> ) | <b>Alpha-cypermethrin:</b><br><b>100 g/L:</b> 160-200 mL/ha;<br><b>250 g/L:</b> 64-80 mL/ha;<br><br><b>Fipronil:</b><br><b>200 g/L:</b> 6.25 mL/ha;<br><b>800 g/kg:</b> 1.5 g/ha; |

### CRITICAL USE COMMENTS:

Speed of kill varies depending on locust maturity, temperature and level of spray contacted. To minimise damage to high value crops it is most effective to treat locust in surrounding non-crop areas by treating the turf, ground or crop edge when locust incursion is first detected. Should they enter into the crop and start feeding on foliage the crop may be sprayed. However, this may not prevent significant damage from occurring before locusts are killed.

### Hoppers

Spray a swath in front of advancing bands before applying directly to the marching front.

Continue spraying until all hoppers have been contacted.

Barrier Spray (fipronil only): Where conditions prevent direct application to hopper bands a barrier spray may be used. Follow label directions under pasture for creation of this barrier.

### Adults

Spray areas in and around crops infested with locust.

DO NOT allow animals to graze treated areas until the appropriate WHPs have been observed. Treat areas that are grazed according to the registered label instructions for pastures and ensure the maximum registered label rate is not exceeded for these situations.

**REENTRY/REHANDLING PERIOD:**

DO NOT allow entry into treated areas or re-handle treated plants for 24 hours after treatment. When prior entry or re-handling is required wear rubber gloves and cotton overalls buttoned to the neck and wrist. Clothing and gloves must be washed after each day's use.

**WITHHOLDING PERIOD:**

Not required when used as directed (non-food producing crops only).

**TO AVOID CROP DAMAGE:**

The sensitivity of most species and varieties of the crops that may be treated under this permit has not been evaluated. DO NOT apply these chemicals without testing first. It is advisable to only treat a small number of plants to ascertain their reaction before treating the whole crop.

**JURISDICTION:**

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

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

**ADDITIONAL CONDITIONS:**

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

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

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

Issued by

Delegated Officer





**PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT**

**FOR CONTROL OF VARIOUS INSECT PESTS IN NURSERY STOCK**

**PERMIT NUMBER - PER12029**

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

**THIS PERMIT IS IN FORCE FROM 30 JUNE 2011 to 31 MAY 2015**

**Permit Holder:**

NURSERY & GARDEN INDUSTRY AUSTRALIA  
c/- AGAWARE CONSULTING PTY LTD  
21 Rosella Avenue  
STRATHFIELDSAYE VIC 3551

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

Persons generally.

## CONDITIONS OF USE

### Product to be used:

DUPONT AVATAR INSECTICIDE

Containing: 300 g/kg INDOXACARB as its only active constituent.

### Directions for Use:

| Crop                                                                                                                                                                     | Insect Pests                                                        | Rate                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|--------------------------------------------------------|
| Nursery stock (non-food):<br>Including seedlings and plugs,<br>potted colour, trees and<br>shrubs, foliage plants, palms,<br>grasses, and fruit trees (non-<br>bearing). | Heliothis, European earwig,<br>Lightbrown apple moth and<br>Weevils | 170 g product / ha<br>or<br>17 g product / 100 L water |

### Critical Use Comments:

Heliothis and Lightbrown apple moth: Target spray treatment against eggs and newly hatched larvae. Apply when larvae reach economic thresholds and damage is observed. Best results are obtained when Dupont Avatar treatments are applied consecutively. Do not retreat within 7 days for Heliothis and within 10 days for LBAM.

European earwig and weevils: Apply spray treatment when damage is observed. Continue monitoring populations levels and repeat treatment if further damage is likely to occur. Do not retreat with 10 days.

Apply maximum 3 foliar spray applications within an annual production cycle.

Thorough coverage of foliage is essential: apply diluent to the point of run-off.

Use in accordance with existing IPM strategy and in accordance with best practice.

Add a non-ionic surfactant<sup>1</sup> at specified label rates. Refer to label directions for mixing and surfactant/wetting agent.

Note 1. DO NOT add surfactant if (i) mixing with another product that already contains a surfactant and/or that product label advises not to use a surfactant, or (ii) if mixing with liquid fertiliser. DO NOT use BS1000 or Activator-90 as these products may cause plant phytotoxicity.

### Jurisdiction:

ALL States except Vic.

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

### Additional Conditions:

1. **THIS PERMIT** provides for the use of a product in a manner other than specified on the approved label of the product. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label.
2. **PERSONS** who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the details and **CONDITIONS** of this permit.

3. To Avoid Host Damage:

Nursery stock is not known to be sensitive to the chemical products listed in this permit when used in strict accordance with the rate and conditions of use. Not all growing conditions and circumstances, however, can be fully evaluated. It is advisable, therefore, to closely monitor plant health and discontinue applications when any adverse (phytotoxic) symptoms post-treatment are observed.

Issued by

Delegated Officer

Note: Permit Holder variation to NGIA made effective 11 August 2011 (Permit Version 2).



**Australian Government**  
**Australian Pesticides and**  
**Veterinary Medicines Authority**

**PERMIT TO ALLOW EMERGENCY USE  
OF REGISTERED AGVET CHEMICAL PRODUCTS**

**FOR THE TREATMENT OF  
NURSERY STOCK (NON-FOOD), ORNAMENTALS,  
NON-BEARING FRUIT TREES AND CUT FLOWERS/FOLIAGE  
FOR MYRTLE RUST**

**PERMIT NUMBER – PER12156**

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

**THIS PERMIT IS IN FORCE FROM 9 SEPTEMBER 2010 TO 30 JUNE 2011.**

**Permit Holder:**

Horticulture Australia Ltd  
c/o AgAware Consulting Pty Ltd  
21 Rosella Av  
STRATHFIELD SAYE VIC 3551

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

Persons generally.

## CONDITIONS OF USE

### Products to be used:

BAYFIDAN 250 EC FUNGICIDE  
PLUS OTHER REGISTERED PRODUCTS  
Containing: 250 g/L TRIADIMENOL as its only active constituent.

SAPROL FUNGICIDE  
Containing: 190 g/L TRIFORINE as its only active constituent.

IMTRADE MANCOZEB 750 DF FUNGICIDE  
PLUS OTHER REGISTERED PRODUCTS  
Containing 750 g/kg MANCOZEB as its only active constituent

---

~~CHEMFARM MANCOZEB 800 WP FUNGICIDE~~  
~~PLUS OTHER REGISTERED PRODUCTS~~  
~~Containing 800 g/kg MANCOZEB as its only active constituent~~

AMISTAR 250 SC FUNGICIDE  
PLUS OTHER REGISTERED PRODUCTS  
Containing 250 g/L AZOXYSTROBIN as its only active constituent.

COPPER OXYCHLORIDE  
PLUS OTHER REGISTERED PRODUCTS  
Containing 500 g/kg COPPER OXYCHLORIDE as its only active constituent

PLANTVAX 750 WP FUNGICIDE  
Containing 750 g/kg OXYCARBOXIN as its only active constituent

TILT 250 EC FUNGICIDE  
PLUS OTHER REGISTERED PRODUCTS  
Containing 250g/L PROPICONAZOLE as its only active constituent

**Directions for Use:**

Directions for Use:

| Crop                                                                                                                      | Disease                                  | Active             | Rate of application<br>per 100 L water                   |
|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------------------|----------------------------------------------------------|
| Nursery stock (non-food and forestry),<br>Non-bearing fruit trees <sup>1</sup> ,<br>Ornamentals and<br>Cut Flower/Foliage | Myrtle rust<br>( <i>Uredo rangelii</i> ) | triadimenol        | 50 ml/100L                                               |
|                                                                                                                           |                                          | triforine          | 130 ml/100L                                              |
|                                                                                                                           |                                          | mancozeb           | 750 g/kg – 210-250 g/100 L<br>800 g/kg – 200-230 g/100 L |
|                                                                                                                           |                                          | azoxystrobin       | 40 ml/100L                                               |
|                                                                                                                           |                                          | copper oxychloride | 300 g/100L                                               |
|                                                                                                                           |                                          | oxycarboxin        | 130 g/ 100L                                              |
|                                                                                                                           |                                          | propiconazole      | 32 ml/100L                                               |
| <sup>1</sup> At least 6 months prior to first harvest                                                                     |                                          |                    |                                                          |

**Critical Use Comments:**

Apply by ground application only e.g. knapsack, powered hand-gun, boom, air-assisted.

Apply in sufficient volume to ensure thorough coverage of all plant surfaces.

Treat a sample area and assess appropriately prior to whole crop treatment to help minimise potential for phytotoxic damage. This action cannot guarantee crop safety as application, environmental and crop conditions may vary from test treatment to whole of crop treatment. This is particularly important for crops in bloom.

DO NOT apply more than 2 consecutive applications of a chemical from the same chemical class (Mode of Action Group). Rotate approved products from different chemical mode of action groups at regular intervals within a structured disease management plan.

For interstate quarantine requirements:

Apply in accordance with the procedures outlined in the appropriate State Import Requirement or Interstate Certification Assurance (ICA) Document. DO NOT apply the same chemical (or chemical class) on despatch that will be used by an importing authority for decontamination on receipt.

**Resistance management strategy:**

| Fungicide          | Activity                                   | Chemical group | Minimum re-treatment interval between consecutive applications |
|--------------------|--------------------------------------------|----------------|----------------------------------------------------------------|
| TRIADIMENOL        | Systemic, curative and protectant          | 3              | 14-21 days                                                     |
| TRIFORINE          | Systemic, slightly curative and protectant | 3              | 7 days                                                         |
| MANCOZEB           | Protectant                                 | M3             | 7 days                                                         |
| AZOXYSTROBIN       | Slightly curative and protectant           | 11             | 14-21 days                                                     |
| COPPER OXYCHLORIDE | Protectant                                 | M1             | 7-14 days                                                      |
| OXYCARBOXIN        | Systemic, curative and protectant          | 7              | 14 days                                                        |
| PROPICONAZOLE      | Systemic, curative and protectant          | 3              | 7 days                                                         |

**Jurisdiction:**

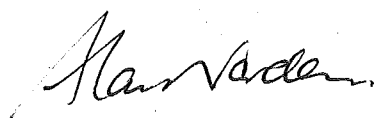
All States

**Additional Conditions:**

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

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

Issued by

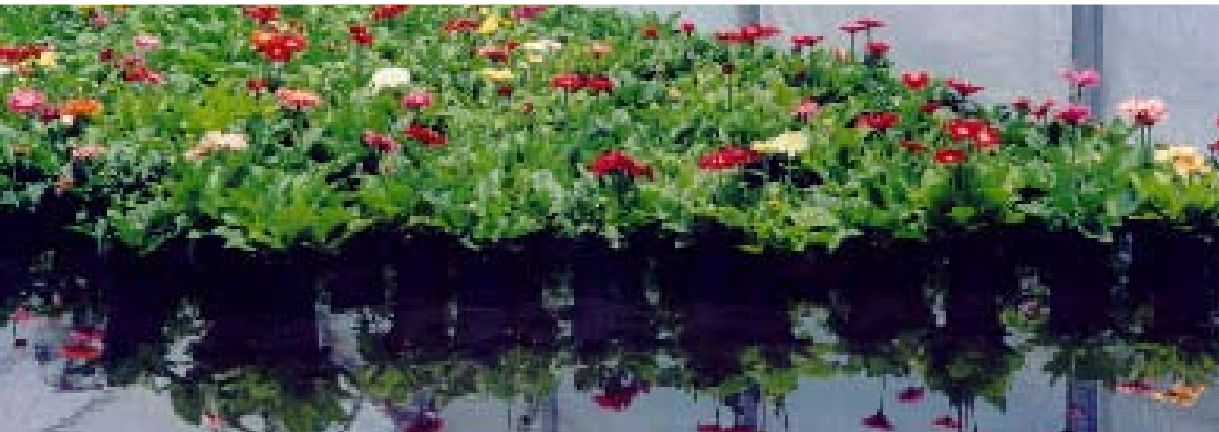
A handwritten signature in black ink, appearing to read "Alan Vaden". The signature is fluid and cursive, with a long horizontal stroke at the end.

Delegated Officer

# Appendix 10



# Nursery Industry Water Management Best Practice Guidelines







# Nursery Industry Water Management Best Practice Guidelines







## FOREWORD

The Nursery and Garden Industry is committed to supporting healthy, thriving and viable businesses by investing industry levy funds into research, tools and other activities which promote best practice and improve profitability.

The viability of the nursery and garden industry is dependant on the availability of water for use in the production and care of plants and the *Nursery Industry Water Management Best Practice Guidelines* were developed in 1997 to promote best practice water management in production nurseries.

With the current water shortages and changing water policy it is more important than ever before for our industry to achieve reductions in water use and demonstrate a commitment to responsible water management. Best practice plays an important role in achieving these outcomes and in response a review of the guidelines was undertaken to ensure that they include the most up to date practices and effectively address the needs of the current situation.

The 2010 updated guidelines include:

- a new Chapter that details irrigation management tools
- updated references from Levy Funded Research and Development Projects
- additional information on irrigation systems, irrigation system design and planning
- additional information on water testing and monitoring water quality

Your business will benefit from the practical application of these guidelines with outcomes such as improved plant quality, increased uniformity, reduced water requirements, and associated cost savings.

In addition the practices outlined in this document demonstrates the commitment of the nursery and garden industry to sustainable water use and provide opportunities for your business to demonstrate its on-going role in responsible water management.

Bryan Hillier  
President, Nursery & Garden Industry Australia



## ACKNOWLEDGMENTS

This publication is the result of an initiative of the National Technical Committee responsible for nursery industry research and development. In particular, a special thanks is extended to the past chairperson of this Committee, Jolyon Burnett. The 2010 revision has been overseen by the National NIASA Advisory Committee (NNAC), Chaired by Gary Eyles. The coordinator also wishes to thank the many staff from departments of agriculture, primary industries, water, and the environment who have contributed to the development of this publication. A special thanks to industry members who took the time to review the draft guidelines.

Nursery Industry Water Management  
Best Practice Guidelines

Update 2005

Edda Keskula, Nursery & Garden Industry, South Australia  
John McDonald, Nursery & Garden Industry, Queensland

Update 2010

Michael Danelon, Nursery & Garden Industry, New South Wales and Australian Capital Territory  
Anthony Kachenko, Nursery & Garden Industry Australia  
John McDonald, Nursery & Garden Industry, Queensland  
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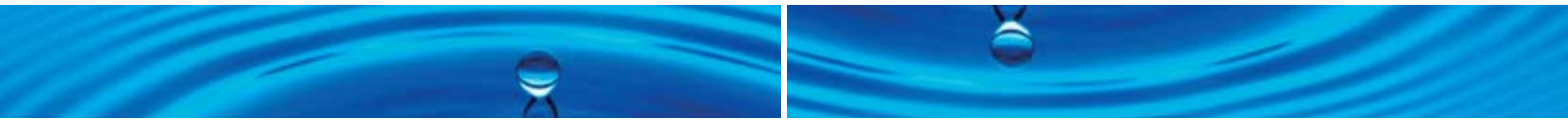
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# INTRODUCTION

Over the last 20 years the Australian nursery and garden industry, in partnership with Horticultural Australia Limited, has invested in research to deliver practical outcomes in the areas of improved irrigation practices, more efficient water use, water recycling and disinfestation technology, as well as funding training and extension to deliver this information to industry.

This publication aims to incorporate all the available information into a set of Best Practice Guidelines. It is intended as a practical guide for both nursery operators and the relevant authorities to use to achieve outcomes that are economically and environmentally sustainable. This guide looks at the six goals for achieving sustainable water use:

1. Efficient water use to minimise the business' demand on the water resource.
2. Irrigation management tools to ensure more productive and efficient use of water.
3. Increased reuse of waste water to minimise the demand of the business on the water resource.
4. Effective management of sediment and litter.
5. Maximising the retention of nutrients to improve efficiency of production and maintain water quality.
6. Environmentally responsible use of plant protection products to produce quality products.

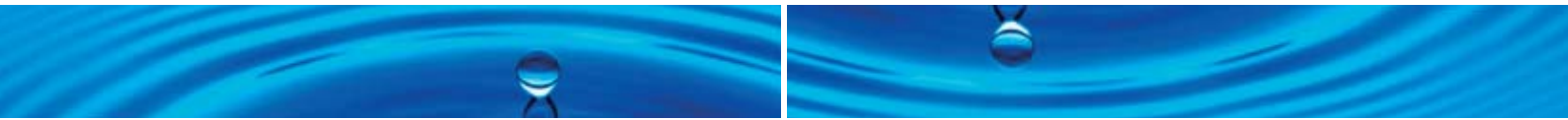
This publication is a guide only and is not intended as a 'do-it-yourself' implementation manual. It should be used in conjunction with the detailed references that are listed in each chapter and with the advice of suitable experts from both government and private enterprise. The State/Territory Nursery & Garden Industry Association and local government offices will be able to assist in identifying these people and in accessing the most up to date information and research.

These best practice guidelines also form the basis for the Water Chapter that is included in the Nursery Industry Accreditation Scheme, Australia (NIASA) Manual and can be used as a reference for achieving the requirements of this section.

In combination with continuing research and the implementation of the industry's National Water Policy these guidelines demonstrate the commitment of the nursery and garden industry to responsible water use and to achieving on-going improvements in water management within industry businesses.

Dr Anthony Kachenko  
National Environmental & Technical Policy Manager  
Nursery & Garden Industry Australia  
October 2010





# 1 EFFICIENT WATER USE TO MINIMISE THE BUSINESS' DEMAND ON THE WATER RESOURCE

Growing a healthy plant to market specification requires the right amount of water and nutrients as well as a suitable growing environment. Plants growing under optimum conditions of light, temperature, nutrition and water will reach marketable size as quickly as possible. If conditions are below optimum, plant growth will be slower, plants may need more nutrients and water, and turnover will be slower.

Ineffective irrigation is the one operation that most often accounts for poor product quality and quality variations in plants produced in the nursery. Under or over watering and uneven water application can lead to under, over or uneven nutrient uptake, which affects quality and consistency of production.

Applying water evenly, to replace only the losses from the containers with a small leaching fraction, will result in substantial savings in water consumption, less contaminated waste water and more even and efficient fertiliser uptake. At the same time a better quality plant can be grown while enhancing the clean, green image that the industry is keen to present. The effort required is not as involved as you may think and can be achieved using a little bit of common sense under the guidance of this document.

The irrigation system you select will depend a great deal on the range of plants you intend to produce, the flexibility you wish to build into your operation, the quality of the water, and how much of it there is available and when it is available. An efficient system that applies water evenly and can be easily controlled to meet the variations of plant water requirements will provide a surprisingly attractive cost/benefit ratio.

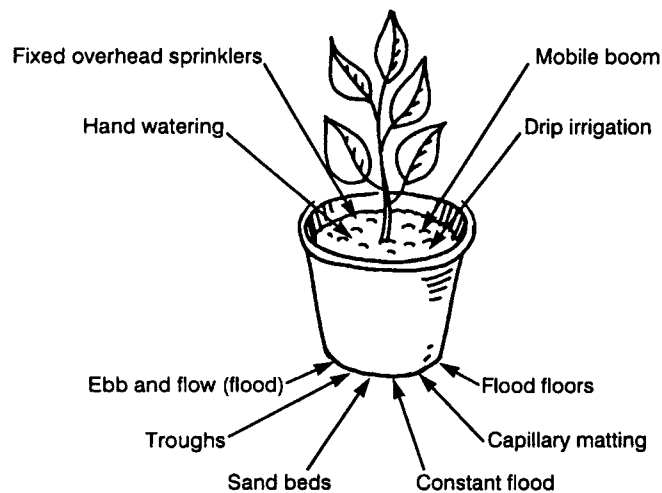
This first section of this chapter will examine each type of irrigation system, set out the best management practice and provide some of the management considerations that will help you select the best, most efficient system for your business.

Once you have selected the types of irrigation systems that suit your operation, you then need to give thought to the irrigation design so that it not only applies water efficiently but also fits into the constraints of your business. To this end, the second section of this chapter will provide some aspects of the design that you as an owner/manager will need to consider before talking to an irrigation designer.

## IRRIGATION SYSTEMS

There are two major methods of applying water that nursery operators can use in their nurseries, each with several available systems. They are:

### 1. Top watering



### 2. Bottom watering

Nursery operators may find that a mixed selection of these systems best suits their operation and plant/container range.

## TOP WATERING

### Fixed overhead sprinkler systems

Fixed overhead sprinkler systems comprise sprinklers set up on a grid pattern. These sprinklers can be either upright or upside down on rigid piping, at a spacing and operating pressure to provide an acceptable pattern to achieve a Coefficient of Uniformity of at least 85 %.

#### FEATURES

The important features of fixed overhead sprinkler systems are as follows:

- relatively cheap to install
- low labour input
- keep foliage clean
- can be used to cool plants and maintain humidity.

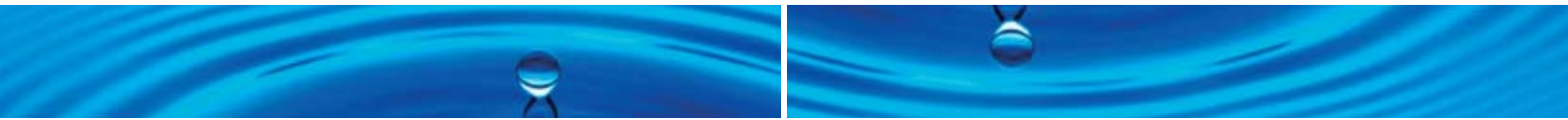
Spacings and discharge rates should be selected to ensure the mean application rate is less than the absorption rate of the potting media (normally less than 20 mm/hour).

Most irrigation systems are run for sufficient time to apply enough water to the driest containers. These are usually found around the edges of blocks. With uneven watering this practice leads to excessive water use and fertiliser leaching. To reduce this practice the Scheduling Coefficient should be less than 1.5.

#### System standard

Coefficient of Uniformity ( $C_u$ ) > 85 %  
Mean Application Rate (MAR) < 20 mm/hour  
Scheduling Coefficient ( $S_c$ ) < 1.5

To calculate whether your system meets the standard, refer to Appendix 1 in this publication. To determine how to calculate these measurements for your existing system you should attend a Waterwork workshop run by your State/Territory Nursery & Garden Industry Association.



### Mobile boom sprinklers

Flexibility and even water application is the secret of a well-designed overhead mobile boom system. A mobile boom system consists of one or more pipes fitted with nozzles that apply water as the system moves over the plants. It may be suspended from an overhead rail system or from a trailer that moves down the aisle. Water is supplied by a hose and the boom is powered by electrically driven cables or batteries.

These systems operate at a pressure to give the best breakup of the jet stream and droplet size (about 200 kPa). The spacing of the sprays should produce a Cu close to 100 %. With a selection of spray nozzles and speeds these systems can water a wide range of plants.

The boom should be wide enough to cover the container area and produce a Sc close to 1.0.

The spray jet size and diameter of coverage can be selected so that the MAR is closely matched to the absorption rate of the growing media. Control devices should be installed to make the boom capable of various speeds, thus giving the system the ability to meet the full range of applications required by the product being irrigated. Most booms apply water at rates of 1–3 mm/hour.

These light applications are ideal for small containers like plugs or seedling trays where good water and fertiliser control is vital for efficient production. By using multiple nozzles these systems can be used for not only irrigation but also applying liquid fertilisers and fungicides by selecting the nozzle that provides the prescribed application rate and droplet size.

If operated outdoors, care should be given to wind protection as the small droplets produced by these systems are very susceptible to wind drift, destroying their high uniformity of coverage.

A range of nozzles is available and these broadly fall into three categories hollow cone, solid cone and fan nozzles.

**Hollow cone nozzles** are most commonly used for spraying insecticides and fungicides. The pattern is produced by the swirling action of the spray liquid within the nozzle. Droplets leave the nozzle with high energy which results in a further breakdown of droplet size. The higher the pressure the smaller the droplet size.

**Solid cone nozzles** are used for spraying insecticides and fungicides at higher volume. The solid cone pattern is usually produced by a 'disc-core' combination. The disc is simply a plate with a circular orifice available in different sizes. The core, which is fitted behind the disc, produces a swirling action and spray pattern similar to a hollow cone nozzle. The core, which also has a hole in the centre, produces a stream that fills in the centre of the hollow cone spray pattern resulting in a solid cone of spray with variable droplet sizing.

**Fan nozzles** commonly come in three types; even flat nozzles, tapered fan nozzles and low pressure fan nozzles.

**Even flat nozzles** distribute water evenly across the nozzle swath and are used where a uniform spray application is required across the full width of the band. Different nozzle height settings will provide different band widths. For information use the manufacturer's recommendations.

**Tapered fan nozzles** produce a tapered distribution across the nozzle swath and are commonly used in spraying flat surfaces such as germination trays. The nozzles are aligned so that the fans are offset by 12° to 15° to avoid the spray patterns interfering with each other. Normally the spray overlaps about 30 % on each side with the combined output of adjacent nozzles giving the required application uniformly across the boom. Height adjustments for tapered nozzles should be made according to manufacturer's recommendations.

## FEATURES

The important features of a mobile boom system are as follows:

- Even watering  
Coefficient of Uniformity of nearly 100 %
- Scheduling Coefficient of almost 1
- Consistent application rate allows accurate watering and fertigation
- Light applications suitable for seedlings and bedding plants
- Nozzle range provides control of mist and irrigation during germination until plugs fill their cells
- Booms use 40 % less water than handwatering
- Booms use 25 % less water than upright sprinklers
- Less labour is needed as water is applied automatically
- Better water control can provide accurate plant water requirements.

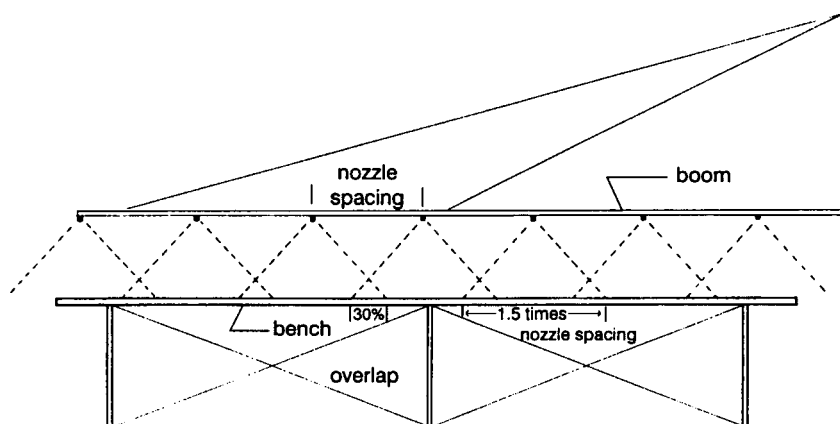


Fig. 1 – Mobile boom irrigation provides even, light (e.g. 5 mm/hr) applications of water which are ideal for plugs and flats

The effect of different plant heights on application rates and uniformity can be minimised by double coverage. This can be achieved most easily by halving the nozzle spacing or by doubling the boom height above the plant canopy. Alternatively, nozzles with a fan angle of  $110^\circ$  can be fitted at the normal spacing of 500 mm and used at a boom height of 500 mm.

In relation to pressure, the following general statements can be made:

- Droplet size decreases as pressure increases (for any particular nozzle).
- Droplet size increases as the orifice size increases (for any given pressure).
- Droplet size decreases with the increase in fan angle (for a given nozzle size and pressure).
- Fan angle increases with pressure.

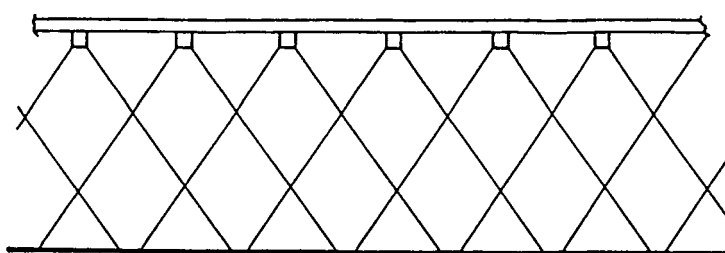


Fig. 2 – Double coverage spray pattern to minimise the effects of plant canopy height variation

**Low pressure fan nozzles** are designed to produce conventional spray patterns, flow rates and spray angles at pressures as low as 70 kPa. Droplets are larger, resulting in reduced drift and low pressure. Their larger orifices will increase the life of each tip and reduce blocking problems.

Some systems are available with more than one boom. These can be fitted with nozzles with different application rates for misting, feeding or pest control.

Choose the nozzle discharge rate and wetted area of the sprays so that the instantaneous application rate does not exceed 12 mm/hour.

## System selection

Before launching into this type of irrigation system, you should discuss your requirements carefully with the boom manufacturer and supplier so that a system can be installed to meet these requirements.

### Nursery windbreaks to protect overhead Irrigation systems

Windbreaks are not only required for container plants in the open but for the sprinklers that provide them with water. Wind over 8 km/hour will badly distort most sprinkler and spray patterns and destroy good irrigation uniformities. Windbreaks must therefore be designed to protect not only the sprinklers but the trajectory of the jet stream.

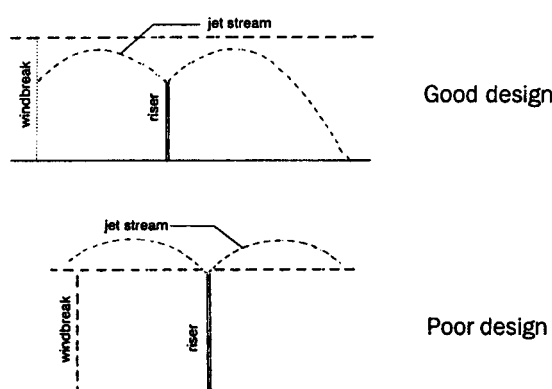


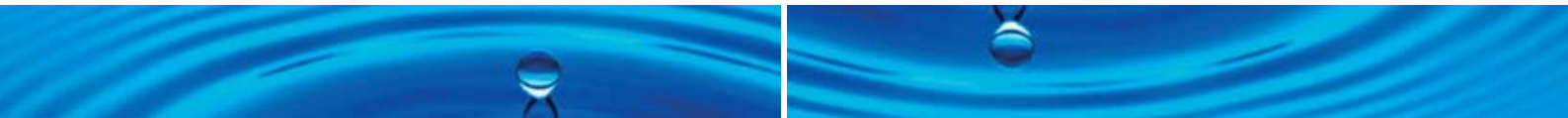
Fig. 3 – Windbreaks should be high enough to protect sprinkler spray patterns

The ability of a windbreak to reduce wind velocity is measured in terms of its porosity. With artificial windbreaks this refers to the openness of the fabric and is measured in percentages. Higher percentages are open and present less obstruction to the airflow and therefore mean less wind reduction. Work needs to be done to test various sprinkler droplet sizes and fabric porosity to achieve minimum distortion.

Porous windbreaks offer the least possible disruption to the air's streamline flow and provide a much larger zone of protection than a solid or very dense barrier which disrupts airflow, creating damaging turbulence and reducing the zone of protection.

Artificial windbreaks are usually erected at right angles to the prevailing wind or along the windward side of the nursery. On level ground this will provide shelter to the leeward of 4 to 6 times the height of the windbreak fence. To calculate the effective shelter a windbreak will provide deduct the height of the sprinkler stream from the height of the fence e.g.

|                   |   |                                             |
|-------------------|---|---------------------------------------------|
| Sprinkler height  | – | 1.2 metres                                  |
| Stream height     | – | 0.8 metres                                  |
| Windbreak height  | – | 6.0 metres                                  |
| Effective shelter | – | $(6.0 - 1.2 - 0.8) \times 6$<br>= 24 metres |



Reducing the wind across the plant canopy not only stops the watering pattern from being distorted, but it also greatly reduces evapotranspiration for the plants, so reducing their water needs.

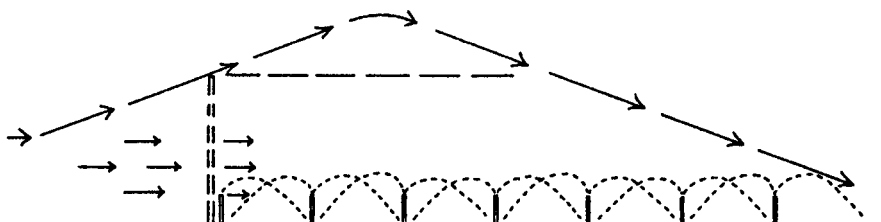


Fig. 4 – A well designed artificial windbreak can protect sprinkler water patterns

Other considerations are as follows:

- The slope of the land in relation to the prevailing wind will determine the protection zone for a windbreak of a given height.
- Ideally windbreaks should be 20 times longer than their height and should extend past the sprinklers or boom and containers at each end.
- Engineering economics dictate that the maximum height of poles must not exceed 6 m, so you may require supplementary breaks through the nursery.

## FEATURES

The important features of hand watering are as follows:

- Cheap to install
- Flexible system for a range of plants.

## For more info

Water use in the nursery and garden industry – results of the 2006 Water Use Survey. *The Nursery Papers* 2007 No 1

Assessment of hand watering in production and retail nurseries, *The Nursery Papers* 2009 No 1

## Hand watering

Hand watering is a common method of irrigation in some 55 % of production nurseries throughout Australia. This practice is perceived by some production nurseries to have several benefits such as enabling the operator to supplement fixed irrigation systems or preventing over watering in low water use areas.

A recent study undertaken by the Australian Nursery Industry indicated not only is the cost of hand watering greater than that of any other irrigation system in terms of equipment and labour costs, it is also an inefficient method in terms of water delivery and use. The study found that hand watering can cost up to 14 times that of an installed overhead sprinkler irrigation system. Even the most expensive capillary matting system, with high initial capital costs, should provide a return on investment after two years purely from labour savings. In terms of labour costs, the cost of hand watering would almost be double that of an automated system and indeed, the labour costs for hand watering will be on-going, and will increase with inflation.

Hand watering is a job for experienced staff only. With this system hose nozzles should be fitted with aerators to reduce water pressure and maintain high volume to minimise disease spread through splash, as well as preventing potting media washing from containers. There needs to be enough aisle space to allow easy access for staff to reach all containers.





### Management considerations

Despite the perception held by some nursery operators, hand watering does not result in even water distribution. Rather, it uses around 40 per cent more water and fertiliser than either ebb and flow or drip irrigation, according to the study in 1994 by J.M. Dole et al., water is applied at much higher rates than the potting media absorption rate. This results in high volumes of leaching and, because experienced staff carry out the task, the labour cost of this system is significant.

Dole's study found that hand watered pots can be expected to produce low quality plants with lower dry weights than either ebb and flow or trickle irrigation systems. Hand watered plants retain the least amount of water when compared to ebb and flow, trickle and capillary mat systems. This is probably due to compaction and forceful flooding top irrigation, loss of medium from flooding the pots, and high application rates. Mix compaction also could decrease aeration and reduce the amount of water available.

### Drip Irrigation

Drip irrigation potentially outperforms all other top watering systems in achieving high plant weights with a minimum of water usage. There are, however, products in this category that do not perform to that standard.

Work by Geoff Cresswell (1996) has shown that few commercial growing media are capable of absorbing water at rates of more than 20 mm/hour from overhead irrigation (see section on maximum MAR for growing medias). The excess water is channelled through non-capillary pores out the bottom. The same occurs with trickle irrigation. A drip rate of one litre/hour is equivalent to 20 mm/hour application rate on a 250 mm pot. Most drippers discharge at 2, 3, 4 or 8 litres/hour.

The common devices that are currently being sold to deliver water to the top of pots in this category include:

- Multi-holed devices
- Spray stakes
- Drippers

#### Multi-holed devices

These devices will discharge between 10 and 100 litres/hour at wetted diameters of between 0.2 to 2.5 metres. For most applications where all the water is contained in the pot, application rates of over 100 mm/hour can be expected – this is well in excess of the growing media absorption rates leading to excessive leaching.

#### Spray stakes

These devices have flow rates ranging from 12 to 23 litres/hour. The 12 litre/hour stake will apply water at a rate of 15 – 20 mm/hour over a wetted area of 2.5 m<sup>2</sup>. When this is restricted to the rim of the container then the rate increases dramatically and will range from 70 mm/hour for a 75 litre bag to 400 mm/hour for a 200 mm pot. Higher discharge rates will result in even higher application rates.

### FEATURES

The major features of drip irrigation are as follows:

- Minimal runoff of water as it is only applied to the top of the container
- Foliage is not wetted thus reducing disease potential in some crops
- Potentially outperforms all other systems in achieving high dry weights of plants
- Allows excellent control of air-water balance in container to maximise plant growth
- Leaching can be controlled to minimise
- Salt build up in media Can be used to irrigate a wide range of plants and container sizes.
- Unaffected by wind – lengthens watering time
- Can deliver liquid fertiliser providing precise nutrient management
- Provides very even watering
- Precise water placement reduces water use up to 85 % compared with spray or hand watering.

## Drippers

As mentioned above, these devices generally have flow rates of 2, 3, 4, and 8, litres/hour and will produce the application rates shown in Table 1.

**Table 1 – Application rates (mm/hour) resulting from the use of drippers on different size containers**

| Container size | Dripper rates in litres/hour |     |     |     |
|----------------|------------------------------|-----|-----|-----|
|                | 2                            | 3   | 4   | 8   |
| 100 mm         | 250                          |     |     |     |
| 150 mm         | 110                          | 170 | 230 |     |
| 200 mm         | 60                           | 95  | 130 | 250 |
| 250 mm         | 40                           | 61  | 80  | 160 |
| 300 mm         | 30                           | 42  | 60  | 110 |
| 330 mm         | 20                           | 35  | 50  | 90  |
| 45 litre       | 20                           | 27  | 40  | 70  |
| 75 litre       | 10                           | 15  | 20  | 40  |

### Management considerations

Table 1 shows that most drippers apply water well above the absorption rate of our growing media es. Adding sand and/or wetting agents to bark mixes has been shown to help horizontal distribution of these concentrated applications which may help the absorption rate, but the only way to match the absorption rates is to slow down the flow rate.

This is done by fitting either a 4-way or 8-way manifold to the top of the dripper connected to 3 or 4 mm tubing and arrow drippers.

For smaller containers such as 150 mm and 200 mm an 8-way manifold on a 2 litre/hour pressure compensated dripper will produce 250 ml/hour and 14 and 8 mm/hour application rates/container, respectively.

For larger containers a 4-way manifold can be used and with a 3 litre/hour dripper will produce the application rates depicted in Table 2.

**Table 2 – Application rates using 4-way manifolds and 3 litre/hour drippers**

| Container size | Volume in litres | Number of outlets/pot | Drip rate litre/hour | Application rate mm/hour |
|----------------|------------------|-----------------------|----------------------|--------------------------|
| 300 mm         | 15               | 1                     | 0.75                 | 10.6                     |
| 330 mm         | 25               | 1                     | 0.75                 | 8.8                      |
| 400 mm         | 35               | 2                     | 1.5                  | 11.9                     |
| 45 litre       | 45               | 2                     | 1.5                  | 11.9                     |
| 500 mm         | 75               | 4                     | 3                    | 15.3                     |
| 100 litre      | 100              | 4                     | 3                    | 15.3                     |
| 150 litre      | 150              | 4                     | 3                    | 10.6                     |



If you wish to use a drip system on smaller containers the select a low discharge rate like 2 or 3 litre/hour that is both pressure-compensated and non-drain. This allows you to pulse the irrigation using a suitable irrigation controller.

For even larger containers it becomes too expensive use this type of dripper configuration and it is better to set up a loop of drip line. Such a system could use 8 mm Netafim Miniscape dripline with dripper centres of 0.5 metres each with a drip rate of 1.9 litre/hour. This can be looped around and joined at a tee with a short length to connect into a normal 13 mm or 19 mm low density polythene lateral. The larger the container, the longer the dripline required and more drippers used.

With this type of product the following application rates depicted in Table 3 can be achieved.

**Table 3 – Application rates using Miniscape dripline**

| Container size in litres | Number of drippers | Drip rate litre/hour | Application rate mm/hour |
|--------------------------|--------------------|----------------------|--------------------------|
| 200                      | 2                  | 3.8                  | 11.4                     |
| 400                      | 4                  | 7.6                  | 11.4                     |
| 600                      | 6                  | 11.4                 | 11.4                     |
| 800                      | 10                 | 19                   | 14.2                     |
| 1000                     | 10                 | 19                   | 11.4                     |
| 1200                     | 15                 | 28.5                 | 14.2                     |
| 1400                     | 15                 | 28.5                 | 12.2                     |
| 1600                     | 20                 | 38                   | 14.2                     |
| 1800                     | 20                 | 38                   | 12.7                     |

Where long lines of drippers are to be used it is best to install non drain drippers so that all the drippers start and shut off together which prevents drainage to low point of the lateral and provides a more even application of water.

Low density polythene that is used as lateral pipe will expand and contract with temperature and it is recommended that each lateral line be tensioned to minimise this movement for laterals that are either connected to an overhead wire or laid on the ground. To tension the laterals each end should be fitted with a suitable tensioning core assembly.

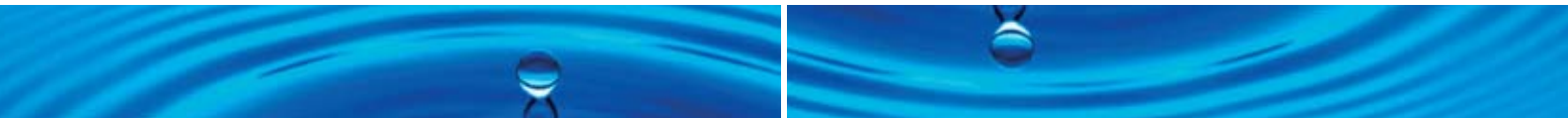
**BOTTOM WATERING**

These systems are gaining popularity in Australia especially with growers whose crops are grown in unprotected cropping systems and for short lines that need to be saleable on a set day like Valentine or Mothers Day.

In a bottom watering irrigation system, the plant’s water needs are supplied by water moving from the system into the growing media via holes in the bottom of the pots and drawn up into the growing media by capillary action.

They can be more expensive to set up than a fixed overhead sprinkler system but they have distinct advantages in that they apply water evenly to a range of container sizes at once and do not water the foliage, thus making them ideal for potted colour and crops susceptible to leaf diseases.

Research and experience has demonstrated that bottom watered crops should be grown with nutrient solutions containing 30 to 50 % less fertiliser than used in conventional top irrigated systems.



Conventional nutrient ratios are in most cases appropriate.

These systems can offer an ideal Cu and Sc and the MAR is automatically matched to the absorption rate of each mix.

Experience has shown that:

- Continuous water encourages algae growth in the trays and mats and loses too much water in evaporation and drainage. Most operators now water intermittently several times/day.
- Plants watered frequently do not allow the mix to dry out too much so capillary action is easy to maintain particularly in pots over 150 mm diameter.
- 150 mm diameter containers can receive almost the same amount of water through bottom watering as through overhead, although the tops will usually remain dry.
- Deeper pots may require a finer particle medium and more compaction with bottom watering.
- These systems lend themselves well to liquid feeding and water recycling by collecting the discharge in holding sumps. As makeup water is added to holding sumps fertiliser is injected usually to a preset conductivity. The pH is often monitored with an in-line meter and automatically corrected using phosphoric, sulphuric or nitric acid or potassium hydroxide. The nutrient solution should be periodically analyzed for nutrient composition.

## FEATURES

The major features of ebb and flow systems are as follows:

- Use the least amount of water of all irrigation systems
- Require much less fertiliser than top watering systems
- Can provide very even water application
- Allow efficient use of liquid fertiliser
- Recirculation of water minimises runoff
- Low risk of spreading pathogens
- No water on foliage reduces foliar pathogens
- Well suited to producing long lines of plants to specified standards.

- Slow release fertilisers and high saline water will accumulate high and very high levels of salt respectively in the top layer on the container which should be flushed out before despatch. If these plants are being grown outdoors then periodic flushing with an overhead system is recommended to prevent salt build up moving into the root zone with light rainfall events.
- Bottom watering systems require reasonably good quality water to avoid salt problems. Many growers in higher rainfall areas will collect rainwater to use as low salinity makeup water. In areas of low rainfall and poor quality water, reverse osmosis (RO) may be required to control salinity. With RO systems it is best to remove salts from the fresh water source instead of attempting to process the recycled water. With RO systems there is the potential problem of brine discharge to consider.

## Ebb and flow systems

With ebb and flow systems benches are flooded with water to a depth of about 20 mm. This water is only held for a short time to saturate the bottom of the pots and it then drains from the containers through channels into the drains. To minimise leaching and stop root damage, this cycle should only take 6 to 8 minutes.

Benches are normally graded level and a combined outlet/inlet valve can be installed at each end of the bench. Discharge into the bench should be matched to the flow capacity of the channels so that the water level rises evenly across the whole bench to allow even flood time for all pots. Modular benchtops are available in 1.2, 1.5, 1.8 and 2 m widths and can be set up for various lengths. For benches longer than 5 m it may be best to flood and drain from both ends of the bench.

Although fully automatic systems are available, many operators choose to operate their

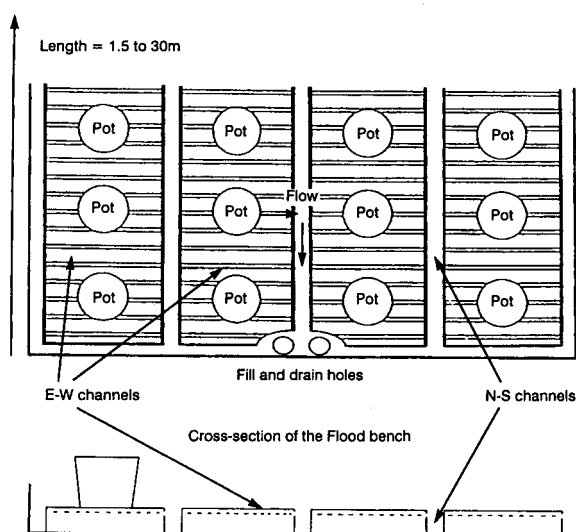


**Fig. 5 – Configuration of an ebb and flow (flood) bench (from Greenhouse systems automation, culture and environment)**

systems manually so that plants are not over watered or allowed to dry out too much. A simple control on flood level for a manually operated system can comprise a hose clipped to the bench (this introduces the water to the bench) and a small piece of polythene pipe that neatly fits into the outlet (drainage) hole. It is important to take this opportunity to inspect plants for pests and diseases.

A water or liquid fertiliser solution is usually stored in a tank and pumped to the table valve via a flexible hose. When irrigation is finished the remaining solution is drained back down the same pipe and diverted via a return valve back to the tank. The same solution can be used for many irrigations and for many benches.

### *Management considerations*

Generally, all salts not taken up by plants will accumulate in the top 10 to 15 mm layer of the growing media. With salty water, a crust of salt will build up on the surface.

Since ebb and flow systems reuse the water, higher efficiencies can be obtained. Attention must be paid to changes in pH and soluble salt content of the water over time, as well as the potential for spread of plant pathogens.

Oxygen concentrations in circulating solutions are much lower than the optimum level because of microorganism activity in the tank. Some operators are now injecting oxygen into their solutions with some surprising results in improved plant growth.

Usually pH is lower in the lower layer of the pot media. This is caused by nitrifying bacteria and may contribute to nutrient deficiency/toxicity. When using nutrient solutions, bench surfaces and supply equipment (pumps, pipes, tank and valves) should be made of something other than metal or at least coated with a non-metallic surface to stop contamination of the solution with heavy metals.

Before dispatching plants all salts in the top layers of the growing media should be leached out with a thorough overhead watering.

## Flood floor systems

There are two systems currently being used. They are concrete floors and sealed gravel floors. We will look at each separately.

### Concrete flood floors

A concrete flood floor system comprises concrete floor modules fitted with underground piping that allows water to flood and drain each module rapidly. In most modules the area is split longitudinally into 4 with 2 rows of pipe located a quarter of the distance across the bay from each side. The slope of the floor is peaked at each edge and in the middle of the bay at a grade of 1:100 to 1:150. The longitudinal grade is flat.

A small curb can be used to isolate modules and to locate supports for the shade house or greenhouse. Floors are usually 100 mm thick and suitably reinforced. Floor heating can easily be included in the construction.

Water is held in an underground holding tank and pumped at high flow rates through the large underground pipe into the module through the inlet/outlet holes. After irrigation is completed the water is quickly drained through the same piping back into the holding tank through a media filter to remove growing media and plant debris.

#### FEATURES

The major features of flood floor systems are as follows:

- Well suited to growing large blocks of plants
- Bottom heating can be incorporated into the floor
- The floors must be built accurately to ensure complete and rapid drainage
- Lower rates of fertiliser required than with top watering systems
- Recirculation of water minimises runoff
- Allow efficient use of liquid fertilisers.

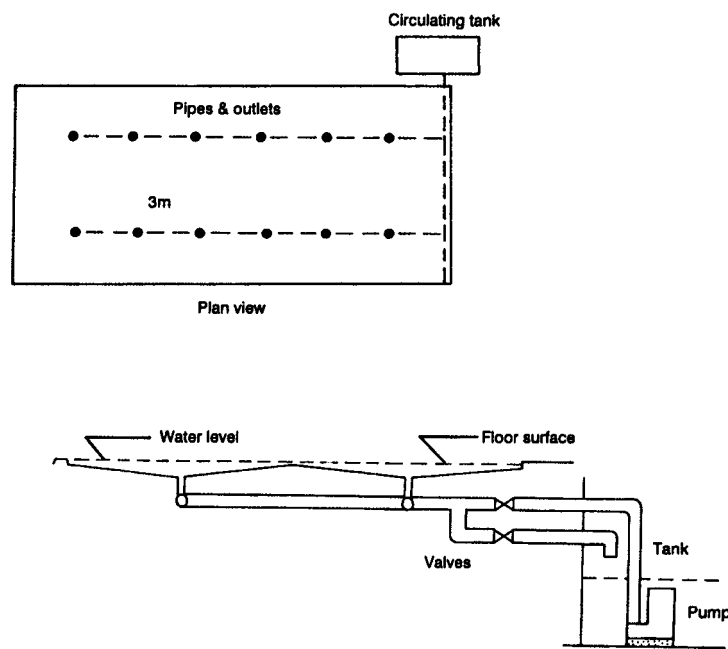


Fig. 6 – A typical arrangement for a concrete flood floor system

## Gravel flood floor systems

A gravel flood floor can be constructed using timber edges, 200 micron (0.2 mm) plastic, 50 mm slotted PVC pipe, 20 mm gravel and two hydraulic valves. The floor is sloped at a grade of 1:100 and is initially flooded by opening the inlet valve and closing the outlet valve. After the water level has reached its predetermined height, the inlet valve is closed which opens the outlet valve emptying the bay.

Water is supplied through slotted PVC pipe and the hydraulically operated normally closed (inlet) and normally opened (outlet), butterfly valves are located at one end. The size of the pipe and valves will depend on the module size. A full watering and dewatering cycle should take about 15 minutes. When calculating the volume of water that needs to be delivered during each cycle, assume that the gravel area will hold 50 % of its volume as water.

This system will only require low-pressure water delivery and it lends itself to recycling. When irrigation is not required any rainfall is passed through the gravel and out the pipe as the outlet valve always remains open unless the system is activated. By using a 50 mm – 100 mm depth of gravel, sufficient air space is always maintained below the containers to suppress disease and root growth.

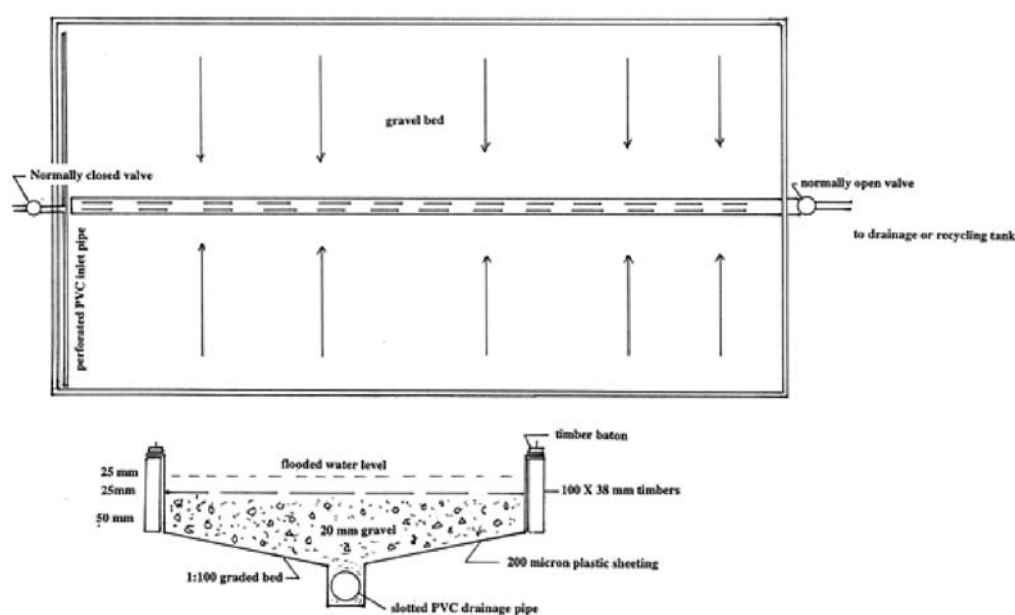


Fig. 7 – Arrangement of gravel flood floor system

## Management considerations

Management considerations for flood floor systems are similar to those for ebb and flow systems. It is important that plants have built up a good root system before being put in this irrigation system.

After each crop is removed it is important to thoroughly clean and disinfect the floor.



## Trough systems

With these systems troughs sized to suit the containers are laid on a grade of about.

1:600 –1:750 with troughs and pots spaced to suit the plant material. Troughs can be made of either aluminium, PVC or steel painted with a marine paint. Water is supplied at one or both ends at a low rate (use an 8 litre/hour dripper or 1.5 to 2 mm microtubing) and drains to the other end or the centre into a gutter which returns the water to a holding tank for reuse.

The pots in the troughs slow the flow down to allow capillary movement of water into them. The slow discharge into each trough keeps the velocity low enough to stop media washing from the pots. As a guide, 150 mm pots are irrigated for about 20 minutes and 200 mm pots for about 40 minutes, each irrigation. The time between irrigations will depend on the crop being grown and the evapotranspiration rate (water use per day).

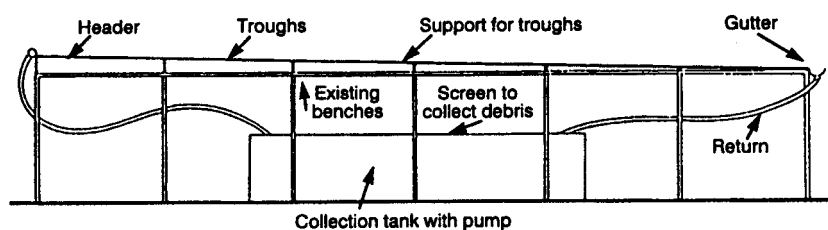


Fig. 8 A typical arrangement of a trough bottom watering system

### FEATURES

The major features of trough systems are as follows:

- Allow retro-fitting of existing bench layouts
- Allow excellent ventilation between plants
- Lend themselves to plant stacking to better use space
- Excellent control over water efficiencies.

This system allows good airflow between the spaced troughs, reducing the humidity that can be a problem with other bench bottom watering systems. Many growers also use steel roofing, particularly when growing potted colour. This has all the advantages of a trough system except the additional airflow. These systems both lend themselves to liquid fertilizing in the irrigation water and a closed system similar to that described in the ebb and flow section.

Other features of ebb and flow and flood floor systems also apply.

### Management considerations

Salt levels in the top layer of the growing media will be high and pH values in the bottom layer will be low with trough systems so the same precautions need to be taken as with ebb and flow and flood floor systems. Essentially, similar management is required for these three systems.

Treatment of irrigation water used in this system to minimise the spread of pathogen diseases is warranted. Care needs to be taken to disinfect the water supply before it is introduced into the system. Disinfecting the water through, say, a slow sand filter before recycling it would be an advantage. It is important to use disease free stock with this system.



## Capillary mat systems

Mats for capillary systems are usually made of synthetic fibrous material like carpet underlay or geotextile fabric from 2 to 6 mm thick. Commonly, black polythene film is laid on a flat bench, and the matting is then put on top of the polythene and covered with perforated plastic sheet. This arrangement is very flexible and in production areas it can be used to cover bench tops or laid out over prepared flat areas either inside shade or poly houses or outside in the open.

The matting is kept constantly wet by applying water, usually through a low volume discharge system like drip tape (the tapes are placed about 60 cm to 2 m apart). Higher discharge driplines are spaced at the wider spacing's. There should be enough water outlets along the pipe to maintain the whole mat at the same moisture content which is also dependant on the thickness of the synthetic fibrous material that carries the water.

Keeping the growing media at a constant moisture content will dilute the soluble salt effect. Black perforated cover sheets will control algae growth better. Pots must have enough drain holes in the base to start and maintain the capillary action. It is usual to top water to help start this capillary action.

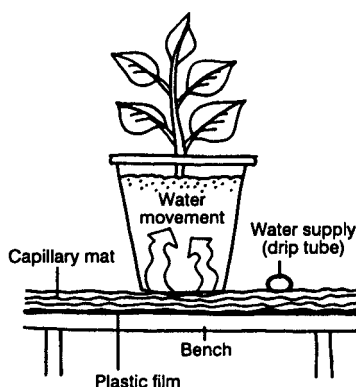


Fig. 9 – Capillary matting efficiently moves water into containers

### Management considerations

Water is supplied to plants as a result of it moving through the capillary pore spaces in the growing media. It is important to select a growing media that can quickly take up water by capillary action.

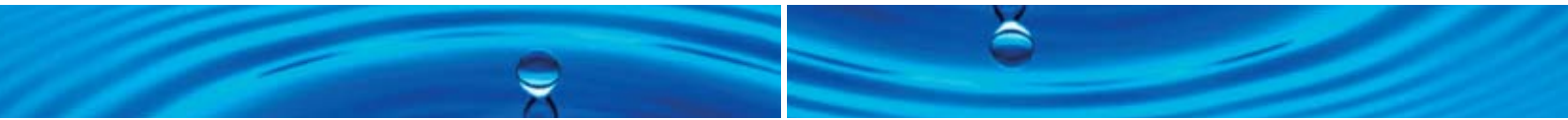
Experience has shown that:

- Pots with a diameter of 150 mm can receive almost the same amount of water through bottom watering as overhead although the tops will usually remain dry
- Pot sizes over 150 mm diameter are very difficult to overwater with bottom watering but plugs and flats are easily overwatered and can rapidly become saturated.
- High moisture levels in pots over 150 mm diameter must be maintained otherwise they may become difficult to re-wet.
- Taller pots may require finer sized particle medium and more compaction with bottom watering.

### FEATURES

The major features of capillary mat systems are as follows:

- Efficient systems where light levels and temperatures are low and humidity is high
- Well suited to short crop cycles like potted colour
- Water level in containers remains constant
- Different plants and pot sizes can be laid out on the same matting.



Growing media salt levels, runoff salt levels and nitrate concentrations tend to be higher in capillary systems than any other system.

Capillary systems also use more water than other bottom watering systems and require more irrigations. Evaporation from the mats, accentuated by the often used black perforated plastic top covering, contributes to water loss and is responsible for the high growing media and runoff salt levels compared with other bottom watering systems. Overall water needs decrease as the canopy cover closes in and the mats become shaded.

To stop salt buildup many operators top water every 3 to 4 weeks and often incorporate a fungicide.

Liquid fertilisers can produce algae problems in capillary mats. These systems usually use less than half the fertiliser of overhead systems with 40 % leaching.

If capillary systems are being used outside then rain is an obvious problem, especially with high intensity storms. Light rain could move the saline top layer in pots into the rootzone which could severely affect plant growth.

In capillary systems the excess water around pots can cause the spread of rotting fungi such as rhizoctonia. Applying fungicides and principles of sound crop hygiene such as wider plant spacings may alleviate this problem.

**Sandbed capillary systems**

With sandbed capillary systems pots are placed in a moist sandbed which is usually constructed by filling a watertight bench with a minimum of 25 mm of sand. Many operators make the sandbed thicker (from 75 to 100 mm) with the saturated level 25 to 50 mm below the surface. The surface of sand beds needs to be dead level but the bottom can be sloped, e.g. 1-in-70, to help remove excess water. A water system should automatically provide water so that the surface sand remains moist but not saturated.

**FEATURES**

The major features of sandbed capillary systems are as follows:

- Probably the cheapest of all subirrigation systems
- Similar features to capillary mat systems.

A typical system would comprise a bed lined with 0.2 mm UV-protective plastic film incorporating plastic drainage pipes to remove excess irrigation water and an overflow pipe at one end to remove rainwater. The plastic and drainage pipes would be covered with 100 mm layer of sand with typical grain sizes as follows:

|               |      |
|---------------|------|
| >2 mm         | 25 % |
| 0.6 to 2 mm   | 30 % |
| 0.2 to 0.6 mm | 30 % |
| 0.6 to 0.2 mm | 15 % |

Normally 40 to 50 % of the sand by weight should be between 0.2 and 0.5 mm. In higher rainfall areas a coarser sand may be needed to help drainage and stop surface saturation. Handreck and Black's book, *Growing Media for Ornamental Plants and Turf*, contains a test for sand to determine its suitability for capillary systems. Sand should also be thoroughly disinfested to ensure it is disease free before use.

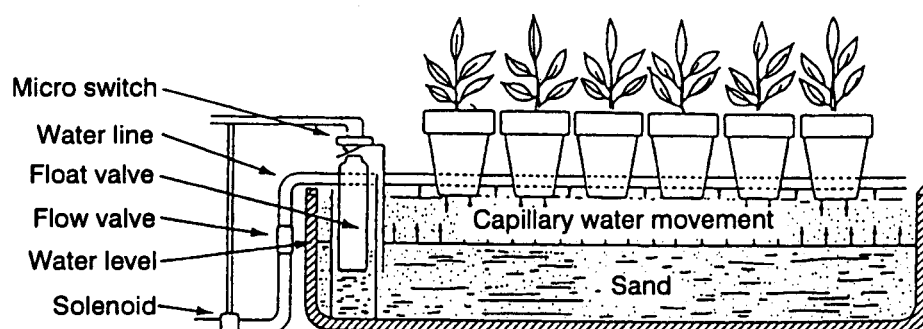


Fig. 10 – A sandbed capillary system arrangement with automatic water level control

### Management considerations

Pots larger than 9 L are not adequately watered on capillary sandbeds.

The growth of roots through pots into the sandbeds is a management problem which must be addressed for most species that grow on beds for longer than 2 months. Some operators use a plastic cover. In such cases pots need to be pressed well into the sand to maintain capillary action.

Liquid fertilisers can produce significant quantities of slime in the sand. Care should be taken when designing systems for outside in high intensity rainfall areas to prevent the sand from washing during storm events.

Other management considerations detailed in capillary mat systems also apply to sandbeds.



## IRRIGATION CONTROLLERS

How efficient and flexible your irrigation system is to manage may depend on the control equipment you choose.

Irrigation controllers are used to start and turn off an irrigation operation (cycle). Automatic irrigation systems are divided into blocks or banks of sprinklers, bottom watering or emitters that are turned on and off by either solenoid or hydraulic valves. The flexibility of an irrigation system and how precisely it applies the right amount of water at the right time is dictated by the controller that operates these valves.

### *Management considerations*

When installing a controller it is important to select one that has the features that are important for your operation. Some of the features that may be useful to incorporate into a nursery system may include:

- Being able to easily combine and change valve groupings to match plant water requirements or turn off empty areas. Stations can easily include two or three valves per station.
- Allowing for the number of start times you want. You need to decide how many you want e.g. 10, 20, 30 or more.

### FEATURES

The major features of irrigation controller systems are as follows:

- Combine and change valve groups
- Enable you to select the number of start times you want
- Multi program stations
- Select run times to suit operation
- Adjust program daily
- Include manual operation
- Backwash filters
- Inject fertiliser
- Control pumps
- Operate disinfection systems
- Protection, fault reporting, system diagnosis
- Can be connected to a computer.
- Whether cyclic water is required to either maintain humidity or to cool plants in hot weather. Sensors can be connected to activate this feature. Controllers with multi-programming functions can have one program for, say, maintaining humidity and another to supply the water requirements, both to the same area using the same valves.
- How would you like your run times configured i.e. in hours, minutes or seconds? What are the minimum and maximum run times you require? Many controllers can provide between 1 second and 99 hours to precisely match your requirements.
- How easy is it to adjust your programs? Some controllers will allow you to increase or decrease all watering times as a percentage of those set, so that on an extra hot day you may wish to increase all programs by, say, 30 % or in overcast conditions you may wish to reduce the watering times by, say, 50 %. This can be done with one switch. You can also include a rain switch to turn off outside stations after a set amount of rain has fallen while keeping the indoor areas on the irrigation schedule.
- Include a manual operation switch to allow you to stop or start programs.
- Use a controller to backwash filters, inject fertiliser, control pumps and operate disinfection systems. Other features that are readily available include on-off key and pause function, password protection, electronic short circuit protection, battery backup, alarm to alert malfunction, lightning and power surge protection, self diagnostics, fault reporting, usage reports on, say, monthly water applied per station. Some controllers can be either directly connected to a computer or indirectly via a modem to allow centralising control and data processing.



## IRRIGATION SYSTEM DESIGN

There is real economic benefit in having an efficient system that can operate within your management constraints. Designing an irrigation system is not all about pumps and pipes – it is about plant water requirements, management constraints and watering evenly. These are the nursery operator's domain.

Once you have worked out the important things, a good irrigation designer can crunch the numbers and prepare an efficient design, so the system works for you, not the other way around.

So your irrigation system should reliably apply enough water evenly to meet all the plant needs in the time available.

- Applying water evenly requires a well maintained hydraulically sound system with application rates matched to growing media absorption rates
- Applying the right amount of water requires knowledge of plant water requirements over the growing cycle.
- Time available needs to take into account the constraints of the site and business.

### Planning an irrigation system

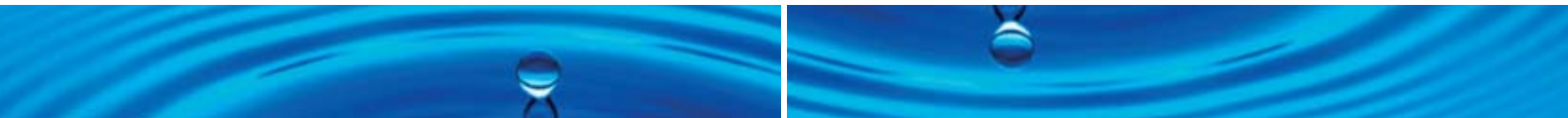
Planning, designing, installing, operating and maintaining nursery irrigation systems is a team effort. This team will include the nursery owner, production staff, irrigation designer, equipment suppliers and system installers. This process starts and finishes with the nursery owner and production staff, as it is their business, they are the experts in what they produce and their future bottom line is dependent on the successful operation of the system.

The irrigation designer will be able to size the pipes, pumps and select the correct valves and filtration equipment, but they will have little knowledge of your plant water requirements or the management constraints of your business and how they relate to the operation of the irrigation system. So you will need to develop an irrigation plan to present to the designer.

Many production nurseries have several growing conditions that may require different or specialised irrigation and water management decisions. Some examples of these might include:

- propagation
- seedling trays
- greenhouses and igloos
- shade areas
- large pots or bags
- hanging baskets
- fixed and rolling benches
- specialised lines like potted colour or spring promotions
- hardening areas
- inground parent material.

Within these divisions there may also be other subdivisions of pot sizes, plant varieties, plant water use etc. which can be dealt with by block management.



Check the most suitable type of system for you to use in each area. There is no reason why you cannot combine several system types in the one nursery. Some examples that you could consider may include:

- Misting or fog systems and separate controls for the propagation area.
- Drippers for tall or large foliage plants, large containers, hanging baskets, flowering plants or plants susceptible to fungal diseases.
- Low application rate sprinklers with fine droplets sizes for seedling trays, ferns and indoor plants with possible thermostat control.
- Capillary matting or ebb and flow systems for potted colour and single sale lines.
- Overhead irrigation with impact sprinklers for the outdoor stock.
- Inverted micro sprinklers for shade houses and areas with rolling benches.
- Mobile boom for bedding plants, seedlings and tube stock.
- Trough system for flowering plants or plants susceptible to fungal disease.

Let's look specifically at various types of systems and the detail you will have to consider so that the irrigation designer can prepare a design that matches your business requirements.

### **Overhead systems**

You will need to consider:

- The layout and shape of each area so that the appropriate sprinkler spacing may be selected taking into account spacing of support posts and windbreaks.
- Upright or inverted sprinklers to be used and the riser or dropper heights to select threaded rigid poly risers screwed into PVC faucet take-off adaptors will allow easy change-over to adjust height to suit different crops.
- The MAR that best suits the growing media's absorption rate and crop being grown.
- The type of sprinkler, diameter of coverage, distribution pattern, height of jet stream and operating pressure.
- Wind conditions likely in each area and the best method of minimising this effect.
- Computer printouts of MAR, Cu and Sc for each spacing and sprinkler selected. (Set up four sprinklers on the spacing and recommended pressure and measure their performance and assess their suitability for your requirements. Waterwork workshop will show you how).
- The location of laterals, submains and risers. Control heads with valve and pressure tapplings (buried or above surface) to allow easy access and be protected from damage by normal nursery operations.
- Sprinkler location to reduce Sc values.

### **Mobile booms**

You will need to consider:

- Will you use the boom to just irrigate or also to apply fertiliser, fungicide and pesticides?
- What range of application rates and boom travel speeds do you require to meet the range of plants over their whole growing cycle?



- Does the boom need to irrigate in both directions and do you require proportional applications by automatically varying the speed?
- What are the water requirements of the plants and what frequency do they require irrigation?
- What operating pressures do each nozzle set require and how will this be regulated?
- Will you require the option to raise or lower the boom height to maintain that fixed watering height to grow plant production runs of different heights?

### **Slow discharge drip systems**

You will need to consider:

- Range of container sizes to be watered so that dripper rates and number of dripper stakes/ container or length of drip tube can be determined.
- If pulsing is required to match application rates to the growing media absorption rate.
- Time needed to apply water to each section (remember this system can operate during windy conditions and will not interfere with staff duties).
- How many drippers are required, what is the discharge rate and pressure required?
- If you will be liquid feeding, what arrangement do you want at the control head of each block?
- If the dripper laterals will be located at ground level or elevated along a wire between rows?
- How you intend to space the containers in these areas so that the drip system is set up to create minimum interference to you as you shift containers in and out of the area?

### **Bottom watering systems**

You will need to consider:

- Frequency and cycle time of each water application.
- Flow rates that will match uptake rates of growing media.
- Line pressure to deliver the required flow rates to each system.
- If water will be recycled or run to waste?
- What type of fertilising system will you adopt?

### **General requirements for all systems**

Having selected the best systems for your needs and budget you now need to assess for each of these systems:

- The type of water quality required and how you can achieve this through pretreatment.
- The most suitable water disinfection treatment to remove plant pathogens.
- The level of automation that suits the management needs and budget constraints.



- The total number of hours the irrigation system will operate in summer and whether this matches your management and site constraints.
- What arrangement of pumps are required in the pumping stations, would a variable speed system best suit your needs, what back up facilities do you need in the event of any pump break down or power failure?
- Pressure tappings to set and check the pressure of each block, the shut off head of pump, head loss across filters and pump operating pressures.
- Protection and control equipment for the pumping unit.
- How will the water recycling system marry into the scheme?

These are decisions that need to be made by the owner/manager and production team before an irrigation designer can set about and complete their section of the plan.

The information that you have collected and the decision you have made from the above criteria will allow the **Irrigation Designer** to:

- Hydraulically design pipe sizes, control valves, filters and pumping duties.
- Prepare a list of equipment that will be needed to complete the system.
- Prepare plans and drawings to show positioning and arrangement of equipment and specification that meet all your requirements.
- Be called on to independently assess the installation or verify its adequacy.
- Comment on alternative arrangements or equipment proposals suggested by equipment suppliers and/or installers.

**The irrigation company and contractors can now:**

- Prepare a quotation for the supply and installation of the equipment.
- Supply and install the equipment once accepted by you.
- When installed check the system meets your requirements by operating and taking all necessary measurements and checks, comparing them with those specified by you and the designer. Set all block pressures then measure, calculate and record the MAR, Cu and Sc for each block. Measure and record the shut off head of the pumping equipment.
- Clarify maintenance and warranty periods prior to acceptance.

Make sure you discuss any suggested changes, additions or modifications with your designer prior to acceptance and installation.

### **Maintenance plan**

The nursery owner and the production staff with assistance from the irrigation company and designer need to draw up a maintenance plan to:

- Meet the service requirements of the pumping equipment. Each component has its own maintenance requirements and must be inspected and serviced regularly to maintain the operation of the original installation. Obtain a copy of the manufacturer's operation and maintenance guide book for each of the components (e.g. pump motor, filter and control equipment).





- Maintain filters and valves in accordance with manufacturers' recommendations.
- Check operation of sprinklers/emitters for both discharge and pressure and assess replacement needs.
- Set protocols to check water quality of irrigation and runoff water, fertiliser concentration in leachate and leachate volume.
- Prepare protocols to set and check disinfestation system performance and monitor chemical use and concentrations.

## FURTHER READING

**Capillary mat maintenance of plants in the retail nursery** (journal), Schuch, U.K.; Kelly, J.J. and Teegerstrom T. (2008), *Horttechnology* 18:250–255

**Economics of five irrigation technologies for container-grown *Viburnum odoratissimum*** (journal), Haydu, J.J.; Beeson, R.C. and Caron, J. (2004), *Acta Horticulturae* 664:309–315

**Market analysis of the capillary mat irrigation technology for wholesale nurseries in the Southeastern United States** (conference proceedings), Hodges, A.W. and Haydu, J.J. (2001), Proceedings of the Southern Nursery Association Research Conference, 46:570–573

**Managing nursery runoff** (book), Creswell, G. and Huett, D. (Eds) (1996), NSW Agriculture, Horticultural Research and Development Corporation, and Nursery Industry Association of Australia, Wollongbar

**Managing water in plant nurseries** (book), Rolfe, C.; Yiasoumi W. and Keskula, E. (Eds) (2002), NSW Agriculture, Orange

**Review and assessment of hand watering in nurseries** (report), Poulter, R. (2009), Lifestyle Horticulture Products & Services, Horticulture & Forestry Science, Department of Primary Industries & Fisheries, Brisbane, Queensland

**Review and assessment of hand watering in nurseries** (report), Poulter, R. (2009), Lifestyle Horticulture Products & Services, Horticulture & Forestry Science, Department of Primary Industries & Fisheries, Brisbane, Queensland



## 2 IRRIGATION MANAGEMENT TOOLS TO ENSURE MORE PRODUCTIVE AND EFFICIENT USE OF WATER

Efficient water management will depend on your irrigation system selection and design but it also depends on the day to day management of water on your nursery. This in turn will have a large impact on the profitability of your business.

The last 10 years have taught us that water and energy are the two items that warrant attention. Water, because it has or is becoming a limited resource and energy as its cost is substantially increasing.

Another significant factor that has become evident from nurseries that have undertaken improvements in water management is the lift in moral of the staff which in turn improves individual productivity and the bottom line.

If each water user is to be held accountable for their management of this diminishing resource, then more attention needs to be given to measuring and record keeping. This will not only improve your water utilisation but it will have a bearing on the quality of your plants and increase your dollar returns.

If you wish to become more efficient and improve your plant quality while saving dollars it is fundamental that you need to know the vital details of your system's performance as well as details on average water use, water costs, pumping costs, maintenance costs or hand watering labour costs, plant throw out percentage etc. If you haven't measured these aspects of your business how are you going to improve the management?

To manage irrigation efficiently, several practices need to be considered starting with an understanding of growing media management.

### GROWING MEDIA MANAGEMENT

Modern growing media used in container nurseries are made from a range of soilless materials which include pine bark, sawdust, peat and peat moss, rice hulls, coir fibre as well as sand, ash, perlite and vermiculite.

When selecting a growing media for a particular aspect of nursery production, it is important to consider the method of irrigation you are going to use.

For bottom watering systems, you need a growing media with good capillary wetting properties. Although peat is useful for improving the water holding capacity of a mix, its capillary wetting capacity is generally poor. Coir fibre, on the other hand, is extremely easy to wet up in this way and would be a useful addition to growing media where bottom watering is used.

#### Wetting agents

Wetting agents are surfactants which promote wetting by reducing the surface tension of water. This allows the water retention to be increased without decreasing the air filled porosity.

They are available in a granular or liquid form. In container nurseries the granular form incorporated into the growing media will last longer for container plants and the liquid form is useful to improve water holding characteristics for growing media blends that have become difficult to wet up.



This product has been found particularly useful in both peat and sawdust based growing media as both an aid to rewetting dry growing media blends and to aid drainage in waterlogged mixes.

Refer to manufacturers directions for application rates.

### **Designing a growing media**

When making up a mix, your main concern should be the physical properties of the growing media components. That is their size, shape, density and the way they pack together. These physical properties determine the proportion of air and water in the growing media when drained as well as the bulk density.

#### **Air filled porosity**

Air filled porosity (AFP) is a measure of the free air space in a growing media which has just drained from a saturated state. Air filled porosity is important as this affects the ability of air to diffuse in and out of a growing media, which is required for good plant growth.

A growing media with a low AFP may need watering less often than one with a high AFP, but it can easily become waterlogged, resulting in slower plant growth. High AFP growing media es need watering more often but can produce more rapid plant growth.

An AFP in the range of 10 – 15 % maybe suitable for plants that are either slow growing or likely to receive little attention once planted out. Most nurseries aim for an AFP in the 15 – 20 % range. For nursery stock in the open in high rainfall areas, 20 % is an absolute minimum.

#### **Container capacity**

A growing media's total water holding capacity (referred to as container capacity) is the amount of water held by the growing media (by weight) following irrigation and initial drainage. In pots, immediately after drainage has stopped, the mix at the very bottom of container remains saturated and the level decreases to be the least at the top.

The amount of water held will depend on the particle size and the AFP. In general, the higher the AFP percentage the lower will be the water holding capacity. Readily available water is mainly held in particles between 0.1 – 0.25 mm. Water held in finer particles is generally unavailable to plants as it is held too tightly. This point is commonly referred to as the refill point and is a significant percentage of the water held in growing media es. Particles of larger size tend to hold air.

The height of the saturated and very wet medium for a given growing media is generally the same, however is influenced on the type of container. For example, a growing medium in a shallow container will have a higher average water content (and a lower AFP) than the same growing medium in a taller container. This is why some shallow containers become saturated under bottom watering systems that supply water continuously.

Different mixes respond differently as shown in Table 3.

**Table 3 – Water capacities and availabilities for various growing medias**

| Some typical mixes                      | Container capacity | Refill point | Available water |
|-----------------------------------------|--------------------|--------------|-----------------|
| 1 – 85 % pine bark, 15 % sand           | 41 %               | 30 %         | 11 %            |
| 2 – 70 % pine bark, 15% sand, 15 % coir | 43 %               | 31 %         | 12 %            |
| 3 – 85 % pine bark, 15 % coir           | 48 %               | 33 %         | 15 %            |

If your irrigation system is working efficiently by applying water evenly at a rate that can be absorbed by the media then the following table details the maximum water applications required to fill a pot from refill point to pot capacity.

**Table 4 – Maximum refill water applications**

| Pot size | Pot volume | Required irrigation in mm |       |       |
|----------|------------|---------------------------|-------|-------|
|          |            | Mix 1                     | Mix 2 | Mix 3 |
| 100 mm   | 500 ml     | 7                         | 7.6   | 9.5   |
| 112 mm   | 1.0 L      | 11.2                      | 12.2  | 15.2  |
| 125 mm   | 1.05 L     | 9.4                       | 10.3  | 12.8  |
| 140 mm   | 1.5 L      | 10.7                      | 11.7  | 14.6  |
| 150 mm   | 2.0 L      | 12.5                      | 13.6  | 17    |
| 165 mm   | 2.4 L      | 12.3                      | 13.5  | 16.4  |
| 180 mm   | 2.8 L      | 12.1                      | 13.2  | 16.5  |
| 200 mm   | 4.5 L      | 15.8                      | 17.2  | 21.5  |
| 250 mm   | 8.1 L      | 18.2                      | 19.8  | 24.8  |
| 300 mm   | 13.5 L     | 21                        | 22.9  | 28.6  |

If you had this range of containers all in the same irrigation block then the 100 mm containers would dictate the irrigation amount and frequency if all the plants had similar water requirements. There would be little point in applying more than 7 mm at any one time using say Mix No 1 (85 % pine bark, 15 % sand).

#### For more info

**Container Media Management** (report), Bodman, K. and Sharman, K., (1993). Contact Nursery & Garden Industry Queensland, Brisbane, Australia for a copy of this report.

#### Water absorption rate

The ability of a growing media to absorb and retain water from a top watering irrigation system cannot be reliably predicted from wettability, AFP, bulk density, water holding capacity or any other properties specified in the current Australian Standard for Potting Mixes AS3743-2003.

To determine the approximate absorption rate of your mix, follow the simple field test procedure outlined in *Managing Water in Plant Nurseries* (pages 89–92).

Recent work in Queensland has determined the maximum MAR for their most common mixes as detailed in Table 5.



**Table 5 – Maximum MAR for various growing medias**

| Growing media components                   | Maximum MAR |
|--------------------------------------------|-------------|
| Pine bark 85 % & sand 15 %                 | 10mm/hour   |
| Pine bark (100 %)                          | 10mm/hour   |
| Pine bark 85 % & sand 15 % & wetting agent | 15mm/ hour  |
| Pine bark (100 %) & wetting agent          | 15mm/ hour  |
| Pine bark 75 % & sand 15 % & coir 10 %     | 20mm/ hour  |
| Pine bark 50 % & coir 50 %                 | 20mm/ hour  |

## **WATER AUDIT**

For those nurseries that already have an irrigation system and currently manage this and other water issues, a water audit will measure and record what actually happens on the nursery and provide valuable information on where improvements can be made and on what priority each of these needs to be given. Operators that carry out this valuable process find many of their assumptions of what is going on are completely different to reality.

This water audit will fall into the following categories.

### **Water sources**

Water quantity – detail the availability of water from each source, note limitations, costs, reliability backup supplies etc.

- Storages – demonstrate how the sizing of the storages relates to the irrigation demand.
- Bores – What is the sustainable long term pumping rate and what is the seasonal variability of the standing water level, detail depth, aquifers, casing size, screens etc.
- Drainage water is it collected or disposed? What are the limiting factors in recycling or reusing this water?
- Town water supply or stream pumping how are the costs escalating and how is the security holding up.

### **Water quality**

Check on the quality of your irrigation and drainage water sources.

- Have samples tested in a laboratory for pH, electrical conductivity (EC), Alkalinity, Chloride, Hardness, Nitrates, CaCO<sub>3</sub> saturated index, Sodium Absorption Ratio (SAR), Calcium, Magnesium, Sodium, Potassium, Aluminium, Arsenic, Boron, Copper, Iron, Manganese, Molybdenum, Sulphur and Zinc and any other tests (i.e. turbidity for UV disinfection).
- Have these tests analysed for the suitability of this water to grow your range of plants, irrigation equipment clogging hazard and disinfection limitations.



## Production requirements

Note any limiting factors from irrigation that effects optimum production. This could include:

- Irrigation times match your production schedules
- Irrigation times minimise wind effects on sprinklers
- Plant disease susceptibility with excessive wet foliage
- Staff working schedules (i.e. dispatch and spraying)
- Off peak power or water periods
- Excessive use of water
- Excessive leaching of nutrients
- Uneven plant growth
- Slow plant growth
- Leaf drop, giving a less attractive product
- Poor inter-node spacing and plant shape
- Excessive drainage
- Elevated or contaminated watertable.

## Irrigation system

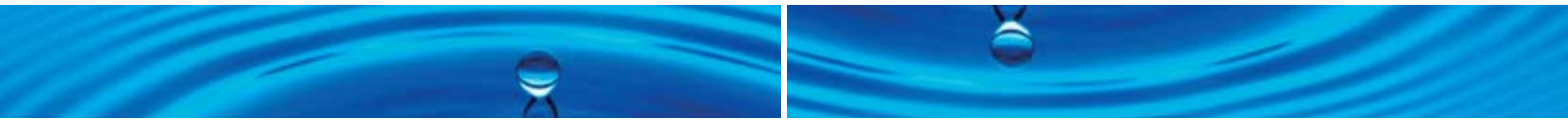
A full evaluation of the current irrigation system and current irrigation management practices should be undertaken. This may require the services of a qualified irrigation specialist for some of the analysis. You and your staff can do much of the legwork collecting data on the sprinkler performances and operating pressures of blocks and pumps.

### *Pumps*

- Details of each pump should be taken noting the operating pressure at each irrigation station. Your local irrigation equipment supplier should be able to provide you with a pump curve for each pump. The irrigation specialist will advise on the suitability of each pump for the range of duties required and can measure/calculate the flow to each station and the range of efficiencies the pump is working at.
- Shut off pressures should be recorded on all rotodynamic pumps and compared to pump curves to check impeller wear.
- Suction losses should be measured and calculated to check efficiency of pumping system.
- Detail the maintenance schedule for your pumping units.
- Energy costs to run these pumps should be recorded for each season. This will indicate how efficient your pumping systems are at present.

### *Filters*

- Note the type and size of filter units. Irrigation specialist can comment on type and capacity of the unit and how it suits your requirements.
- Record the back flushing frequency and what maintenance you carry out on this unit.



### ***Sprinkler/dripper performances***

- With a series of catch cans measure and calculate the MAR, Cu and Sc for each irrigation block, noting the operating pressure, types of sprinklers/drippers and spacing. A Waterwork Calculator and procedures to follow to measure sprinklers can be found in the Waterwork course.
- Draw up your current irrigation schedule for each block including the block area and your daily irrigation timings with whatever season variations you normally adopt. How does this match your crop water requirements?
- Record how you currently decide on how long to water each block.
- Outline your maintenance schedule and how you monitor the system performance (pressure, output etc.).

### ***System hydraulics***

- The irrigation specialist can check the hydraulics of the system and comment on the adequacy of the pumps, piping and valves and suggest any changes that are required.
- Do you flush and disinfect your pipelines. If so, detail how and at what frequency.

### ***Energy audit***

Irrigation, recycling and water transfer pumps are a significant proportion of most nurseries energy cost. Reassessing the efficiency of your pumping units can provide a considerable saving. One of the most recent innovations in pumping that is particularly suited to production nurseries is the packaged pressure systems that consist of two or more pumps in parallel and can combine variable speed and fixed speed pumps. These systems give nurseries the flexibility to irrigate anything from a small polyhouse to several hectares of production. The key is they only use the energy required to meet the specific duty. This can provide substantial savings in electricity where you have great variability in your pump duties.

An irrigation specialist should be able to assess the energy usage for your current range of pump duties and suggest improvements.

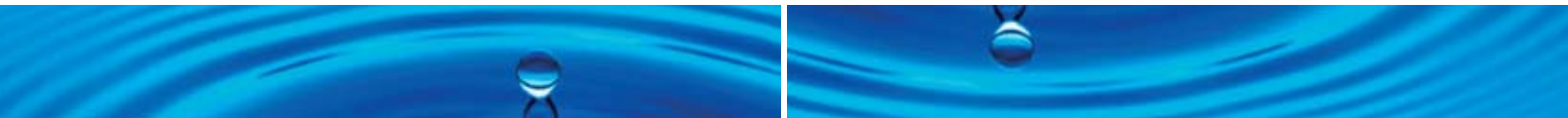
### ***Drainage/recycling and management***

An evaluation of the current drainage and recycling system and current drainage management practices is every bit as important as the irrigation system (See Chapter 4).

### ***Existing drainage system***

- Describe in general terms the drainage system detailing the types of drains used and comment on their adequacy in heavy rainfall.
- Show how you manage drainage to minimise downstream pollution. Detail any sections of the current system that need attention (e.g. erosion, ponded water etc).
- Does your drainage system match the slope, soils, and rainfall intensity as detailed in Waterwork course?
- Does the system meet all necessary state and local regulation?
- What is your recycling/reuse options? How are they managed?
- Does the quality of stormwater runoff from your nursery meet local environmental guidelines?





### ***Drainage storage***

- Show how you manage your drainage storages to optimise water retention and minimise return of any pollutants in the water to surface and groundwater systems.
- Demonstrate that the storages are located on suitable sites to minimise losses through seepage.

### **So what do you do with all this information?**

This auditing process will highlight the limitations and opportunities for optimising efficient water utilisation on your nursery. The changes will fall into two categories:

- Management changes
- Technological changes

### ***Management changes***

When you have assessed how much water you apply to each block each day and match this to the actual water requirements of these blocks you may need to reorganise your irrigation schedule.

Maintenance of the irrigation equipment and drainage system may need to be upgraded.

### ***Technological changes***

If your irrigation and/or drainage system needs significant upgrading, list out the requirements for modification or replacement. This list can be a brief to the designer.

### **Draw up a plan of action**

The nursery industry has developed a Nursery Production Economic Model which is a decision model utilising a series of economic spreadsheets for the nursery industry to assess proposed changes to a business in regard to water saving technologies to allow growers to plan and implement water use efficiencies based on a return on investment. The details to run this model are provided at Appendix 2 – Input data for Nursery Production Economic Model.

It will also provide estimates on other operational cost savings such as reduced electricity cost, plant throw outs, fertiliser and chemical usage. Contact your local Nursery Industry Development Officer for assistance with this model.

From the results of the model and water audit the nursery can prepare a timetable for implementing the development/upgrade with a summary of costs and returns anticipated.

- Describe any new scheduling system you may now use.
- Outline how you will monitor the irrigation system for performance (pressure, output etc.).
- Outline how you will manage drainage to maximise reuse and minimise downstream pollution.
- Outline how you will manage drainage storages to optimise water retention and minimise the return of pollutants to surface and groundwater systems.
- Give each change a priority in terms of water use efficiency benefit and cost or regulatory requirements and briefly explain why you have given this priority.

Once these changes have been fully costed then this information can form the basis of a business plan for your friendly financial institution to finance the upgrade.



This process will also demonstrate to the catchment authorities or environmental regulators the responsible approach your business has taken to improve water utilisation and minimise the impact your business will have on the local environment.

It will also reduce downtimes, better meet the water requirements of your plants and improve your productivity and profitability.

### Nursery retrofit case study

This nursery had 1.2 ha under production and had been in operation for several generations with a 15 to 20 year old irrigation system installed as the nursery grew over generations.

Performance data pre-retrofit was Cu 66 to 91 %, MAR was excessively high at 14 to 51 mm/hr and the Sc ranged from 2.1 to 5.0.

Under the old irrigation system, the maximum daily water use varied from 48 kilolitres per day during winter to 98 kilolitres per day during summer. This equated to a total water use ranging from 22 megalitres to 26 megalitres per year, with water provided by a dam.

Post retrofit, performance data and water use has significantly increased. The Cu has increased and ranges from 88 to 93 %, MAR has reduced lowered and ranges from 8 to 17 mm/hour and the Sc has stabilized and ranges from 1.03 to 1.4.

The retrofit has provided annual water savings of 6.5 megalitres, a reduction of 27 % from the previous system. Water and operational costs savings of approximately \$831 per year have also been achieved.

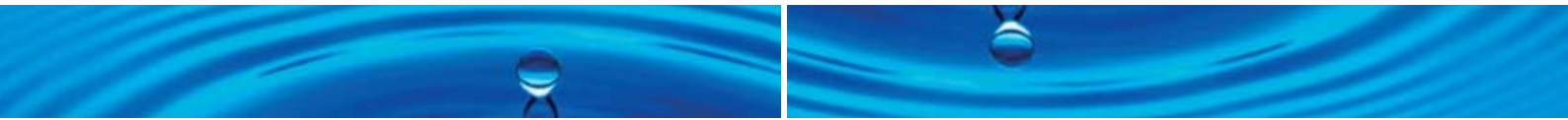
A map of the nursery with the new and old water use efficiency values for the different irrigation zones is shown below.



### For more info

Upgrading an irrigation system can improve water uniformity and reduce your operating expenses. *The Nursery Papers* 2008 No10

A generic economic decision model for the nursery industry to assess proposed changes to a business. *The Nursery Papers* 2008 No 11



## IRRIGATION SCHEDULING

Irrigation scheduling is generally explained as ‘applying the right amount of water at the right time’. Most plants use more water on hot sunny days than cool overcast days and different plants require different amounts at different stages of production. Unfortunately many nurseries just water to keep their plants alive. This often means that the plants with the highest water use or most frequent demand dictate how the whole nursery is irrigated.

In nurseries that grow a range of woody ornamentals water use has been measured and the daily water use for similar sized plants in the same sized containers under identical conditions can vary by more than 300 %. Add to this the range of container sizes the development stage of the crops, variations in growing conditions (shade etc) as well as the climatic conditions that create up to a further 300 % daily variation in evaporation in summer.

Many nurseries simply apply a scheduling system by setting a watering regime for summer and winter ignoring all these variables. This approach to irrigation scheduling leads to:

- Excessive use of water.
- Excessive leaching of nutrients.
- Poor plant growth.
- Leaf drop, giving a less attractive product.
- Poor internode spacing and plant shape.
- Saturated pots covered with algae and moss.
- Excessive drainage with elevated nutrients.
- Elevated or contaminated water tables.

All of these results will affect your bottom line because nutrients and water are interrelated. Plant growth depends on the management of nutrients, which in turn depends on your management of water.

The whole system of water use is driven by transpiration at one end and available water at the other end. The amount of water used by a plant depends on the solar radiation, temperature, wind and humidity. If there is not enough water available, or if it becomes too hard to extract from the growing media, then the metabolic process starts to close down; the plant stops growing and becomes overheated and starts to wilt. If this is occurring on a regular basis then the bottom line is being affected by poor plant growth and too many throwaways.

Plants in the open, exposed to full sunlight and wind will use more water than plants under shade cloth, where solar radiation, temperature and wind are all reduced. Plants in poly or glass houses can experience higher temperatures and humidity, but are exposed to less radiation and wind, so they will generally use less water than plants outside in summer. However, the opposite could be the case in winter.

### For more info

**Scheduling irrigation to maximize efficiency.** *The Nursery Papers* 2006 No 008

With a range of plants using different amounts of water throughout their growth cycle, a range of growing conditions (outdoor, shade, poly house etc) and daily variations in potential evapotranspiration some measurements need to be taken and recorded.

The four key measurements are:

- Water holding capacity of the growing media.



- The daily evaporation at the nursery.
- How much water do the plants use.
- The application rates of the irrigation system.

### **Growing media – readily available water**

#### ***How is water held in containers?***

Water is held by surface tension in the small pores of the media called micro-pores. The water held in the larger pores, macro-pores, generally drains out providing the air porosity. The smaller pores are referred to as capillary pores and will move water into the mix under bottom watering systems. The larger pores filled with air are called non-capillary pores.

Underneath topsoils are subsoils and underneath pots is air. This makes a very big difference in the amount of water held in just drained media in pots (container capacity) as would be the case in just drained soil (field capacity).

The water holding capacity, air filled porosity and absorption rate of your mix will have a great bearing on how you irrigate your plants as noted at the start of this chapter.

### **Measuring daily evaporation**

There are many automatic weather stations now available that will calculate this figure and provide it on a daily basis

Alternately you could install a Class A evaporation pan and read the previous days evaporation first thing in the morning before setting the irrigations for the day.

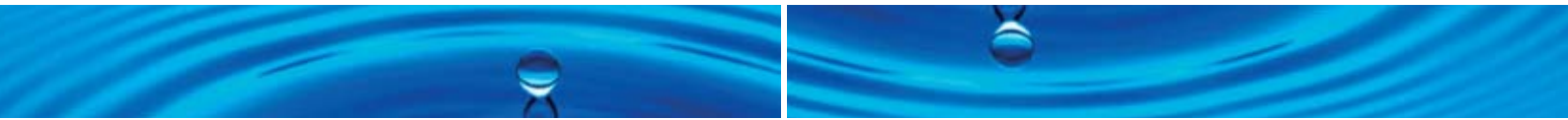
### **Measuring actual plant water use**

There are many tools to measure soil moisture for in ground horticulture. Container grown plants using artificial media provide some challenges for many soil moisture monitoring tools. Capacitance tools seem to have the most promise but care needs to be taken as some are affected by high temperatures that occur in pots and will provide false readings in high EC solutions. These tools need to be calibrated to the growing media and refill points determined for the range of plants being monitored.

In 2007, the nursery industry conducted research into soil moisture sensors in a containerised production environment. The project aimed to identify whether soil moisture sensors are appropriate for use in a containerised production environment and to evaluate the effectiveness of soil moisture sensors for irrigation scheduling in organic based growing media.

There are a variety of soil moisture sensors available:

- 1) Insertion units (monitoring tool) with moisture, temperature & EC
  - Simple, quick, requires little technical experience.
- 2) In-situ units (monitoring or automation tool)
  - Technical experience needed to install.
  - Can be connected to irrigation controller.
  - Generally more expensive.



The research looked at five soil moisture sensors and set about identifying the right soil moisture sensor to use with the criteria being:

- Size of sensor – the sensor needs to fit into growing containers (numerous types of containers being used, i.e. tubes, 100 mm diameter pots and upwards).
- Type of sensor – volumetric or soil potential sensor and be robust and provide reliable data.
- Cost – should be financially viable for smaller nursery operators.
- Availability – should be readily available with after sales technical support.
- Simplicity/ease of use – can be installed and maintained by the nursery staff.
- Interface/connection – the product can be connected to existing irrigation controllers.

The results of the trials suggest the soil moisture sensors tested can be used to either monitor or automate the irrigation system to improve water use efficiency in comparison to timed and/or deficit irrigation. The tangible benefit here is reduced leaching and hence the opportunity to preserve the overall water storage if water recycling systems are not installed to manage run off and preserve water budget.

A more simple method is to weigh plants before and after irrigation. Some simple measurements taken at various stages of plant development will give you a handle on the range of water requirements across the nursery.

 **For more info**

**Do soil moisture sensors have a role in containerised nursery production?** *The Nursery Papers* 2008 No 8

Select the size of the container and the plant that is going to dictate the irrigation frequency for each block. Weigh a representative sample of these pots (containing plants) that have received the average application rate for these blocks, after you are confident that the containers are at their maximum water holding capacity. Before you next irrigate, weigh the same containers to determine the water (weight) loss. Table 6 provides you with the weight loss for a range of container sizes for each millimetre of water required to replenish the container.

**Remember that** – one litre of water weighs one kilogram.

If you know the MAR and Sc of the system for each block then Table 6 will match the irrigation time to the water requirements.

**Table 6 – Equivalent weight loss for one millimetre of water application**

| Container size<br>(mm) | Weight loss<br>(grams) |
|------------------------|------------------------|
| 80                     | 5                      |
| 100                    | 10                     |
| 150                    | 20                     |
| 170                    | 25                     |
| 200                    | 30                     |
| 250                    | 50                     |
| 300                    | 70                     |

Take for example a 200 mm container that is irrigated in a block that has a MAR of 9 mm/hour and a Sc of 1.3 to water the driest pot in the block. The container weighs 4,460 grams after rain or irrigation. Just before applying the next irrigation it now weighs 4,280 grams.



The water loss is 180 grams (4,460 – 4,280) which is equivalent to 6 mm (180÷30 taken from Table 6).

$$\begin{aligned}\text{Time to irrigate} &= \frac{\text{application} \times 60 \times \text{Sc}}{\text{MAR}} \\ &= \frac{6 \times 60 \times 1.3}{9} \\ &= 52 \text{ minutes}\end{aligned}$$

If plants within the block you have measured have either high volumes of leachate or no leachate and the application rates are similar, it illustrates that these plants have a different water requirement and should be moved to a more appropriate block. Initially this could be as simple as high water users, low water users and the rest.

Carrying out this procedure over the full range of plants in the nursery will allow the staff to split the crops into water requirements rather than pot size or what ever system you currently employ. This can be converted to a crop factor so all water requirements can be connected to the daily evaporation reading. For example in a given day of an evaporation reading of 5 mm one plant may use 4 mm and another 8 mm the crop factors for these two crops would be 0.8 and 1.6, respectively.

In time as plants are potted up they can be located in their appropriate irrigation block where you can apply the right amount of water at the right time.

### Water requirements

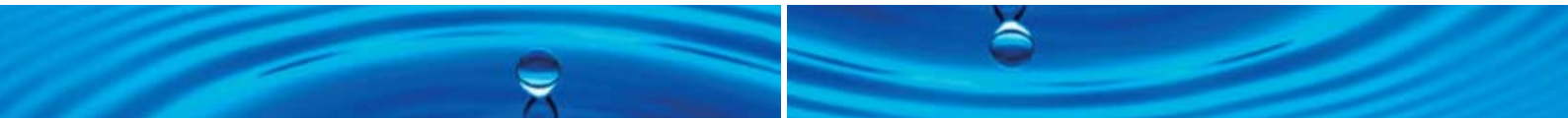
Crop requirements can vary greatly in container nurseries. When plants are freshly potted up the bulk of the water use is via evaporation from the pot surface. As the plants grow this surface is shaded reducing the surface evaporation but this is then offset by the increased plant water use. If the canopy area is about the same as the surface area of the top of the container then the crop factor will average about 1 for plants with moderate water requirements. Some plant varieties will use more than this while others will use less.

If the canopies are allowed to grow substantially larger than the container surface area then the crop factor will increase rapidly and will be a function of the canopy area. For example if the canopy diameter is 500 mm and the container diameter 300 mm then the crop factor will be 2.8.

Water requirements are going to vary each year depending on effective rainfall, evaporation and stages of plant growth and plant species. A long term average annual water requirement is usually based on a crop factor of 1, the effective rainfall of 20% and using the decile 5 monthly rainfall figures.

To determine an average annual water requirement for irrigation it is necessary to look at average monthly evapotranspiration rates of the plants and subtract the proportion of this requirement that could be expected to be supplied by the median rainfall (decile 5). The shortfall is what can be expected to be applied as irrigation. These factors are all measured as depth of water in millimetres. To convert these depths to a volume it is necessary to multiply this depth in mm by the area being irrigated in square metres to arrive at a volume in litres which can be converted to megalitres.

The methodology of water requirement calculations using the above data is explained in NGIA workshop, Waterwork (Module 1: Water supply, treatment and disinfestation).



## **FURTHER READING**

**Increasing adoption of innovative irrigation technologies in Australian nurseries** (report) Hunt, D. (2008), Lifestyle Horticulture Products & Services, Horticulture & Forestry Science, Department of Primary Industries & Fisheries Queensland

**Growing media for ornamental plants and turf 4th edition** (book), Handreck, K.H. and Black, N.D. (2010), University of NSW Press

**Managing water in plant nurseries** (book), Rolfe, C.; Yiasoumi, W. and Keskula, E. (Eds) (2002), NSW Agriculture, Orange





### 3 INCREASED RE-USE OF NURSERY WASTE WATER TO REDUCE BUSINESS DEMAND ON THE WATER RESOURCE

A number of major Australian nurseries recycle water successfully. The success of these enterprises, whose products range from advanced trees to seedlings, is based on careful monitoring of water quality, inputs of high quality water to improve quality of their waste water, and treating water to minimise pathogen spread.

It is essential to monitor and treat nursery waste water as its quality varies greatly. For instance, storm runoff from roofs is generally of high quality and usually does not need disinfection while the quality of runoff from roads and paths is not as high because of oil contamination and road base colloids. This is especially so if these roads and paths are not sealed, which increases the risk of plant disease spread.

Water collected from production areas is even poorer in quality because it often contains nutrients, floating potting media constituents, humic acid and agricultural chemicals. It may also contain plant pathogens. To make it suitable for reuse this water may have to be pretreated to remove contaminants such as litter, silt and plant pathogens, or it may have to be acidified. Because water from production areas comes mainly from irrigation drainage it is good practice to manage irrigation and fertiliser application so that runoff and nutrient leaching are kept to a minimum (see Chapters 1 and 5).

To maximise quality of irrigation runoff, production areas should be covered with plastic (at least 200 micron (0.2 mm) thickness) which is covered with screenings or aggregate and overlaid with weed mat. Different water collections can be kept separate or blended to produce a supply suitable for recycling onto production areas or for reuse for other purposes.

Finally, it is important to note that although legislation is in place regulating the disposal of some nutrients and agricultural chemicals into the environment, the water policies of most State/Territory environment protection agencies are continually being reviewed.

#### **REUSING NURSERY WASTE WATER**

This publication recommends three alternative uses of nursery waste water:

- reusing it for other purposes including garden and pasture irrigation
- recycling it back onto nursery stock
- disposal to the environment.

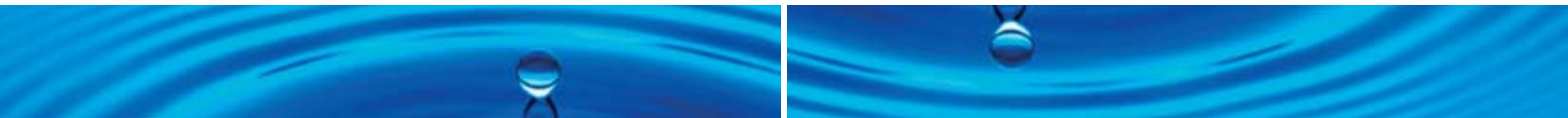
The first two alternatives are discussed in this chapter while disposal is dealt with in Chapter 4.

#### **Reusing nursery waste water for purposes other than nursery production**

There are several ways of reusing nursery waste water for purposes other than nursery production.

##### ***Crop production and fertilisation***

Using waste from nurseries for other crop production (if there is enough land available), and pasture and garden irrigation is a good practice to use up excess nutrients that may otherwise be released to the environment. If you do consider this option, remember that some nutrients will accumulate in the soil unless they are removed from the site by harvesting.



The quality of water for reuse for other plant production need not be as high as for container plant production and disinfestation is unlikely to be necessary. Nevertheless, the quality limits for irrigation water as outlined in the following section on recycling should be followed if possible.

### ***Wetlands***

Constructed wetlands are designed to mimic natural wetlands, while maximising the performance of those aspects of natural wetland systems that are known to improve water quality. Put simply, by controlling and manipulating water flows, including retention time (to allow for sediment and nutrient trapping) and depth of water, wetland functions can be optimised.

Just how effective wetlands are, especially as far as their ability to address the full range of water quality problems as well as their limitations are concerned, has been the subject of much controversy. Constructed wetlands can, however, be effective in achieving things such as improving water quality, creating habitat for native fauna, and providing an environment for passive recreation and community education.

Their limitations can be reduced and their effectiveness enhanced or optimised through the use of multi-objective design based on a greater understanding of wetland processes. More research is needed into these processes to develop better guidelines.

Constructed wetlands can be divided into those where the water flows over the surface of a ponded area where water plants are present (often called surface flow wetlands or free water surface wetlands) and those where water flows through a substrate material which supports water plants (often called subsurface flow wetlands).

### ***Deep dams***

Although it has not been confirmed experimentally, deep dams containing enough organic matter may promote anaerobic conversion of nitrates to nitrogen gas.

## **Recycling water onto production areas**

Table 7 lists the limits for all key factors for plant production in the nursery as far as water is concerned.

Many of the essential plant nutrients occur in useful levels in nursery and flower farm waste waters, and these industries could save on the use of fertilisers by recycling water and reusing the nutrients.

### **For more info**

**Water quality survey of the Australian nursery and flower industries** (report), Beardsell, D. and James, L. (1995). Technical Report for HRDC Project No. NY 320

Nutrient levels vary greatly at different nurseries and at different times of the year so regular monitoring and good management are necessary to maintain the quality of recycled water at an acceptable level.

If you do adopt this strategy be aware that daily fluctuations occur in nutrient content of leachates in nurseries depending on irrigation and fertiliser practices, especially after liquid feeding. As well, in a yearly production cycle, water quality should be monitored at least at the following times:

- soon after potting on
- once during winter and summer
- once during dry or wet periods.





It is essential that you measure electrical conductivity, pH and nitrate when recycling water onto production areas. Other factors including sodium, chloride, bicarbonate alkalinity, phosphate, boron, manganese, aluminium, iron and copper can also be regularly monitored if they are likely to be a problem at individual enterprises.

Note that water to be recycled may also contain residues of plant protection products. See Chapter 6 for more information.

### **Water pretreatment**

Water to be recycled onto nursery stock needs to be pretreated to improve quality and assist in eliminating plant pathogens. Procedures to consider are clarification, filtration and storage.

#### **Clarification**

Turbid water can be clarified with flocculants such as aluminium sulphate, ferric alum and gypsum. Ferric alum is effective in the pH range of 5.5 to 8.5, and aluminium sulphate in the pH range 6.8 to 7.5. These chemicals lower the pH of the water so monitoring this factor before and after application is essential. To clarify water use alum at 0.5 to 0.75 kg per 10,000 L of water. Gypsum can be used at a rate of 3.5 kg per 10,000 L. Mix these chemicals with water before applying them. They are best used in storage tanks.

#### **Filtration**

The filtration method you use will depend on the quality of water to be recycled. If the water contains large amounts of silt and other solids it may need pretreatment with a hydrocyclone filter.

Before disinfestation and recycling, the following filter grades should be used: media filters containing 1 mm crushed basalt, disc filters of 120 – 140 mesh, and automatic disc filters of 150 – 200 mesh. In addition, an 80 mesh filter is preferable to a 120 mesh filter after a disc gravel filter.

Increasing the filtration grade of the automatic filter within the range listed above will protect the check filter better, but will also increase the backflushing frequency. A low pressure differential for activating the flushing works more efficiently. Increasing the filter grade causes more backflushing than reducing the pressure differential.

When using gravel filters it is better to use smaller filters such as 6 x 20 inch rather than 3 x 36 inch filters. When backflushing the excess is delivered through five filters instead of two. Grade 1 crushed basalt is nominally 1 mm in size (0.7 – 1.5 mm). Two millimetre is too coarse. The gravel will take about 2 months to bed itself in. If the water is very dirty, the velocity of discharge will have to be decreased.

#### **Storages**

To minimise the demand of the business on water, collecting part of the runoff will have many benefits, including being less reliant on other water supplies. Water collected is free, and storm water runoff from buildings and hard areas is often of better quality than existing sources. To calculate the size of storage required, determine the area to be drained in square metres, the amount of rainfall (in millimetres) per time period and the amount of irrigation per time period.

**Drainage volume (litres) = (area m<sup>2</sup> x rainfall mm) + (area m<sup>2</sup> x irrigation mm)**

#### **Example**

For 2,300 m<sup>2</sup> of nursery area in Castle Hill in northwest Sydney during the wettest month of the year (March, 120 mm), this rain falls in 11 days so irrigation is necessary for the other 20 days of the

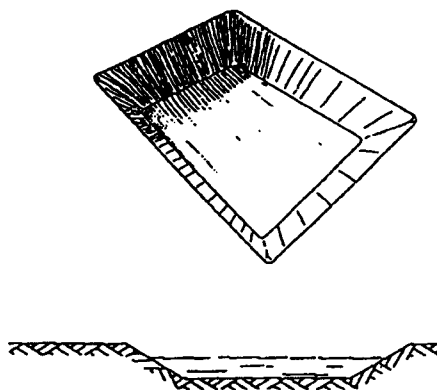
month (20 days @ 3.5 mm/day = 70 mm).

$$\begin{aligned}\text{Drainage volume} &= (2,300 \times 120) + (2,300 \times 70) \\ &= 276,000 + 161,000 \\ &= 437,000 \text{ litres in the wettest month}\end{aligned}$$

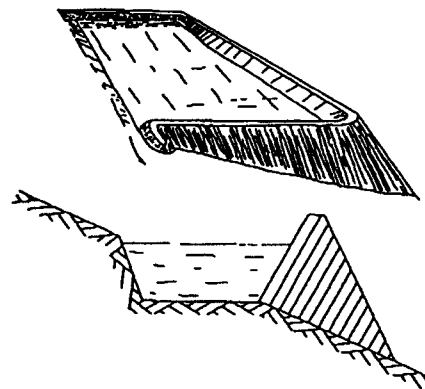
For a storage to meet this capacity it would have to be as an air space in the storage coming into the wet month.

Storages can be built as excavated tanks with all the storage below ground, or as a turkey nest with aboveground storage that can be replenished with a large flood lifter pump. Turkey nest storages use less earthworks. If water is collected mainly from clean catchments such as roofs, the storage should be plastic lined to maintain quality.

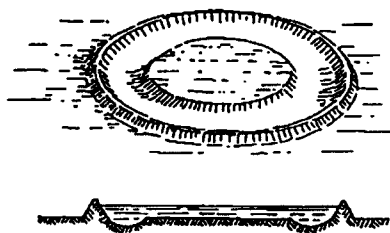
Small nurseries may be able to use concrete or poly tanks, depending on the amount of storage required. Some nurseries, such as those on flat land or on sand, may not be able to drain to a single storage area. Sumps such as septic tanks with small pumping units matched to the runoff discharge and controlled by two level float switches can be put in series. The runoff can then be moved to a main storage using polythene or PVC piping. Guidelines for building storages can be found in the publication *Managing Water in Plant Nurseries* available through State/Territory nursery associations.



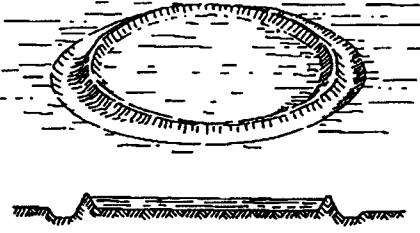
Excavated storages



Hillside storages



Ring tank storages



Turkey nest storages

## Managing nitrate, phosphate and potassium for recycling

One management issue when recycling nursery water is algal growth on dams. Bluegreen algal blooms occur at low concentrations of nitrate and phosphate. Between 10 and 100 mg/L nitrate-nitrogen accompanied by phosphate with a nitrogen:phosphorus ratio of between 16 and 20:1 has been known to cause outbreaks.

Controlling algae with chemicals such as copper salts may be hazardous when recycling because they can accumulate to potentially phytotoxic levels. In storages chelated copper products such as Coptrol®, when used strictly as instructed on the label, have been found to give good results. Algae can also be controlled by manipulating nitrogen and phosphorus levels in water, for instance by removing nitrogen by adding straw bales or other materials with a high carbon to nitrogen ratio to water supplies.

Useful potassium levels are found in recycled water. Potassium application could be reduced by as much as 20 per cent with water recycling.

**Table 7 – Nutrient and other factor levels in irrigation water for general ornamental plant production.**

Based on Hart (1974); Ayres and Westcot (1976), Aikman (1983), Degremont (1991), Yeager et al (1994), Bienbaum 1993.

| Factor                             | Phytotoxic limits                                        |
|------------------------------------|----------------------------------------------------------|
| Nitrate (as NO <sub>3</sub> not N) | <100 mg/L (excessive soft growth)                        |
| Phosphorus (as phosphate)          | <15 mg/L for phosphate sensitive plants                  |
| Iron (Fe++) (Yeager et al)         | 5 mg/L                                                   |
| Copper                             | 0.2 mg/L                                                 |
| Boron                              | 0.3 mg/L                                                 |
| Zinc                               | 2.0 mg/L                                                 |
| Manganese                          | 0.2 mg/L                                                 |
| Aluminium                          | 5.0 mg/L                                                 |
| Molybdenum                         | 0.01 mg/L                                                |
| pH (nutrient imbalances)           | 5.5 to 7.0                                               |
| Salinity (EC–dS/m)                 | 0.75 to 3.0 (low to severe problem*)                     |
| Chloride                           | 200 mg/L                                                 |
| Sodium                             | 100 mg/L                                                 |
| Alkalinity                         | 40 to 500 mg/L CaCO <sub>3</sub> (low to severe problem) |

\* Safe salinity limits will depend on the type of crops grown. The optimum levels of nutrients in irrigation water will also vary with the crops grown. Refer to hydroponic texts for guidelines.

### For more info

**Managing water in plant nurseries** (book), Rolfe, C.; Currey, A. and Atkinson, I. (eds), (1994) NSW Agriculture, Horticultural Research and Development Corporation and Nursery Industry Association of Australia

### For more info

**Water quality survey of the Australian nursery and flower industries** (report), Beardsell, D. and James, L. (1995). Technical Report for HRDC Project No. NY 320



### For more info

**Draft irrigation and fertilisation Best Management Practices for producing container grown woody environmental plants** (booklet), Yeager, T.; Fare, D.; Gilliam, C. and Niemiera, A. (1994), University of Florida

### Managing salinity

The key to managing high salinity in recycled water is having a source of low salinity water to mix with recycled water. In some nurseries where water is recycled, salinity is not a problem because of the availability of high quality mains water and because runoff, including rainwater, is collected.

As a guide, an electrical conductivity (EC) of above 1 dS/m indicates a salinity problem in unused water. If the water is low in sodium and chloride (balanced hydroponic solutions can have an EC of over 2 dS/m) higher ECs can be tolerated.

Chloride is also toxic to plants, especially at concentrations above 200 mg/L. For this reason keep chloride levels below 200 mg/L in recycled water, although with good management higher levels can be tolerated depending on the crops grown.

Sodium should be kept below 100 mg/L in recycled water, preferably with a sodium absorption ratio (SAR) below 5. Levels of sodium higher than 100 mg/L can be tolerated if other cations are in balance.

### Managing pH and alkalinity

The ideal water pH level for plant growth is from 5.5 to 7.0, although levels from 5.0 to 8.0 can be acceptable depending on the crops you are growing and the amount of buffering of pH in the water.

Recycled water with a pH too high for safe chlorination will require acidification.

Acidification is an easily automated process for which commercial units are available. There are several options to do this and each option has its advantages and disadvantages. Be aware of the following:

- when disinfecting recycled water by chlorination pH must be below 7.0.
- hydrochloric acid increases chloride levels and phosphoric acid may cause excessive phosphorus levels, however, if chloride levels in water are not already high, hydrochloric acid is the easiest to use.
- sulphuric acid is the safest to use in plant terms but not in terms of operator safety.

Alkalinity is a common problem in nurseries in South Australia and other areas where bicarbonate levels over 100 mg/L of calcium carbonate equivalents to pH 4.5 are regularly encountered. Lime or dolomite need not be used in potting media irrigated with water with an alkalinity higher than 100 mg/L  $\text{CaCO}_3$ . Seedling nurseries are especially vulnerable to increases in pot media pH when irrigating with water with high alkalinity levels.

### Calcium and magnesium

A survey of recycled water in Australian nurseries conducted in 1995 (Beardsell and James) showed that waste water in contained useful levels of both calcium and magnesium. Excess calcium can induce magnesium deficiency if the latter nutrient is lacking.

### Other nutrients

Useful levels of sulphur, iron, manganese, copper, boron and zinc can be found in nursery waste water.

In fact, all of these nutrients, except sulphur, can reach toxic levels and may need to be monitored in certain cases (this is why some are regarded as pollutants by environment protection agencies).

Table 7 lists the limits for each of these micronutrients. Levels higher than these can be toxic to sensitive



crops. As an example, high copper levels can occur in runoff water if copper compounds are used to control algae on paths etc.

### **Fluoride**

Fluoride ions are toxic to some plants, especially in the Liliaceae and Marantaceae families. Reticulated water contains 1 mg/L fluoride, just below toxic levels for these two groups of plants. It also occurs as a contaminant in some phosphatic fertilisers. Several nurseries have been found to have high levels of fluoride in their waste water, some of which would have been from bore and other water sources.

### **Herbicides and other agricultural chemicals**

Herbicide and pesticide residues may be detected in runoff water at nurseries, and may build up in storages that collect this water. For more information see Chapter 6.

### **Disinfection chemicals**

Chlorine (as available hypochlorous acid) is toxic to some plants at levels above 5 mg/L. Unfortunately there are no reliable published figures on the phytotoxic levels of chlorine dioxide, hypobromous acid and other bromine compounds. There is some data on ozone phytotoxicity, but this relates to photochemical smog damage. Using disinfectants such as Biogram® in poorly ventilated glasshouses can damage sensitive crops such as ferns.

### **Colour, turbidity and ultraviolet (UV) transmittance**

For most nursery purposes, colour and turbidity of water are not problems unless they cause spotting on leaves, thus reducing market quality. Ultra violet transmittance of water, which is related to water colour, is important if using UV radiation to disinfest it. For successful UV treatment water should have a UV transmittance of at least 50 % (at 254 nm) which relates to colour of less than 30 hazen units.

### **Handling agricultural chemicals**

Handle agricultural chemicals in strict accordance with the best practice developed for users by manufacturers and regulators. As well, when making up agricultural chemicals, just enough should be prepared so that little excess needs to be disposed of.

## **WATER TESTING**

Good quality water for nursery production contains adequate but not excessive concentrations of inorganic ions and compounds in the correct ratios, while maintaining low levels of suspended solids and bacteria. Whether you are fertigating or relying on fertiliser placed in the mix the nutritional program needs to be designed in conjunction with water analysis data.

It is difficult to establish accurately how much each of the various substances in water contributes to the clogging of your irrigation equipment. However, it can be generally stated that clogging problems due to the occurrence of impurities in irrigation water become more acute if the water is high in the following:

- Suspended particles of organic or inorganic matter.
- Precipitate-forming elements, such as iron, manganese, calcium and magnesium.
- Bacteria that secrete slime which causes the suspension to accumulate or which acts chemically and causes the accumulation of sulphides and insoluble compounds of heavy metals.



Plant growth and nutrient uptake will depend on the chemical cocktail that is available in the container, some of which will be supplied by your irrigation water.

Water testing criteria can be categorised as follows:

- Biological
  - Bacteria
  - Algae
- Physical
  - Turbidity, light penetration
  - Colour
  - Suspended solids
- Chemical
  - pH
  - Electrical conductivity (salinity)
  - Nutrients (nitrogen, potassium and phosphorous)
  - Inorganic ions and compounds
  - Organic ions and compounds

The number of criteria that you have tested will be determined in part on the source of the water and the product you are growing. If you are recycling water or using liquid fertiliser then you will require more tests and more frequent monitoring to maintain the correct nutrient balance and unclogged irrigation equipment.

### **Other tests**

Other tests that may be required include:

- Total suspended solids (TSS).
- Volatile suspended solids (VSS).
- Total dissolved solids (TDS).
- Turbidity. Important for nurseries contemplating using UV disinfestation
- Hydrogen sulphide (H<sub>2</sub>S). Water from deep bores (e.g. artesian basin) may require H<sub>2</sub>S determination.

### **Irrigation water quality parameters**

Other water quality parameters have been discussed in Table 6.

### **Monitoring water quality**

An easy way to monitor your water quality is to regularly check some basic measurements such as salinity levels, pH, and nitrate concentrations. This can indicate if further testing by a laboratory is required. Ideally, these basic measurements should be taken and recorded regularly.

Nursery & Garden Industry Australia have developed an industry specific Environmental Management System (EMS) referred to EcoHort that provides businesses with a systematic approach to assess their environmental and natural resource management responsibilities, as part of their daily business management. The EcoHort program has stipulated that wastewater, release water and irrigation water should have the pH, EC and nitrate levels taken and recorded monthly. This program also recommends that irrigation water should be fully tested in a laboratory every 6 months.





## Disinfestation best practice

In Australia water is usually disinfested by chlorination using either sodium hypochlorite or direct injection of gaseous chlorine. Some nurseries have chloro-bromination systems and several others use UV radiation. Whatever water disinfestation strategy you decide to use it is vital that you do a complete analysis of water quality over a 12 month period because various factors will influence how well disinfestation strategies will work.

There is not a lot of information on best practices as far as disinfestation is concerned but the following is the best available information on water disinfestation for the nursery industry. Much of this information has been generated by levy funded projects in Australia.

### Chlorine (as hypochlorous acid)

Limited field and anecdotal data indicates that a 1 minute exposure to chlorine will control zoospores of *Phytophthora cinnamomi* and spores of *Alternaria alternata* at 2 and 3 mg/L free chlorine respectively. However, there is little extensive quantitative data on other fungal plant pathogens. It is known that above pH 7, the amount of available hypochlorous acid in solution falls rapidly until little occurs at pH 8. Since the 1995 survey of nursery waste water showed that pH above 7 is typical for Australian nurseries (average 8 in Queensland), acidification is likely to be required in many nurseries.

Another disadvantage of chlorination is that its efficacy is reduced by organic matter, iron and nitrogenous compounds. Because of the occupational health and safety dangers of chlorine gas, this chemical will be phased out in the near future.

### Chlorine dioxide

Chlorine dioxide has been shown to be highly effective for disinfesting a range of plant pathogens including *Fusarium oxysporum*, *Alternaria zinniae*, *Colletotrichum capsici*, *Pythium ultimum* and *Phytophthora cinnamomi* (zoospores and chlamydospores) over a range of water pH levels.

It needs to be applied at an available concentration of 3 mg/L for 8 minutes to control waterborne fungal pathogens. Chlorine dioxide also oxidises iron.

In poorer quality water typical of that used after recycling, higher concentrations of chlorine dioxide to overcome demand by contaminants in the water will be needed. If you are applying chlorine dioxide using automated equipment it must have sensors placed in such a position in the irrigation system to account for chlorine dioxide drawdown by impurities in the water.

Disinfestation properties of chlorine dioxide are unaffected by pH as high as 10, so this method is widely applicable to the nursery and flower industries in Australia which, overall, have high water pH. Although chlorine dioxide equipment is more expensive than other chlorination systems, this method of disinfestation is likely to be more effective considering the quality of water in Australia.

The only factor stopping chlorine dioxide being recommended as best practice for water disinfestation is data lacking on its phytotoxicity and testing its efficacy on a wider range of organisms. A nursery in Victoria has successfully used chlorine dioxide without obvious phytotoxicity problems on a wide range of Proteaceae. Chlorite ions produced from chlorine dioxide may be hazardous to plant and animal health.

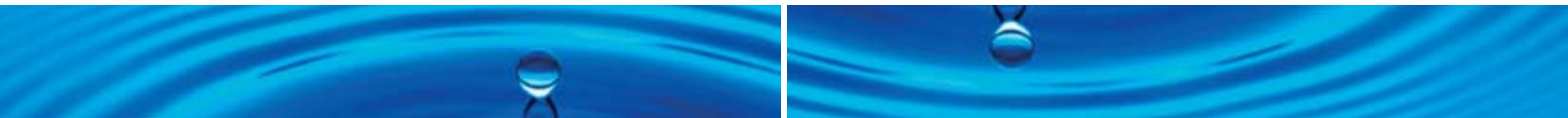
### For more info

**Water disinfestation – chloro-bromination and ozone systems get the thumbs up!** *The Nursery Papers* 1997 No 008

### For more info

**Characterisation of water quality for ozonation processes. Part 1: Minimal set of analytical data** (journal) Hoign, J. (1994), *Ozone Science and Engineering* 16:113–120

**Disinfectious effect of ozonation on water infested with several root-infecting pathogens** (journal), Yamamota, H.; Terada, T.; Naganawa, T. and Tatsuyama, K. (1990), *Annals of the Phytopathological Society of Japan* 56:250–251



### **Bromination and chloro-bromination**

Treatment of water by chloro-bromination is effective. The concentration (total chlorine and bromine) and exposure times required to control common plant pathogens in water are: *Phytophthora cinnamomi* chlamydospores at high pH, 8 mg/L for 8 minutes; *Fusarium oxysporum* 2 mg/L for 2 minutes; and *Pythium ultimum* at neutral pH, 2 mg/L for 8 minutes.

### **Ozonation**

Ozone kills chlamydospores of *Phytophthora cinnamomi* in dam water at an average residual dose of 1.4 mg/L over 16 minutes. As the decay of ozone is logarithmic, a dose of 1.4 mg/L at 16 minutes indicates an initial dose between 2.5 and 3.5 mg/L. Oospores of *Pythium ultimum* in tap water are controlled with an average dose of 1.2–1.5 mg/L ozone and 4 minute contact time, and in dam water, an average residual dose of 0.5–0.7 mg/L for 8 minutes is required. *Fusarium oxysporum* conidia in dam water are killed after 4 minutes contact time with an average of 1.8 mg/L residual ozone. Ozone demand increases with alkalinity, and the concentration of bicarbonate, iron and ammonium.

### **Ultraviolet (UV) radiation**

Ultraviolet radiation is an effective and environmentally friendly method of controlling *Phytophthora cinnamomi*, *Fusarium oxysporum*, *Colletotrichum capsici* and *Alternaria zinniae* if water has high UV transmission (greater than 50 % UV transmission after filtration) and exposure dose is at least  $5.0 \times 105 \mu\text{W.s.cm}^{-2}$ .

*Alternaria zinniae* has dark coloured spores and is the most difficult to kill with UV radiation and makes this method impractical. If you only want to kill *Phytophthora cinnamomi* and *Pythium ultimum*, radiation levels of only  $4.3 \times 104 \mu\text{W.s.cm}^{-2}$  are required which is economically feasible if water quality is high.

#### **For more info**

Using ultra violet radiation and chlorine dioxide to control fungal plant pathogens with water, *The Nursery Papers* 1996 No 005

Equipment for irradiating water with UV must be designed so that pressure changes in pipes between the pump and the UV reactor are minimised, otherwise pathogens may be protected from the radiation. You also need to make sure that flow in the UV reactor is turbulent, otherwise organisms may be protected from radiation exposure. Water must also be filtered because solid particles may protect pathogens from radiation.

Ultra violet radiation can be recommended as best practice for nurseries which have recycled water with UV transmission greater than 50 % at a wavelength of 254 nm because of its environmentally friendly operation and low cost. Water with a UV transmission less than this can be disinfested with UV radiation, however, the dose needed increases greatly as UV transmission falls.

### **Heat**

Although heat is used widely in Europe to kill plant pathogens in water it is likely to be very expensive in Australia. If the waste heat can be efficiently used for preheating, it might be considered in places where gas is cheap, such as in Victoria, however, the water must be treated at 95°C for at least 30 seconds for adequate disinfestation.

### **Microfiltration and slow sand filtration**

Microfiltration and membrane filtration has been shown to be impractical in Europe because the poor quality water in nurseries there clogs filters. It also has extremely high operating costs.

#### **For more info**

A review of possibilities for disinfection of recirculation water from soilless cultures (journal) Runia, W.Th. (1995), *Acta Horticulturae* 382:221–229



Work on slow sand filtration (SSF) has demonstrated control of *Phytophthora* at flow rates below 300 L/hour/m<sup>2</sup> of surface area. *Fusarium oxysporum* was controlled but only at lower flow rates. This type of SSF may be used in conjunction with other non-chemical disinfection methods. Disinfectants in the sand filter will cause it to fail.

Biological broths which are antagonistic to plant pathogens such as *Botrytis* and algae can be grown and added to water supplies. These biological agents need proper scientific evaluation.

**Table 8 – Making a disinfestation decision**

| Method                           | Advantages                  | Disadvantages                                                                             | Cost                       | Degree of evaluation                    |
|----------------------------------|-----------------------------|-------------------------------------------------------------------------------------------|----------------------------|-----------------------------------------|
| Slow sand filtration             | No chemicals                | Maximum flow 300 L/hour/m <sup>2</sup>                                                    | Cheap                      | Well tested                             |
| Chlorine dioxide                 | Works in poor quality water | Cost                                                                                      | Expensive,                 | Well tested will get cheaper            |
| Chloro-bromine                   | Works in poor quality water | 8 minute contact time                                                                     | Cheap                      | Rejected in Europe                      |
| Membrane filter                  | No chemicals                | Maintenance difficulties                                                                  | Expensive                  | Rejected in Europe                      |
| Heat                             | No chemicals                | Expensive unless cheap gas available                                                      | Expensive to run           | Well tested in Europe                   |
| Ultra violet radiation           | No chemicals                | Only suitable for high quality water, and for <i>Pythium</i> and <i>Phytophthora spp.</i> | Cheap                      | Well tested                             |
| Hypochlorous acid (chlorination) | Simplicity                  | Does not work above pH 7                                                                  | Cheap                      | Only tested on <i>Phytophthora spp.</i> |
| Ozone                            | Few residual chemicals      | Cost, difficult to monitor                                                                | Expensive will get cheaper | Well tested                             |

## SUMMARY RECOMMENDATIONS FOR WATER RECYCLING BEST PRACTICE

- Nitrate-N levels in runoff water and dam water should be minimised and measured preferably on a monthly basis, and suitable adjustments made to fertiliser rates. Nitrate levels should not exceed 100 mg/L. Corresponding phosphate levels should not exceed 40 mg/L (15 mg/L for P-sensitive plants)
- Electrical conductivity of recycled water should be below 1 dS/m.
- Sodium levels should be below 100 mg/L (50 mg/L for roses).
- Sodium Adsorption Ratio for use on soil should be below 5.
- Chloride levels should be below 200 mg/L.
- pH should be in the range 5.0 to 7.0, depending on alkalinity level of water and disinfestation strategy.
- Calcium and magnesium levels should be balanced in a ratio of about two to one, with potassium 2 to 5 per cent of cations.

### For more info

**Slow flow sand filtration (SSF) for water treatment in nurseries and greenhouses**, *The Nursery Papers* 1999 No 003

**Disinfection of recirculating nutrient solutions by slow sand filtration** (journal), Wohanka, W. (1995), *Acta Horticulturae* 382:246–251

**A review of possibilities for disinfection of recirculation water from soilless cultures** (journal), Runia, W. Th. (1995), *Acta Horticulturae* 382:221–229



### For more info

#### Transmission of pelargonium flower break virus by recirculating nutrient solutions with and without slow sand filtration (journal),

Berkelman, B.; Wohanka, W. and Krczal, G.(1995), *Acta Horticulturae* 382:256–262

- Iron (ferrous) levels should be below 5 mg/L (in situations where iron blocks irrigation lines lower levels may be required).
- Manganese levels should be below 0.2 mg/L.
- Copper levels should be below 0.2 mg/L. Copper based fungicides and algicides should be used sparingly if at all.
- Zinc levels should be below 2 mg/L.
- Boron levels should be below 0.3 mg/L.
- Aluminium levels should be below 5 mg/L.
- Molybdenum levels should be below 0.01 mg/L.
- Fluoride levels should be kept below 1 mg/L.
- Herbicides should be kept below 0.1 mg/L. Persistent herbicides such as atrazine and simazine should not be used. Apply pot herbicides Rout and Ronstar® judiciously with minimum wastage on ground between pots.
- Disinfection chemicals such as hypochlorous acid should be monitored. Hypochlorous acid (available free chlorine) levels in irrigation water should not exceed 4 mg/L.
- UV transmittance of water at 254 nm should be regularly monitored if UV radiation is used for disinfection.
- Chlorine dioxide be considered for disinfection if available residual level irrigated onto crops can be kept below 2 mg/L.
- Solids, sediment, pinebark and perlite flotsam need to be removed before recycling.
- Only make up enough of any agricultural chemical for task required so that there is no excess to be disposed of.
- Operators should complete the National Farm Chemical Users Course or equivalent.



## FURTHER READING

**Characterisation of water quality for ozonation processes. Part 1: Minimal set of analytical data** (journal), Hoigne, J. (1994), *Ozone Science and Engineering* 16:113–120

**A compilation of Australian water quality criteria** (paper), Hart, B.T. (1974), Australian Water Resources Council Technical Paper No.7, Australian Government Publishing Services, Canberra

**Constructed wetlands in the Hawkesbury-Nepean** (information sheet) (1995), Hawkesbury Nepean Catchment Management Trust

**Constructed wetland manual** (book) (1997), NSW Department of Land and Water Conservation

**Disinfection of recirculating nutrient solutions by slow sand filtration** (journal), Wohanka, W. (1995), *Acta Horticulturae* 382:246–251

**Disinfectious effect of ozonation on water infested with several root-infecting pathogens** (journal), Yamamoto, H.; Terada, T.; Naganawa, T. and Tatsuyama, K. (1990), *Annals of the Phytopathological Society of Japan* 56:250–251

**Disinfestation of plant pathogens in recycled water using UV radiation and chlorine dioxide** (report), Mebalds, M.; Hepworth G.; van der Linden, A. and Beardsell, D. (1995), Technical report to HRDC

**Draft irrigation and fertilization Best Management Practices for producing container-grown woody environmental plants** (booklet), Yeager, T.; Fare, D.; Gilliam, C. and Niemiera, A. (1994), University of Florida

**The fourth international symposium of soil and substrate infestation and disinfestation** (journal), Vancher, A. (1995), *Acta Horticulturae* 382

**Growing media for ornamental plants and turf 4th Edition** (book), Handreck, K. and Black, N. (2010), University of NSW Press

**Managing water in plant nurseries** Edition 2, Rolfe, C.; Yiasoumi, W. and Keskula, E. (2003), NSW Agriculture

**Nutrition in horticulture** (proceedings), Hunter, M.N. and Eldershaw, V.J. (1993), Proceedings of a review workshop, Gatton 4–6 May 1993

**Put your water through analysis** (journal), Biernbaum, J.A. (1993), *Greenhouse Grower*, Nov 1993:32–36

**A review of possibilities for disinfection of recirculation water from soilless cultures** (journal) Runia, W.Th. (1995), *Acta Horticulturae* 382:221–229

*The Nursery Papers*, Nursery & Garden Industry Australia

**Transmission of pelargonium flower break virus by recirculating nutrient solutions with and without slow sand filtration** (journal), Berkelman, B.; Wohanka, W. and Krczal, G. (1995), *Acta Horticulturae* 382:256–262

**Waste water re-use from the standpoint of irrigated agriculture** (journal), Aikman, D.I. (1983), *Public Health Engineer* 11:35–41

**Water quality for agriculture, irrigation and drainage Paper No. 29** (paper), Ayres, R.S. and Westcot, D.W. (1976), FAO, Rome

**Water quality survey of the Australian nursery and flower industries** (report), Beardsell, D. and James, L. (1995), Technical Report for HRDC Project No. NY 320

**Water sources: the detection and pathogenicity of *Phytophthora* spp. in water** (report), Smith, P.M.; Ousley M.A. and Middleton J. (1985), Glasshouse Crops Research Institute Report 1984, 102–105

**Water treatment handbook** (book), Berne, F. and Richard, Y. (eds) (1991) Vols. 1 & 2., 6th Edition, Degremont Lavoisier, Paris



## 4 EFFECTIVE MANAGEMENT OF SEDIMENT, LITTER AND DRAINAGE

Nursery developments change the natural land surfaces and drainage patterns of irrigation and storm waters by increasing and concentrating runoff volumes. This can produce high velocity flows which cause erosion resulting in sedimentation and litter movement. Sedimentation produces muddy streams and silts up dams and watercourses with nutrient rich material. Litter, in particular polystyrene, plastics, growing media and mulches, can clog pumps and drainage lines. It is also aesthetically displeasing and environmentally unacceptable. To minimise the effect of nursery development and runoff water on the environment, an erosion, sediment and litter control plan should be prepared for each site for both for when the nursery is being developed and for general day-to-day operation of the nursery. Each plan needs to be site specific and take into consideration topographic limitations, climate patterns, soil types, drainage system, product being grown, and business management practices. This chapter details some of the options and practices that you, as a nursery operator, can consider when preparing control plans to manage sediment and litter for both the development and operation phases of the nursery. It also outlines some of the drainage design considerations that will help reduce erosion and litter transfer.

### **What causes sedimentation?**

Many nurseries have shallow water tables caused by frequent irrigation, hard areas like roads and carparks, buildings, glasshouses and igloos, and areas covered by plastic and matting. This produces high volumes of runoff water when it rains. The increased volume and concentration of runoff will increase the velocity of the flows and unless the drainage system has been designed to cope, excessive erosion is likely to occur. Some soils are more prone to erosion than others, and the soil type and slopes should be carefully looked at when designing your drainage system.

### **SITE ASSESSMENT FOR DRAINAGE SYSTEMS**

Nurseries are located in all sorts of places and not all of them are easy to develop for drainage systems. It is therefore important to collect all the useful and relevant information about the site and location to fully assess the drainage system.

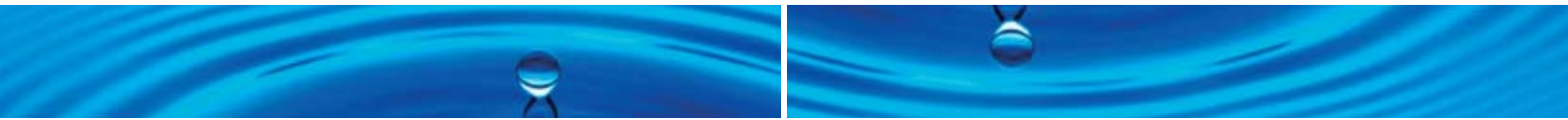
#### **Topography**

Most drainage systems rely on gravity to move water from the highest points to the lowest parts of the nursery. The slope available will dictate the size and type of drains employed. For most sites the cost of a complete topographical survey of the nursery that picks up all features, providing the basis for the location of drains, crossings, inspection pits, sumps and storage areas, will be well repaid in the quality of drainage system design, not to mention an accurate plan of all the nursery features including underground services.

#### **Rainfall intensities**

The volume of stormwater you are likely to deal with can be calculated from the rainfall intensities and frequency of storm events in your area. This can be calculated by using the *Australian Rainfall and Runoff* program that is detailed in Waterworks Module 3 notes that also provide a calculator to provide this information for most nursery locations within Australia.

The volumes of water the drainage system needs to deal with can be determined by knowing the size of various areas from the topographical survey.



### **Water table**

If the water table under the nursery is high then a subsurface drainage system may be required to lower this level so that surface slumping is prevented from vehicle movement around the nursery.

### **Runoff quality**

All water that runs off a nursery is not the same quality. This can be illustrated by examining the water source, such as:

- Roof runoff from potting and machinery sheds and glasshouses is a source of excellent quality water, which should be highly valued.
- Traffic areas such as roadways, carparks access lanes may have mud and vehicle contaminants but can usually be disposed of as ordinary storm water.
- Runoff from production areas is likely to contain dissolved and solid material that might not conform to the local environmental requirements. This may require some treatment before disposal or reuse.

The ideal situation is to design your drainage system to allow for a separation of water according to quality. That way you will not need to have in place systems that can handle large amounts of contaminated water, when only a small percentage of your drainage falls into this category. However, the size and layout of the nursery set-up will determine the ability and financial viability of separation.

### **Regulations**

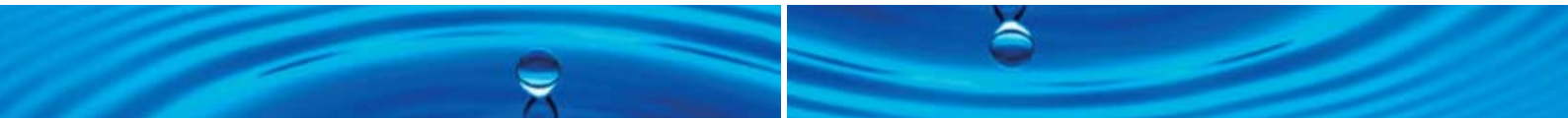
Before you design and/or upgrade the drainage system there are a number of regulations that you will need to consider. These will include:

- Environmental legislation
- Water management acts
- Local catchment management plans
- Local government regulations
- Common law

### **DRAINAGE SYSTEMS**

A well designed, installed and maintained drainage system will minimise erosion and control sediment and litter movement. Most systems can deal with daily irrigation runoff and moderate storm runoff. Heavy storm runoff may cause some erosion and flooding. Sediment and litter traps can be installed to provide for such events. Drains are classified according to their physical location as being either subsurface or surface drains. Most nurseries use a combination. The type of drainage system you use will be determined by considerations such as:

- runoff volumes
- slope
- required drain capacity
- soil type
- location of the drain
- maintenance requirements.



### Surface drains

These should be designed and constructed so that they do not erode in heavy rain and can be easily maintained to allow their designed capacity to pass water at all times. Grassed waterways or concrete drains are most commonly used. Grassed waterways are only suitable for collecting and transporting stormwater. They are not to be used for transporting irrigation runoff because the regularity of irrigation means the drains would not dry out and they would become soggy and choked with weeds, reducing their capacity.

Masonry drains, gutters and gravel drains can be incorporated where the area is too restricted or too steep. These conduits can handle higher velocities than grass and can handle irrigation and stormwater runoff.

Unsealed drains cause erosion and contaminate drainage water with soil particles. Sealed drains are easier to maintain and the water is easier to treat before disposal or reuse.

Shallow dish drains can be sealed with plastic or weedmat then topped with coarse stone to dissipate energy and slow velocity to prevent erosion.

### Subsurface drains

These can be used to carry high quality water from roofs and production areas. PVC stormwater piping is usually suitable for most installations. The most common pipes in nursery drainage are slotted subsoil drainage pipe (known as Ag pipe) wrapped or packed in sand or gravel, PVC stormwater pipe and concrete pipes.

Generally a pipe grade of less than 1 in 100 will not provide sufficient velocity to self clean pipes that are likely to carry debris from production areas. It is recommended that this be the flattest grade used.

By dividing up the nursery into sections you can size piping to suit the rainfall intensities for each area. These discharge rates can then be combined as pipes join to continue sizing for the whole system.

Where pipes change directions or join with other pipes, junction boxes should be installed. These can be constructed on-site or purchased as pre-cast boxes of different dimensions made from concrete and fibre cement or prefabricated polyethylene. They come with grates or metal and concrete lids to suit.

When moving from subsurface drains to surface drains a suitable transition needs to be constructed to reduce the high velocity coming from the pipe to a non-erosive velocity to suit the open drain. Concrete structures or large rock rip-rap are usually considered here.

See Table 9 for more information.



**Table 9 – Some considerations when selecting a drainage system**

| Surface drains                                                                              | Subsurface drains                                                                                             |
|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Lower installation costs                                                                    | Higher installation costs                                                                                     |
| Loss of land use for other purposes                                                         | No loss of land use for other purposes                                                                        |
| Regular maintenance required                                                                | Maintenance is usually minimal                                                                                |
| Remedial work readily undertaken                                                            | Remedial work can involve significant costs and time                                                          |
| Only collects surface runoff                                                                | Capable of collecting both surface runoff and groundwater                                                     |
| Major structures such as culverts, bridges, fences may be required                          | No major structures required                                                                                  |
| Potential hazard to pedestrian and vehicular movement                                       | Not a potential hazard to pedestrian and vehicular movement                                                   |
| May be aesthetically poor                                                                   | Not visible, hence no aesthetic effect                                                                        |
| Drains are visible and potential problems can be acted upon before major difficulties arise | Drains are not visible and potential problems cannot be acted upon until the difficulties manifest themselves |
| Drain capacity is limited only by the area available for the installation                   | If a pipe system, drain capacity is limited by the pipe cross section                                         |
| Litter traps can be incorporated in the drain itself                                        | Collect litter before water enters drain                                                                      |
| Can be readily expanded/extended                                                            | Can be difficult to expand                                                                                    |

### **Drainage system capacity**

The capacity or volume of drainage water to be handled by the drainage system is mainly a function of rainfall intensity, surface type and drainage area. Calculating drainage volume is not complicated but it does require a knowledge of hydrology and an understanding of acceptable degrees of risk.

Many local authorities will dictate the degree of risk relevant to your situation. For example, you may be asked to design your drainage system so it can cater for a 1 in 20 year storm event. In other words, the risk (in terms of inconvenience and damage caused by a storm event greater than 1 in 20 years) is acceptable in relation to the cost of providing that capacity drainage system.

If your local authority does not have any guidelines for design storm events, a suggestion is to adopt, as a minimum, a 1 in 20 year storm event for permanent drainage structures.





## **CONSIDERATIONS WHEN DEVELOPING SEDIMENT AND LITTER CONTROL PLANS**

When you are building a new nursery or expanding an existing nursery, the risk of the disturbed soil eroding is high. A plan to control the movement of sediment needs to be prepared before work starts so that you stop erosion from occurring. Things you can consider including in this plan are detailed in the following section. Further information can be found in Appendix 3.

### **Construction phase control plan**

Prevention is the best way of avoiding the impacts of sedimentation and litter generation. If you are developing a construction phase control plan consider the following to minimise the impact of erosion, sedimentation and litter generation.

#### **Site selection**

A good place to begin is to identify natural features such as drainage lines, water bodies and existing vegetation that can be retained in the development. Try to:

- avoid hazard areas like steep slopes, unstable slopes and drainage lines
- integrate runoff management with erosion, sediment and litter control.

Making the development fit the terrain will minimise the risk of erosion and sedimentation. For example, aligning access roads and laying out igloos and production areas to minimise the amount of land that needs to be disturbed can also minimise the risk of erosion.

#### **Expose the smallest possible area of land for the shortest possible time**

Try to stage development so that land disturbance is confined to areas of manageable size. This will also limit the time disturbed areas are exposed to erosion.

At the same time, try to retain as much of the natural vegetation as possible. This is the most effective form of erosion control as vegetation both absorbs and uses water. As well, revegetating areas once they are disturbed is costly and time consuming.

Seasonal variations in rainfall result in periods of varying erosion risk during the year. Where possible, try to schedule land disturbance operations during the time of year when erosion is least likely to be a problem.

#### **Save topsoil for reuse**

With any land development it is essential that stripped topsoil be stockpiled. Put these topsoil stockpiles outside drainage lines and protect them with temporary control measures to stop them becoming a source of sediment. Respread the topsoil on areas to be revegetated.

#### **Control site runoff**

Permanent drainage works must be installed early in the development to protect disturbed areas from runoff and to carry stormwater safely through the site. All runoff must be carried away slowly enough so it doesn't cause erosion.





### Select sealing materials carefully

The road and path sealing material you use can affect the amount of sediment generated. On one hand, a properly constructed bitumen or concrete sealed road or path will generate no sediment. On the other hand, a path or road sealed with a road base material such as crushed shale will erode over time and generate a clay sediment. Similarly, crushed sandstone will generate sand sediments, and recycled concrete or crushed demolition material will also erode and generate sediments.

To help minimise sediment generation it is a good idea to install adequate drainage controls and make sure that the road base material is well compacted.

### Maintain stockpiled material

Stockpiles of excavated earth are a potential source of sediment and litter. To minimise sediment and litter generation from stockpiled material consider the following:

- when excavating, keep stockpiled topsoil separate from underburden
- apply a sediment control fence
- mulch, roughen and seed excavated stockpiles with sterile grasses if you are keeping them for more than 28 days
- enclose all unstabilised excavated stockpiles with silt fences or a drainage system that will collect contaminated runoff.

### Operation control plan

Once you have built the nursery, or completed the extensions, and it is producing, you need to develop a plan to deal with the day-to-day risks of erosion and generation of sediments and litter. The EcoHort program can further assist you in developing a plan for your business.

Consider the following general principles:

#### *Prepare an erosion sediment and litter control plan*

It is advisable to consider a strategy to manage erosion, sedimentation and litter early in any development. If you operate an existing nursery it is a good idea to assess the situation and quickly implement a plan.

Many local authorities can help you to prepare your plan. In your plan erosion control must be recognised as being of primary importance. This can be done by managing runoff so that the speed at which it flows does not cause erosion, by minimising the length of slope exposed during land shaping, and by protecting the soil surface.

Sediment and litter control involves trapping and containing material that has already been eroded. Erosion control is more effective than and preferable to sediment control and will often be the only alternative for fine grained and dispersible soils.

#### *Control site runoff*

Try to maintain natural drainage lines and control runoff entering from neighbouring properties. As well, it is advisable to divert clean runoff from within your property around developed areas to alternative stable outlets or to storage dams for later use for irrigation. All runoff should flow at a speed that doesn't cause erosion.



### **For more info**

**Urban erosion and sediment control field guide** (booklet) (1995), NSW Department of Conservation and Land Management, Sydney

**Environmental guidelines for major construction sites** (booklet) (1996), Environmental Protection Authority, Victoria, Melbourne

#### *Use erosion control measures*

Use erosion control measures during all stages of development and ongoing nursery operation to minimise sediment generation. Controlling erosion close to its source can reduce the demand on sediment trapping structures.

#### *Use sediment control measures*

Filter runoff through sediment trapping structures to minimise or stop sediment leaving the site or entering your water storage. These measures work by reducing the velocity of runoff and letting sediment settle by gravity or filtration. Eroded sediment must be trapped before it leaves the site and affects adjacent property and downstream watercourses.

### **Implement litter reduction strategies**

Potential litter sources while you are building or extending the nursery include building material washed away during a storm and rubbish thrown away by construction workers. Other sources include rubbish thrown away by employees, and plastic pots, labels, growing media, mulch and polystyrene washed or blown from their storage area. Litter is often caused by thoughtlessness and the absence of suitable litter bins on the site. So that litter is not generated and is disposed of responsibly it is suggested that:

- you and your staff practise a high standard of housekeeping
- bins be provided for staff at convenient locations, e.g. where they eat lunch
- materials are not left where they can be washed away to become litter i.e. provide suitably enclosed storage areas for stockpiled materials like growing media and designated storage areas for polystyrene boxes, plastic pots, cardboard and product name tags
- you make staff aware of the need to avoid littering.

#### **Use litter control measure**

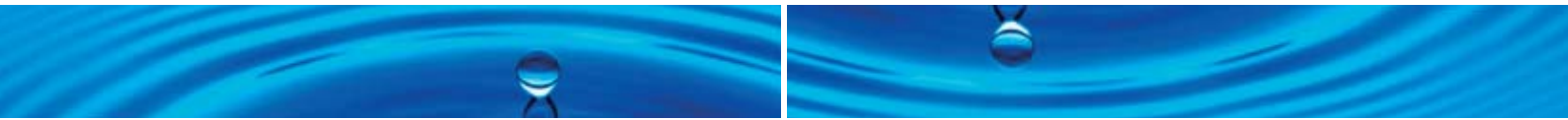
Pass runoff through litter trapping devices to minimise or stop litter leaving the site, entering your water storage or blocking drains. These devices work by physically trapping the litter but allowing water to pass through them.

#### **Rehabilitate disturbed areas**

Vegetation is the most effective way of controlling erosion and sedimentation. When areas are disturbed or made bare it is essential to stabilise them and establish a grass cover as soon as possible. Similarly, all roads, parking areas, delivery bays, etc must be stabilised or maintained with appropriate subgrade material.

#### **Implement an Irrigation management strategy**

Overwatering plants will result in unnecessary runoff. Runoff from irrigation can cause erosion and carry litter. Poorly maintained irrigation pipes and fittings (including sprinklers) can leak and add to the unnecessary runoff load. It is important to implement an irrigation strategy (or redesign existing irrigation systems, or do both) to avoid overwatering.



### **Maintain stockpiled material**

Stockpiles of growing media and other materials are a potential source of sediment and litter. To minimise sediment and litter generated from stockpiled material consider the following:

- locate stockpiles away from drainage
- provide a cover over the stockpile
- minimise the number and size of stockpiles
- build the stockpile with no slope greater than 2:1 (horizontal to vertical)
- provide suitably enclosed storage areas for stockpiled material such as growing media or enclose the growing media stockpile with silt fences or a drainage system that will collect contaminated runoff, or do both
- avoid locating stockpiles close to waterways.

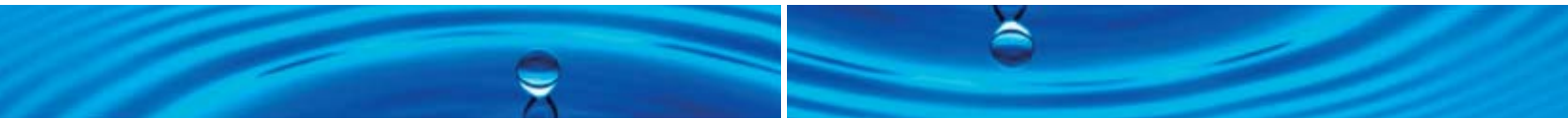
### **Maintain erosion and sediment control measures**

Regularly inspect and maintain all erosion and sediment control measures to ensure they function efficiently. A suggested maintenance schedule is outlined in Table 10.

Inspections, particularly during storms, will show whether devices are operating effectively. Where a device proves inadequate, it should be quickly redesigned to make it effective.

**Table 10 – Suggested maintenance schedule for erosion and sediment control measures**

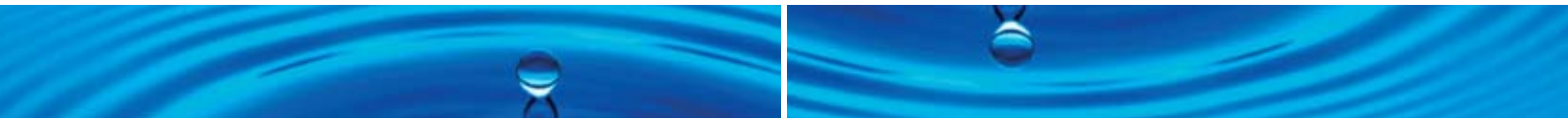
| Installation                                                   | Possible problems                            | Inspection frequency                       | Remedial action                                                                                                                                                                                  |
|----------------------------------------------------------------|----------------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Drainage<br>(drains and banks)                                 | Water diversion not achieved                 | Weekly                                     | Repair damaged drains and/or relocate drains                                                                                                                                                     |
|                                                                | Weed growth, sediment                        | Monthly                                    | Remove weeds, litter and sediment                                                                                                                                                                |
| Sediment devices<br>(hay bales, filter fences, sediment traps) | Ineffective sediment control                 | Weekly, or within first 2 hours of a storm | Remove sediment/litter from device and ensure control is properly built. Replace damaged geotextile of hay bales                                                                                 |
| Check dams                                                     | Movement or damage to dam                    | Monthly                                    | Repair/replace damaged structure                                                                                                                                                                 |
| Roads                                                          | Soil on paved roads                          | Weekly                                     | Maintain rumble grids                                                                                                                                                                            |
|                                                                | Rilling of unsealed roads                    | Weekly                                     | Suitably pave roads and ensure drainage controls around area                                                                                                                                     |
| Vegetated buffers                                              | Vegetation loss                              | Weekly                                     | Revegetate and keep traffic off vegetated areas and install drainage controls around the area                                                                                                    |
| Level spreaders                                                | Erosion rills and damage to vegetative cover | Monthly                                    | Repair damaged areas and ensure outlet size is adequate                                                                                                                                          |
| Stockpiles and bare slopes                                     | Erosion and sedimentation                    | Weekly                                     | Minimise exposure to run-off and install effective stabilisation measures                                                                                                                        |
| Sedimentation basins                                           | Sediments not effectively removed            | Weekly                                     | Modify basin design to increase retention time and/or add flocculants                                                                                                                            |
|                                                                | Erosion rills and loss of vegetative cover   | Monthly                                    | Repair damaged area and/or revegetate                                                                                                                                                            |
| Unvegetated areas                                              | Erosion rills and sedimentation              | Weekly                                     | Place mulch or geofabric and ensure adequate drainage around area                                                                                                                                |
| Litter control devices                                         | Litter on and off site                       | Daily                                      | Clean up litter originating on site. Review number/position of rubbish bins. Speak to staff about litter disposal and ensure materials are not stored in a way that results in generating litter |



## Summary

For both existing and proposed nurseries, consider the following measures to minimise erosion, sediment and litter generation:

- try to retain natural drainage lines and, if suitable, existing vegetation
- prepare a strategy to control erosion and sedimentation
- keep land clearance to a minimum
- avoid clearing areas of highly erodible soils and steep slopes
- revegetate and mulch construction work as it is completed
- keep the time between clearing and revegetation to an absolute minimum
- coordinate work schedules so that there are no delays in construction activities as this could result in disturbed land remaining unstabilised
- program construction activities so soil is exposed, as much as possible, when the risk of erosion is low
- maintain stockpiled material effectively
- stockpile topsoil for reuse during construction. Vegetate and stabilise where appropriate.
- install drainage works as soon as possible
- stabilise the site and install and maintain erosion control devices
- implement litter reduction strategies
- install and maintain sediment and litter control devices
- keep vehicles to well defined roadways
- keep roadways off steep slopes wherever possible
- design the slope of earth excavations to minimise the angle of incline
- rip bare surfaces to increase water infiltration (this will both decrease the amount and velocity of runoff water)
- implement an irrigation management strategy that includes maintenance
- use sealing materials that won't erode.



## **SEDIMENT CONTROL STRUCTURES AND DEVICES**

There are many techniques and devices for controlling erosion and collecting sediment and litter. Some of these are described briefly in this section and accompanied by illustrations to help you assess whether they are applicable to your nursery. Control measures can take several forms, including:

- reduction and control of discharges and runoff
- source reduction
- water velocity control
- erosion control devices
- sediment control devices
- litter control devices.

### **Reducing and controlling discharges and runoff**

Accounting for the physical limitations of development imposed by landform, soil types and drainage characteristics can help reduce and control discharges and runoff. Stabilisation and revegetation work should be done as soon as possible after any earthworks are finished, and groundcover vegetation should be retained wherever possible. In this way, the volume of runoff is reduced by increasing the amount of pervious area.

Try to divert clean runoff away from areas that have been cleared or are not adequately sealed. This stops clean runoff from becoming contaminated with sediment or litter. To do this build diversion banks and intercept drains around the site while ensuring that the water discharging from the banks or drains is disposed of without causing erosion.

Runoff should enter a storage dam or leave the property through a sedimentation control installation. By doing this silt laden runoff cannot escape the site and pollute surface waters, rather it can be treated on site.

### **Source reduction**

Sediment from surface runoff can be reduced using infiltration devices, on-site detention and overland flow modification.

#### ***Infiltration devices***

These include dutch drains (rubble trenches or french drains), lawn coring, recharge basins, seepage pits, and porous pavements.

#### ***On-site detention***

This includes using areas above ground such as carparks or purpose built underground tanks to temporarily store stormwater runoff. On-site detention helps control flooding and reduce erosion and sedimentation. It also allows smaller diameter pipes to be used in the drainage system and reduces flow rates to levels which are manageable in downstream drainage systems.

#### ***Overland flow modification***

An alternative to conventional kerb and gutter and other impervious drains. Grassed swales (shallow, broad surface drains) are typical of this type of device. They reduce peak runoff volumes by increasing the amount of pervious area.

## Water velocity control

There is a direct relationship between how fast water flows over exposed soil and the rate of erosion. The higher the flow velocity, the greater the potential for erosion. An effective way of minimising flow velocities is to minimise the length of continuous slopes where flowing water can scour.

Installing rock or masonry structures to slow water flows is an effective measure to reduce erosion in areas where high water flows are expected.

To stop scouring, drainage lines need to be lined or velocity reducing structures, such as crushed rock or geotextile, installed.

## Erosion control devices

These devices include:

- catch drains and banks
- diversion drains and banks
- energy dissipators
- level spreaders.

### *Catch drains and banks*

Both catch drains and banks run across the slope and must be built at a non erosive grade.

They are physically smaller than diversion drains and banks. For example, the depth of a catch drain is typically from 200 to 300 mm while a diversion drain can be over a metre deep. Otherwise, there is no difference between catch drains and diversion drains or catch banks and diversion banks.

These drains are best stabilised by grass. However, depending on location and design practices, stone pitching, geotextile or masonry lining may be more suitable, particularly in steep terrain or areas with highly dispersive soils. Drains and banks are used together or individually to intercept and direct runoff to a desired location. For example they may be used to:

- intercept and direct sediment laden runoff to a sediment control device
- intercept and direct clean runoff to a storage dam
- reduce the flow path length of slope, thus reducing the velocity of flow and the potential erosion/ sediment hazard.

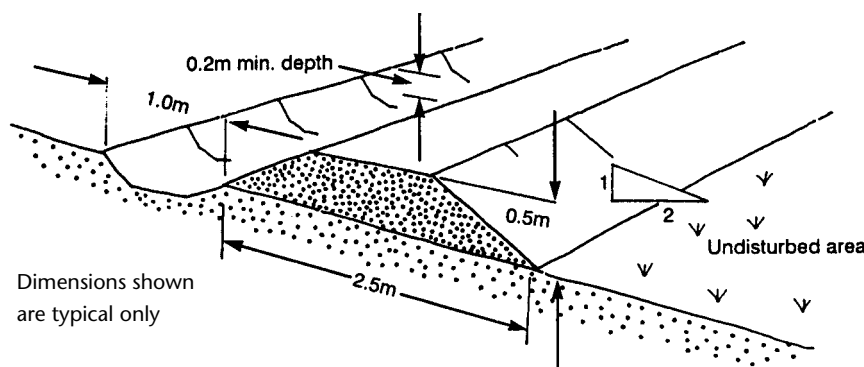


Fig. 11 – Bank with drain

### Energy dissipators

An energy dissipator, for example a rock check dam, is built across a channel or flow path to reduce the velocity of flow. Energy dissipators can be temporary structures, like the one illustrated in Figure 12, or they may be permanent masonry structures. By reducing the flow velocity energy dissipators alleviate potential channel erosion and, depending on their design, can also act as sediment traps.

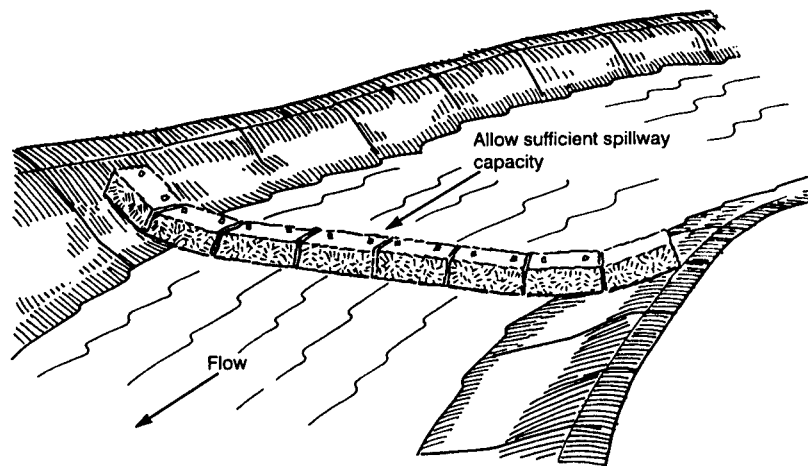


Fig. 12 – A check dam – an example of an energy dissipator

### Level spreaders

Level spreaders (or sills), are shallow, level excavations at the outlet of an earth channel or bank. The level section (sill) dissipates the flow from the channel or bank by spreading it over a wider area. In a way they act like a spillway on an earth dam. By spreading the flow the erosive effect of the water flow is reduced below the outlet.

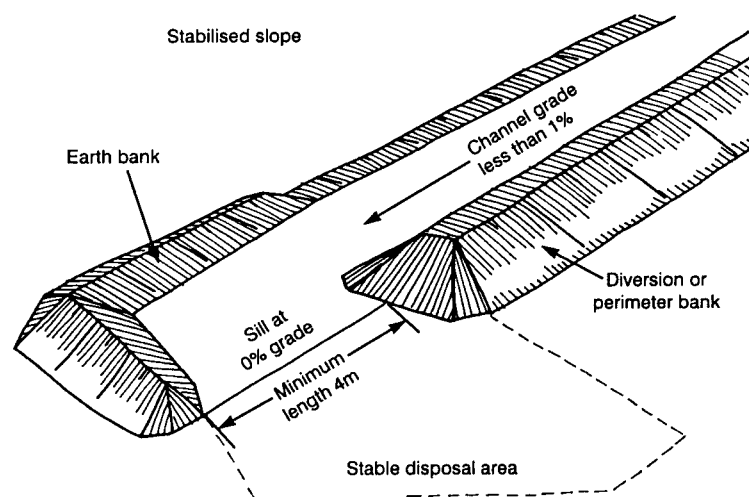


Fig. 13 – A level spreader or sill



## Sediment control devices

These devices stop coarse sediments getting into dams and waterways. Sediment control devices include:

- hay bales
- filter fences
- sediment traps
- sedimentation basins.

Permanent groundcover is an effective way of minimising sediment runoff so it is advisable to try to retain existing vegetation and revegetate bare areas.

### *Hay bales*

Hay bales are temporary structures placed around the perimeter of an area and held in place with stakes (typically star pickets). They are used to stop sediment moving from the area they enclose or to stop sediment entering an area they line.

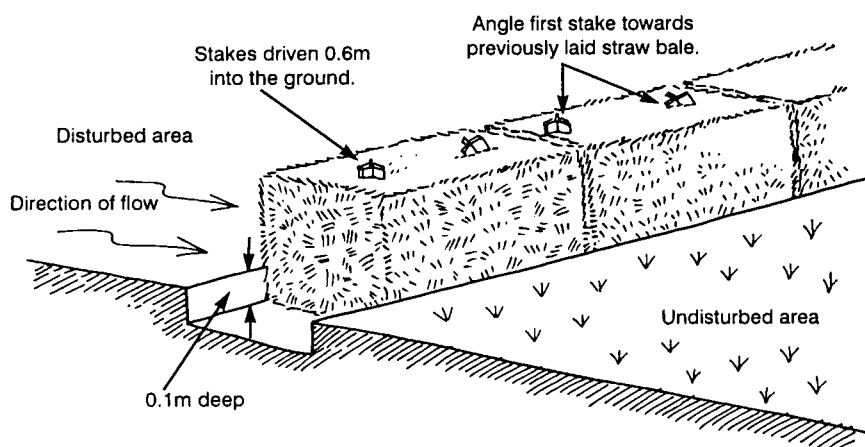


Fig. 14 – Straw bale sediment filter

### Filter fences

Filter fences (also called sediment fences) are temporary barriers of geotextile material, usually supported by steel posts or, occasionally, steel mesh. These structures filter runoff, trapping the sediment and allowing filtered water to pass through. They could be particularly useful around large stockpiles of growing media and similar materials.

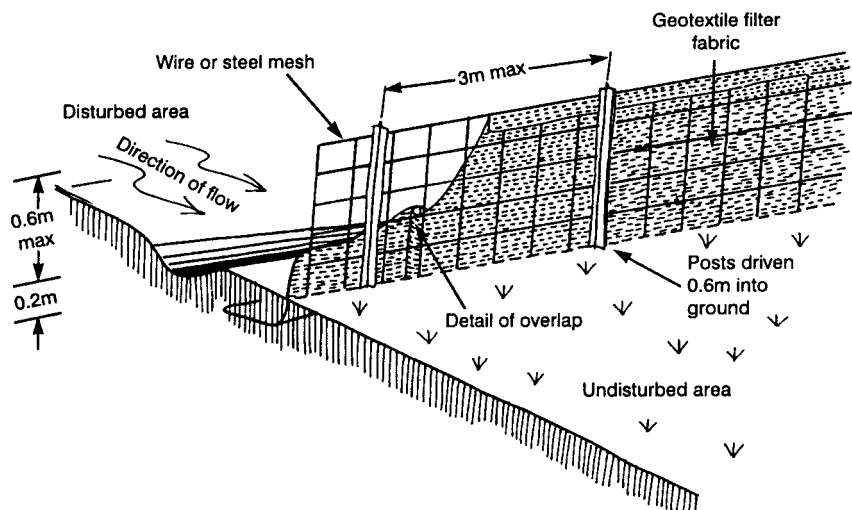


Fig. 15 – Typical sediment fence

### Sediment traps

Sediment traps use an excavation or an embankment or both with an overflow raised above the bottom of the excavation. They are used at runoff outlets where flow is concentrated. The traps slow the water velocity and allow the sediment to drop out of suspension. These devices must be cleaned regularly.

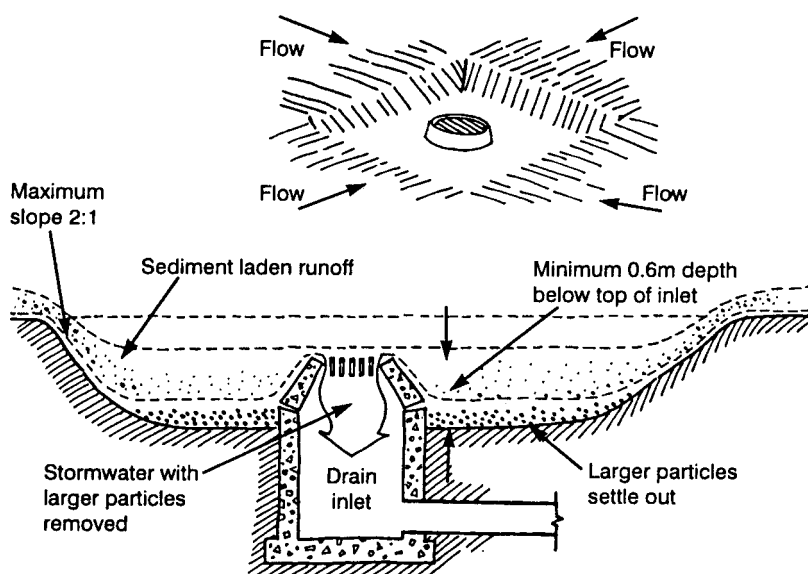


Fig. 16 – Sediment trap

### ***Sedimentation basins***

Sedimentation basins are dams (or large excavations) which intercept sediment laden runoff and retain the sediment.

They are designed to trap sediment that has escaped other sediment control devices like filter fences located further upstream in the drainage catchment. They hold the sediment contaminated runoff long enough for the suspended material to settle out.

### **Litter control devices**

These devices stop litter from getting into dams and waterways. Both sediment and litter control devices are designed to stop drainage lines getting blocked as this can increase the risk and frequency of flooding. Installing these devices upstream of flow retardation basins and wetlands also brings other benefits, including: reducing maintenance of the controls, prolonging their life, and reducing the amount of litter that accumulates in them. Litter control devices include:

- trash racks
- trash baskets
- baffled traps.

#### ***Trash racks***

Trash racks are normally made of metal bars but timber slats can be used. The bars or slats are spaced at intervals slightly smaller than the expected width of the floating debris. They are placed where flow is concentrated to trap debris but allow water flow through them.

#### ***Trash baskets***

Trash baskets are made of metal mesh and are placed in excavations, similar to the sediment trap arrangement previously illustrated, which are readily accessible to allow easy removal of the basket for cleaning. They are placed where flow is concentrated to trap debris but allow water flow through the bottom of the basket.

#### ***Baffled traps***

Baffled traps contain a series of parallel slats (in timber or metal) spaced at right angles to the flow direction. The baffles are normally alternated with high and low positions. A baffle trap will allow water flow between the baffles but traps floating debris within the baffle spacing.

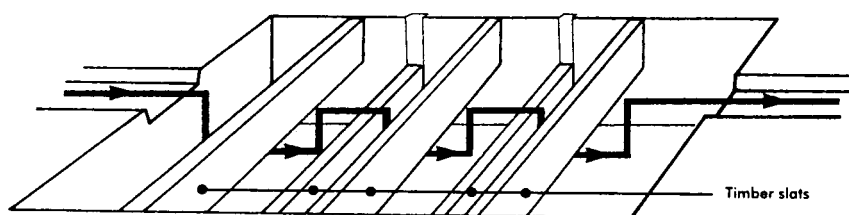


**Fig. 17 – Typical baffled trap**



## Legislative responsibilities

Comprehensive environmental legislation gives considerable power to many public authorities to regulate the consequences of development, including the impact of runoff. These powers range from environmental planning instruments through to more detailed development control plans.

Check with your local authority to ascertain the requirements you may have to meet.

## Acknowledgments

Elie Elia, Environment Protection Authority, Victoria Neil Rendell, NSW Department of Land and Water Conservation Department of Land and Water which was the source for Figures 11 to 16 in this chapter.

## FURTHER READING

**Australian rainfall and runoff** (booklet), Pilgrim, D.H. (Ed) (1987), Institute of Engineers, Australia

**Design manual for urban erosion and sediment control** (book), Scott & Furphy Pty Ltd (1988), National Capital Development Commission, Canberra

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**What do all the numbers mean?** (pamphlet), Hazelton, P.A. and Murphy, B.W. (1992), NSW Department of Land and Water Conservation, Sydney



## 5 MAXIMISING THE RETENTION OF NUTRIENTS TO IMPROVE THE EFFICIENCY OF PRODUCTION AND MAINTAIN WATER QUALITY

Most nursery waste water is the product of the water that drains from pots (leachate) after rain or irrigation, and the water that falls on the ground between pots and onto other non producing areas of the nursery such as pathways, roads and buildings.

While leachate is the lesser in quantity of the two, it contributes most of the nutrient present in nursery waste water. This means that the key to minimising nutrient losses in waste water is reducing leachate which is achieved by adopting practices that result in water and fertilisers being used more efficiently.

However, this is not to ignore the need to minimise the amount of water falling on non productive ground, a subject covered in detail in Chapter 1.

### MANAGEMENT STRATEGIES

There are five main strategies for reducing nutrient loss in nursery waste water. They are as follows:

- improve the delivery of fertilisers to pots
- improve the delivery of water to pots (less water falling on the ground)
- improve the retention of fertilisers in the growing media (less leaching)
- improve the retention of water in the growing media (less leaching)
- recycle waste water (less water disposed).

#### Improved delivery of fertilisers to pots

Whenever fertilisers and foliar sprays are applied to nursery plants some inevitably miss the target and end up being removed from the site in waste water. The most critical times for these losses are at potting up and when pots are topdressed, sprayed or drenched with fertiliser.

Growing media and surface applied fertilisers can also spill onto the ground when pots are watered, handled or knocked over. On the ground, coated fertilisers are easily damaged and this can cause nutrients to release quickly into waste water.

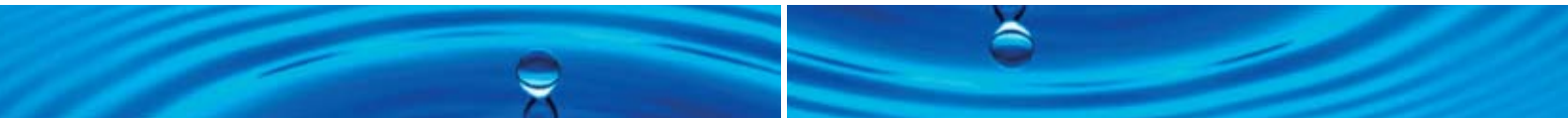
#### *Management strategies*

There are several strategies that you can implement in the nursery to improve fertiliser delivery to pots. These are as follows:

- Keep floor areas used for making or storing growing media and for potting up free of media and fertilisers. These areas may need to be bunded to contain runoff during periods of heavy rain or roofed in (see next section on improving delivery of water).
- If possible, mix or dribble fertiliser into the growing media at planting to

#### For more info

Trace elements in pot plants. What's the best way of supplying them? (journal), Handreck, K.A.(1995), *Australian Horticulture*, June pp 49–51



minimise subsequent spillage. Fertilisers should only be surface applied when it is necessary to top up the nutrient program.

- If you apply liquid fertilisers through overhead sprinklers make sure the waste water is collected for reuse or is treated before disposal. Liquid fertilisers can be applied less wastefully using drippers and bottom watering systems such as ebb and flow.
- It is preferable to mix micronutrients with the growing medium rather than doing it after planting as foliar or liquid fertiliser applications. Preplant micronutrients will usually last for 12 to 18 months. You may need to add boron more often.

#### For more info

**Managing nursery runoff. Techniques to reduce nutrient leaching from pots** (booklet), Cresswell, G.C. and Huett, D.O. (1996), NSW Agriculture, Orange

**Managing water in plant nurseries** (book), Rolfe, C.; Currey, A. and Atkinson, I. (1994), NSW Agriculture, Horticultural Research and Development Corporation and Nursery Industry Association of Australia

**Water use and runoff comparisons of greenhouse irrigation systems** (journal article), Neal, C.A. and Henley, R.W. (1992), Proceedings Florida State Horticultural Society, 105:191–194

### Improved delivery of water to pots

Most nurseries in Australia use sprinkler irrigation systems.

Sprinkler irrigation without recycling is an inefficient way of watering containerised plants because water falls on the ground whether it is covered with pots or not and because high application volumes are often used to compensate for uneven watering patterns. Water use efficiencies can be as low as 10 %, where as much as 80 % of the water from a sprinkler may miss the target.

While it is often not practical to change from an already established sprinkler irrigation system, if you do have one it should be designed and maintained to maximise water application uniformity. The system should also be tested annually for uniformity.

#### *Management strategies*

Strategies to improve water delivery to pots with an overhead sprinkler system are as follows:

- Consolidate plants in irrigation bays to minimise watering open areas. Turn water off as areas become vacant.
- Reduce the spacing between pots and the area devoted to pathways so water wastage is minimised. Even when pot density is high more than half of the water from sprinklers generally falls outside of pots.
- Repot plants into larger containers as early as possible. This will reduce irrigation water losses between pots and increase the amount of stored water available to each plant allowing for longer periods between irrigations.

Bottom watering and drip irrigation offer water savings of 75 % or more over sprinklers and produce relatively little leachate so they should be used in preference to fixed sprinklers wherever possible.

### Improved retention of fertiliser in potting media

#### *Cation exchange capacity*

Growing media generally have lower cation and anion exchange properties than fertile soil and consequently are less able to retain applied nutrients under leaching conditions.

In nurseries using an overhead irrigation system leaching losses are most severe in the first two weeks (7 to 14 waterings) after plants have been potted up. During this time most of the soluble fertiliser in the growing media is washed out and waste water nutrient concentrations are at a maximum.



Although controlled release fertilisers are less susceptible to leaching than soluble fertilisers, they still produce an initial flush of nutrients which is often the result of early release from damaged prills.

Organic fertilisers are also vulnerable to severe leaching soon after application. Losses of nitrogen and potassium from pelleted poultry manure are highest in the first 4 weeks after addition.

#### *Management strategies*

When thinking about ways of improving retention of fertilisers consider the following:

- Adding growing media amendments such as zeolite or clay may increase cation exchange capacity and help retain soluble nutrient cations such as ammonium, potassium, calcium and magnesium.
- Composting or ageing organic materials used in growing media generally increases their cation exchange capacity.

#### *Controlled release and soluble fertilisers*

Dissolved nutrient salts and finely ground additives such as lime, dolomite and superphosphate are readily leached from most well drained potting media.

Research shows that leaching can remove from 53 to 93 % of applied soluble fertilisers and from 34 to 47 % of controlled release fertilisers during the life of a crop. Under Australian conditions, around 86 g of calcium and 75 g of sulphur is leached each month from every cubic metre of growing media .

#### *Management strategies*

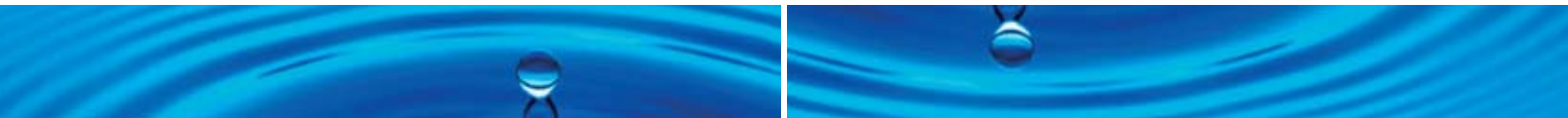
When selecting or using controlled release and soluble fertilisers, consider the following:

- Controlled release fertilisers are less prone to leaching than soluble fertilisers such as potassium nitrate, calcium nitrate and urea because the prill is coated, to stop rapid dissolution of the nutrient salts inside.
- Use growing media as soon as possible after controlled release fertilisers have been added. Moisture and high temperatures associated with composting will trigger the release of nutrients and, without leaching, the salts may build up to toxic levels before the mix is used.
- Controlled release fertilisers may deteriorate if they are stored under conditions that are too hot or humid. Manufacturers will be able to advise on the best method of storage for their products. Don't use fertilisers with damaged coatings as they will release nutrients rapidly.
- The rate of nutrient release from controlled release fertilisers increases as soil temperature rises. Use fertilisers with thicker coatings for summer crops, e.g. a '9 month' formulation for a three-month growing period.
- Don't liquid feed plants immediately before a clear water irrigation or if rain is expected as most of the application could be flushed from the pot.
- Don't liquid feed when the crop is unlikely to use the fertiliser e.g. when temperatures are low or very high, or when light is low.

#### **For more info**

**Managing nursery runoff – techniques to reduce nutrient leaching from pots** (booklet), Cresswell, G.C. and Huett, D.O. (1996), NSW Agriculture, Orange





## Improved retention of water in growing media

### *Irrigation scheduling*

Nutrient leaching in sprinkler irrigated nurseries is often caused by overwatering. In these nurseries frequent, heavy irrigation is used to compensate for uneven watering patterns which result in dry pots, as well as to ensure that high basal fertiliser rates do not cause salinity.

#### **For more info**

**Managing water in plant nurseries** (book), Rolfe, C.; Currey, A. and Atkinson, I. (1994), NSW Agriculture, Horticultural Research and Development Corporation and Nursery Industry Association of Australia

Water use efficiency is at an optimum level when pots are only irrigated long enough to replace water lost since the last irrigation and a small amount for leaching. The amount of water applied should therefore closely match crop water use and evaporation losses. To achieve this, your irrigation schedule must be responsive to daily weather conditions.

The clock-based irrigation controllers used in most nurseries cannot satisfy this requirement. However, large water savings can still be made where these controllers are used if you can adjust the scheduling more often (see section on controllers in Chapter 1).

### *Management strategies*

When scheduling irrigation in your nursery consider the following:

- Irrigate your plants when they need water rather than on a rigid cycle. You can anticipate water needs from weather data (evaporative pan), electronically (moisture and light sensors), by weighing pots (1 ml of water = 1 g), or simply from the appearance of plants.
- Change irrigation schedules with the season to account for natural patterns of rainfall and evaporation. Don't irrigate if enough rain has fallen (you can fit rain shut off devices to electronic controllers).
- Irrigate less when plant water use is low, such as when the weather is overcast or when plants are small.
- Group plants with similar daily water needs within irrigation bays to simplify scheduling. Plant species, size and canopy density are some of the factors that influence water needs.
- Maximise the uniformity of water application from sprinklers as this will reduce the volume of water needed to replace daily losses. Choose sprinkler nozzles that are appropriate for the spacings and line pressures at each site.

### *Growing media*

Depending on their composition, growing media can have different abilities to retain surface applied water.

Under standard overhead irrigation (25 mm/hr), the most retentive mixes absorb as much as 80 per cent of the water as it drains through the mix, meaning that just 20 % is wasted. However, many mixes retain less than half and some as little as 20 % of the water applied.

Water retention is influenced by factors such as wettability, moisture content at irrigation, porosity and depth of the media, and the intensity of water application. On one hand, media that are still wet when they are irrigated have a reduced capacity to hold water. On the other hand, media that are allowed to dry out, especially those based on pine bark or with a high proportion of sphagnum peat, can be difficult to rewet.





There is a limit to how quickly water can be absorbed by any mix and as the application intensity increases above this limit, water retention decreases greatly. As a general rule, few media are capable of absorbing water at a rate above 20 mm/hr.

### *Management strategies*

When irrigating consider the following:

- Allowing media to become too dry between irrigations may make rewetting difficult. Even short periods of moisture stress can slow plant growth.
- Use a wetting agent (commercial product, coir etc) to improve water absorption in media that are difficult to rewet.
- Reduce the intensity of water application from sprinklers or drippers and shorten the length of irrigation to increase water absorption (see Chapter 1).
- With sprinkler or drip systems use two or three short waterings with a half to one hour interval between them in preference to a single lengthy irrigation (pulse watering). The time between each irrigation pulse allows water to be absorbed by the growing media and in this moistened condition some media become less water repellent. The optimum irrigation sequence will vary between nurseries and will be influenced by factors such as application intensity, media type, and plant and canopy size.
- Evaluate any new media under normal irrigation conditions to ensure that it has acceptable water retention properties (more than half of the applied water should be retained). This can be done by weighing pots before and after an irrigation to establish how much water the media has held.

### *Leaching fraction*

The quantity of nutrients lost as a result of leaching is strongly related to the amount of water that drains from a pot at an irrigation. As the amount of leachate is reduced relative to the amount of water applied in an irrigation (called the leaching fraction or LF %), nutrient losses decrease and soil solution concentrations increase.

Some leaching (around 12 per cent LF) is needed to stop the crop being injured by salinity. However, any increase in the leaching fraction beyond this level will slow plant growth at low fertiliser rates. The leaching fraction in nurseries using fixed sprinklers commonly ranges from 50 to 80 %.

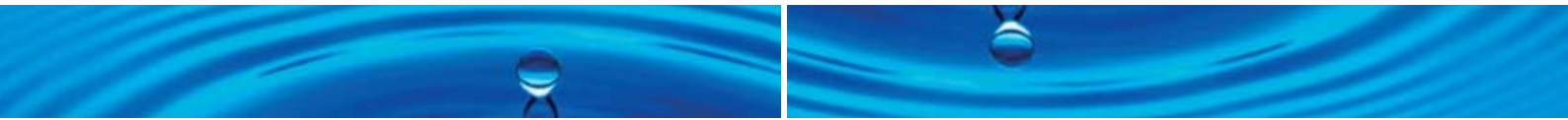
### *Management strategies*

Some important management strategies to keep leaching to a minimum are as follows:

- Ensure the Sc of overhead systems is less than 1.5 to minimise variation in the leaching fraction over the bed or bench (see Chapter 1).
- Irrigate for long enough to give the smallest leaching fraction while still allowing for adequate rewetting of the growing media. A leaching fraction of 20 per cent or less is a useful target.
  - Reduce fertiliser rates rather than increase the leaching fraction if media salinity rises after irrigation scheduling has been optimised.
  - Consider a bottom watering system as an alternative to sprinklers or drippers. There is relatively little nutrient leaching when pots are watered from the bottom and this means that less fertiliser is needed.

#### **For more info**

**Managing nursery runoff – techniques to reduce nutrient leaching from pots** (booklet), Cresswell, G.C. and Huett, D.O. (1996), NSW Agriculture, Orange



### ***Fertiliser application***

For greatest efficiency, supply nutrients at a rate that both reflects plant demand and satisfies losses due to factors such as nitrogen volatilisation or drawdown. When nutrient supply is too high, those nutrients dissolved in the soil solution are vulnerable to leaching. Nutrients are commonly oversupplied in the first few weeks after planting or repotting when plants are small and do not have a fully developed root system.

### ***Management strategies***

When applying fertiliser consider the following:

- Use the lowest rate of fertiliser that will give acceptable growth and quality. The optimum fertiliser rate will vary according to species, irrigation method, media type and growing conditions and so should be developed by each nursery. As an example, lower fertiliser rates are needed for outdoor stock in winter when plants are growing slowly.
- For advice on how to conduct research trials on commercial nurseries so you can determine the fertiliser regime that best suits your operation, speak with your State/Territory Nursery & Garden Association.
- Monitor the electrical conductivity (EC) of the growing media (see Appendix 3). If the EC increases when plants are receiving enough water a lower fertiliser rate may be appropriate.
- Evaluate your current nutrient program by comparing plant performance at lower and higher fertiliser rates (+/- 20 %) and by using plant tissue analysis to identify nutritional disorders.
- Minimise leaching losses by evening out nutrient supply to avoid periods when supply greatly exceeds demand. Applications can be split into two or more and spaced over the production period. Controlled release fertilisers with different release rates and formulations can be combined to better match nutrient supply to plant and climatic requirements.

#### **For more info**

**Plant nutrient disorders**  
**5. Ornamental plants and shrubs** (book), Cresswell, G.C. and Weir, R.G. (1997), Butterworth-Heinemann, Melbourne (in press)

### ***Recycling waste water***

Many factors can affect the nutrient composition of nursery waste water. These factors include: plant species and stage of development, form of fertiliser used, the rate of and time since fertiliser application, rainfall, irrigation method, water scheduling, leaching fraction, and growing media composition.

### ***Managing waste water***

Large seasonal changes in the nutrient content of nursery water are normal. Collecting and storing waste water ensures that the most nutrient rich water does not leave the nursery as runoff or deep drainage without dilution. Additionally, nutrient concentrations in runoff can be greatly reduced by collecting water from roadways, carparks and buildings as the nutrient content of this water is normally lower than that collected from areas where containers are located (see Chapter 3 for more information).



### *Management strategies*

To manage waste water in your nursery, consider the following:

- Collect and store waste water in a structure such as a dam or tank. (The larger the storage, the greater the potential for diluting this nutrient rich runoff.)
- Ensure the first 10 to 15 minutes of runoff water after an irrigation is collected or treated as this portion usually contains most of the debris, including growing media and fertiliser prills.
- Collect and treat all water from areas used for potting up, watering in after potting, or for storing media before it leaves the nursery.
- Monitor the quality of stored water and adjust the fertiliser program to make use of recycled nutrients. If the nutrient concentration increases or decreases over time you might need to change the fertilizer rate or formulation used.
- Seal growing areas and drains to minimise infiltration of contaminated waste water into soil.

Waste water may also need to be treated to reduce nutrient concentrations before being discharged where permitted.

One technique for reducing nutrient, chemical and sediment loads is to pass waste water through vegetated filter strips and constructed wetlands. Preliminary work has shown that nitrogen can be reduced tenfold in runoff water after passing through a constructed wetland. Constructed wetlands are also useful for containing runoff water after heavy rain. General design principles are based on holding or slowing the passage of water through the constructed wetland where a range of chemical, physical and biological processes can operate to store, transform or remove various pollutants. Generally, the longer the residence there the greater the treatment.

For more detail on filtering methods and reducing sediment loads, see Chapter 4.

### **For more info**

**Recycling water in the Australian nursery and flower industries: managing water quality and pathogen disinfestation** (report), James, E.; Mebalds, M.; Beardsell, D.; van der Linden, A. and Tregear, W. (1995), Final Report HRDC Project NY320, Horticultural Research and Development Corporation, Sydney



## FURTHER READING

**Analysis of efficiency of overhead irrigation in container production** (journal), Beeson, K.C. and Knox, G.W. (1991), *Horticultural Science*, 26:848–850

**Artificial or constructed wetlands** (journal) Anon (1996), *Australian Nursery Magazine*, 20(4):14–16

**Constructed wetland manual** (book) (1997), NSW Department of Land and Water Conservation

**Light and fertiliser recommendations for production of acclimatized potted foliage plants** (journal), Conover, C.A. and Pool, R.T. (1990), *Nursery Digest*, 24(10):34–36, 58–59

**Loss of nutrients from containers with nursery plants** (report), Van der Boon, J. and Van Elk, B.C.M. (1986), Instituut voor BODEMVRUCHTBAARHEID, Report

**Managing nursery runoff – techniques to reduce nutrient leaching from pots** (booklet), Cresswell, G.C. and Huett, D.O. (1996), NSW Agriculture, Orange

**Managing water in plant nurseries** (book), Rolfe, C.; Yiasoumi, W. and Keskula, E. (Eds) (2002), NSW Agriculture, Orange

**Plant nutrient disorders 5. Ornamental plants and shrubs** (book), Cresswell, G.C. and Weir, R.G. (1997), Butterworth-Heinemann, Melbourne (in press)

**Recycling water in the Australian nursery and flower industries: managing water quality and pathogen disinfection** (report), James, E.; Mebalds, M.; Beardsell, D.; van der Linden, A. and Tregea, W. (1995), Final Report HRDC Project NY320, Horticultural Research and Development Corporation, Sydney

**Trace elements in pot plants. What's the best way of supplying them?** (journal), Handreck, K.A. (1995), *Australian Horticulture*, June pp 49–51

**The DOOR manual for plant nurseries** (book), Hunter, M.L. and Hayes, G.W. (1996), Queensland Department of Primary Industries, Brisbane

**The effects of temperature and time on the solubility of resin coated controlled release fertiliser under laboratory and field conditions** (journal), Lamont, G.P.; Worrall, R.J. and O'Connell, M.A. (1987), *Scientia Hort.*, 32:265–273

**Using pour-through extraction procedure in production regimes: optimum fertiliser rates and associated leachate electrical conductivity levels of twelve foliage plants** (journal), Conover, C.A.; Pool, R.T. and Steinkamp, K. (1992), *Foliage Digest*, (December): 3–7

**Water use and runoff comparisons of greenhouse irrigation systems** (journal), Neal, C.A. and Henley, R.W. (1992), *Proceedings Florida State Horticultural Society*, 105:191–194



## 6 ENVIRONMENTALLY RESPONSIBLE USE OF PLANT PROTECTION PRODUCTS IN QUALITY PLANT PRODUCTION

While the nursery industry alone is not a large enough user of plant protection products to affect whole catchments, it does have significant local impacts in terms of point source pollution. This is especially so where nurseries are located in an urban area or close to one.

In the last few years legislation has been enacted in most States/Territories to regulate some nursery practices to minimise their effects on the environment: This legislation, which many nurseries are already reacting to on their own initiative, can dictate how nurseries use chemicals and manage possibly contaminated waste water.

This Chapter presents some guidelines that detail how to manage your nursery whilst being mindful of the environment. For a more comprehensive overview, speak with your Industry Development Officer about the EcoHort guidelines. This program covers key areas including managing water, wastewater, noise, odour and air pollution. It also looks at enhancing energy efficiency and managing pesticides and chemicals above. This program builds on to NIASA as part of the Nursery Production Farm Management System.

### Chemical application

Vapours, sprays and dust drifting in the air is a common problem that can be regulated relatively easily. This chapter outlines some options for using plant protection products in a way that ensures pest control as well as maintaining the safety of the environment and plant quality.

### Waste water disposal

Another problem that is less well known (but probably as common) and more difficult to regulate, is the transport of materials such as pesticides, sanitisers and growth regulators in both runoff and drainage water.

In the largest segment of the nursery industry, namely containerised plant production, as well as in plant retailing, waste water problems are more specific. These problems relate to the fact that the permanently inundated soils and impermeable surfaces that are part of containerised plant production reduce or stop drainage through soil profiles. This increases runoff volumes and flow rates and does not allow the stripping of pesticides from waste water, which occurs naturally when it passes through soil.

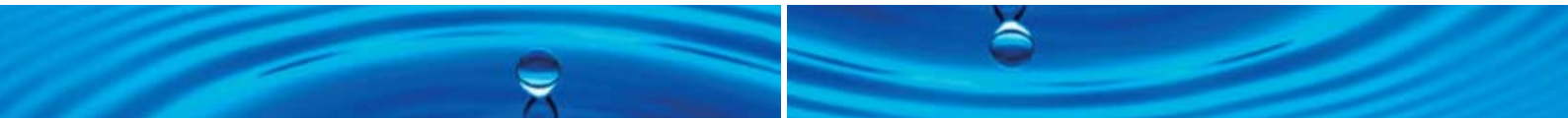
Fortunately, a compensating factor is that the nursery industry uses much less pesticide, particularly on an active ingredient per site basis, than many other horticultural industries.

*Note.* Figures for maximum levels of a range of pesticide pollutants in water are available in the current Australian and New Zealand Environment and Conservation Council guidelines.

It is apparent from a number of Australian case studies that these figures are most likely to be those used to adjudicate on the acceptability of waste water as it either leaves the production site or enters common waters.

### For more info

**Australian water quality guidelines for fresh and marine waters**, (booklet), (1992), Australian and New Zealand Environment and Conservation Council



#### For more info

**How to cope with urban sprawl** (journal), Whitten, M. (1994), *Nursery Manager*, April 1994:42–49

### Industry response to legislation and community pressure

It is interesting to examine a set of conclusions reached by the North American nursery industry, which has had to deal with government regulatory restrictions and very concerted community complaints for longer than the Australian industry. According to Whitten (1994) these are to:

- Operate only within current legislation.
- Have a properly documented environmental protection plan and code of practice for business. A contingency plan should be part of this.
- Maintain scrupulous records on pesticide use.
- Know and use independent experts, where available.

Nursery operators are constantly seeking information on techniques that will allow them to reduce pesticide use without compromising quality plant production. It is the aim of the chapter to provide a background to this, with a particular focus on maintaining a water quality suitable for reuse and discharge.

### REDUCING LEVELS OF PLANT PROTECTION PRODUCTS IN WASTE WATER

Management practices you can adopt to, firstly, reduce contamination levels and, secondly, further reduce levels in recycled and discharged waste water before reuse or discharge are as follows.

#### Reducing pesticide use

A major way you can minimise the quantity of plant protection products finding their way into waste water is by reducing your overall total use of them. There are a number of strategies for doing this. Each of these strategies relies on either:

- limiting the number of applications
- or
- reducing the amount of active ingredient used for each application.

This will reduce the amount of chemical that can get into and be transported by water.

#### For more info

**Best practice manual for pesticide application in the nursery and garden industry** CD-ROM, Version 1 (2004), Horticulture Australia Limited

**Ball field guide to diseases of greenhouse ornamentals** (book), Daughtrey, M. and Chase, A.R. (1992), Ball Publishing, Geneva, Illinois

### Improving diagnostic techniques on site and more routine use of diagnostic services

Knowing when and what disease or pest is affecting plants in the nursery is an essential first step to reducing chemical use. Unfortunately, the variety of species produced, the need for highly cosmetic plants to sell, the extreme artificiality of most of the plant environments in nurseries, and the large number of pests and diseases that can affect a plant species have all served to undermine the confidence of many nursery operators in diagnostic services.

As a result many operators rely heavily on the preventative, routine use of pesticides in combined applications. This means that some chemicals are used many more times in a year than is actually necessary, and some are used where they are never really needed at all.





While there will always be a need for some preventative, routine treatment (roses are a good example), there are many generic pests and diseases of nursery crops that you can learn to identify on site rather than having to rely on a consultant or diagnostic service. The more difficult or uncommon diagnoses are the only ones that should be referred to consultants or laboratories. You can learn these identification skills from:

- consultant training on site
- training institutions, particularly TAFE
- State nursery industry organised workshops and associations
- computer databases
- reference materials
- specialist nursery industry libraries, e.g. GrowSearch.

Other help is available through universities, State Government public and private laboratories, and a number of unaffiliated consultants. Some chemical distributors also offer diagnostic services to their customers.

### Choosing the best chemicals and application strategies for your needs

If you don't identify a pest or disease correctly then you will probably apply the wrong chemical or chemicals. The result is crop damage by pests and diseases, wasteful use of chemicals, and an extra burden of pesticide in waste water.

It is important that when you do identify a pest, disease or weed correctly you also carefully choose the chemicals to use to control it. When choosing and using a chemical ask yourself the following:

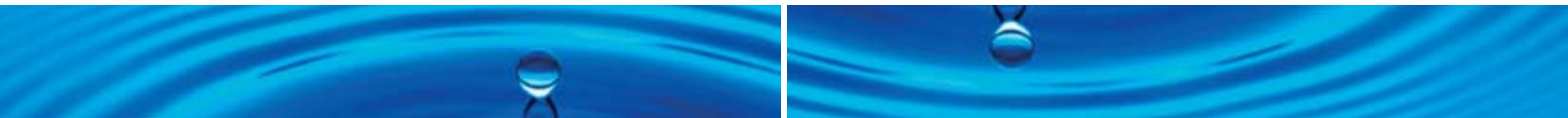
- Do I really know if it works? Even chemicals registered for specific jobs may no longer work.
- Do I know if I need to use it on the whole nursery, just one crop, or just one part of the crop?
- How often does it really need to be used?
- Could I choose an equally good or better chemical that needs to be used less often?
- What other choices are available so that I can rotate chemicals and the quantity of the one active ingredient used on the nursery is reduced? Correctly alternating or more broadly rotating chemicals not only reduces the risk of resistance buildup (and the consequent need to use the chemical at higher doses or frequencies) but also reduces the concentrations of individual contaminants in waste water.
- Can I use the chemical more sparingly by treating motherstock or propagules rather than newly planted and spaced crops? This can also reduce the need to treat as often, and is relevant to a number of pests as well as many diseases.
- Can I use a chemical incorporated into the growing medium rather than an overall spray or drench? This can reduce runoff concentrations.
- Can I use the chemical more effectively by applying it at the most sensitive stage of the pest or disease lifecycle, thus reducing the number of applications?

### For more info

**Ornamental plants – pests, diseases and disorders** (booklet), Bodman, K.; Carson, C.; Forsberg, L.; Hughes, I.; Parker, R.; Ramsey, M. and Whitehouse, M. (1996), Information Series Q196001, Queensland Department of Primary Industries, Brisbane

**Pest control in ornamental crops** (booklet), Bodman, K.; Hargreaves, J. and Parker, R. (1993), Queensland Nursery Industry Association, Brisbane

**The Nursery Industry Accreditation Scheme, Australia** (booklet), Bodman, K. and Forsberg, L. (1994), Australian Horticultural Corporation, Sydney



### For more info

**A review of pesticides in waste water and comments on implications to nursery production** (booklet), Bodman, K. (1997), Queensland Department of Primary Industries, Brisbane

- Can I choose a chemical that controls more than one pest or disease, thus reducing the need to use a combination?
- How residual is the chemical in soil and water? It is important that you choose the least residual chemical or, if persistent pesticides are needed, that they only be broadly applied where the risk of runoff and drift is low.
- Given that the largest amount of pesticide is lost from the application site during and soon after the first heavy irrigation or rain, is it possible to time broadscale applications so that the pesticides have the longest possible time to be fixed to the crop and growing medium, and even degrade somewhat before leaching and heavy runoff?
- Knowing all of this is a tall order, particularly if you need to use a broad range of chemicals. However, your reseller and the label can answer at least some of these questions.

- Information on residual activity and environmental sensitivity of a number of useful nursery chemicals has been published and is generally available. However, remember that you need to refer your more specific enquiries to manufacturers' representatives, either directly or through their agencies.

### Application equipment and chemical handling and storage

The most significant causes of chemical overuse and wastage are:

- inefficient equipment
- lack of operator training and inadequate supervision
- inadequate equipment and maintenance.

Fortunately these factors, which should be the first to be looked at when developing reduction strategies, are all generally easy to correct. Large savings are possible, for instance with the amount of active ingredient used.

There are excellent reference materials on this subject, and nationally accredited training courses on pesticide use are conducted regularly in all states.

The following strategies are recommended to reduce pesticide losses in drainage and waste water, as well as spray drift into water supplies:

- Keep pesticides under lock and key, well away from water supplies and direct drainage lines, and above all recorded flood levels. This should avoid the problem of highly concentrated point source pollution from concentrate spills, which has been a cause of concern in the past. For information on storing pesticides safely see Bartok 1996 and Ahrens et al 1994 as well as manufacturers' and government regulatory publications.
- Thoroughly rinse empty pesticide containers, and dispose of them in an approved way. You may collect the rinse water and use it during normal spraying operations.
- It is important to stop anti-backflow siphoning to protect water supplies used for filling spray vats. This will avoid acute water-source contamination, incidences of which have already occurred.
- Do not allow drainage and runoff from pesticide mixing and equipment washing

### For more info

**Courses aim for pesticide safety** (journal), Tyldens, J. (1996), Australian Horticulture, August p 87

**Guidelines to safe pesticide storage** (journal), Bartok, J.W. (1996), Greenhouse Management and Production May pp 56–57

**Managing the pesticide risk** (journal), Smith, E. (1996), Australian Horticulture, August pp 90–91

**Pesticide application manual** (book), Banks, A.; Broadley, R.; Collinge, M. and Middleton, K. (1994), 2nd Edition, Information Series Q1 89003, Queensland Department of Primary Industries, Brisbane





facilities to enter water supplies. This may involve using banded mixing areas on concrete, complete with sump traps, if other sites on the nursery are unacceptable.

- If possible, allow for buffer zones between application sites and receiving waters in the design of your nursery.
- If you do not use all of the diluted pesticide in the spray vat in a normal spraying operation and don't want to keep it to use in the next application dispose of it by spraying it onto vegetated, porous, non water-repellent soils well away from watercourses and drainage pathways. It is best to do this when low rainfall is predicted. Removal by a toxic waste disposal company is another, expensive, alternative. You must not, under any circumstances, allow it to enter water.
- Have an emergency strategy to deal with an accidental spill of either concentrate or spray dilutant anywhere on the nursery site. This is necessary for both workplace and environmental safety. If only a small area of soil is involved in a spill it can be excavated and spread over, or preferably cultivated into, much larger volumes of soil in non-sensitive areas. The highest risk spills occur in drainage pathways. Where these spills have entered irrigation supplies they have caused crop damage, either quickly or months after the event.

For more information on dealing with spills see Ahrens et al, 1994. Manufacturers also have more specific safety data and this is available from all resellers, generally when you buy the pesticide.

- Use diversion drains and, where possible, grassed banks to protect dams from contaminated waste water.

Many of these strategies are used by nursery operators already, particularly where they also affect personnel safety. Some nurseries with low volume storage requirements and use have found that the cost of storing pesticides and having mixing facilities that adhere to the regulations have been a deterrent to having them installed. However, it is worth noting that one government regulatory body has commented that the cost of preventing contamination is a fraction of that of cleaning it up.

### Using alternatives to pesticides

The relatively recent development of very effective pesticides, miticides, fungicides, herbicides and nematicides has allowed agriculture to stray from traditional practices of good hygiene and environmental control. This has a strong parallel with preventative human and veterinary health practices after the development of antibiotics.

However, we are now discovering the value (and, in some cases, necessity) of putting more effort into these practices.

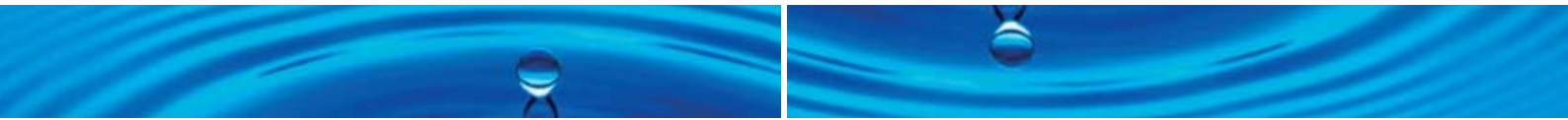
The first swing away from pesticides occurred with the development of broadscale pesticide resistance and more recently this has been supported by the need for more environmentally acceptable practices, both for the workplace and the general community.

The first thing that comes to mind when pesticide alternatives are mentioned is integrated mite and insect control. Although these techniques are what we read about in the literature most, they are a very small part of total pest and disease integrated management.

Many traditional practices that have been abandoned can be considered as aspects of pest, disease and

### For more info

**Recycling and resource conservation – a reference guide for nursery and landscape Industries,** (book), Ahrens, J.F.; Bonnet, R.E.; Castagnero, C.; Cornell, C.F.; Glenister, C.S.; Gouin, F.R.; Hock, W.K.; Kabashima, J.; Michalsen, L.H.; Niermiera, A.X.; Nuss, J.R.; Ross, D.S.; Rynk, R.F.; Skimina, C. and C. Champney Urbano (1994), Pennsylvania Nurserymen's Association Inc., Harrisberg, Pennsylvania



weed integrated management and deserve to be revisited and reintegrated in nursery crop protection programs. In particular, we need to reinvest in techniques of pest and pathogen exclusion as well as consider wider use of biological agents.

Pathogen exclusion techniques are not always understood in nurseries today. These techniques can be as simple as inspecting, quarantining, and rejecting or treating new plant intakes to stop 'new' pests, diseases and weeds being introduced into the nursery. They can also be comprehensive, expensive integrated procedures such as water treatment, upgrading standing surfaces and drainage, treating media (not always necessary), and installing insect proof houses. Of course, none of these investments will be fully realised without effective staff training.

As well as exclusion, which is a hygiene measure, modifying plant environments can result in use of less pesticides, particularly fungicides. Usually these techniques involve things such as decreasing humidities through modifying irrigation, improving air drainage and wider crop spacing or modified growing structures.

What is stopping the broader adoption of techniques to reduce dependence on pesticides are obviously the capital costs involved and, in many cases, the need for information. While the start up costs of these methods are high there are good examples of nursery operators making large savings through increased productivity, quality and consumer satisfaction.

#### For more info

**Recycling and resource conservation – a reference guide for nursery and landscape industries,** (book), Ahrens, J.F.; Bonnet, R.E.; Castagnero, C.; Cornell, C.F.; Glenister, C.S.; Gouin, F.R.; Hock, W.K.; Kabashima, J.; Michalsen, I.H.; Niermiera, A.X.; Nuss, J.R., Ross, D.S.; Rynk, R.F.; Skimina, C. and C. Champney Urbano (1994), Pennsylvania Nurserymen's Association Inc., Harrisberg, Pennsylvania

Using biological agents is more expensive in some cases than using chemicals (but only where effective chemicals are available), however, history has shown that it is unwise to assume that new pesticide resistance is not just around the corner.

Another limit to the adoption or readoption of the above techniques is the lack of established support industries, including consultants, to the nursery business.

#### **Dealing with pesticide spills**

Handling concentrates, unsprayed solutions and suspensions has been identified as a critical step in protecting water from pesticide contamination. Spills during these operations are regarded as being major human and environmental health problems. As such, it is vital that businesses have a written protocol, available to all staff, which deals with spills as well as other chemical emergencies.

Herbicide spills which have ultimately entered water storages have caused major crop damage. As well, the highest recorded concentrations of other types of pesticide pollutants in dams have resulted from spills. Information on reducing the risk of and cleaning up spills can be found in Ahrens et al .1994, Appendix D. More specific information is also available from chemical manufacturers and is included in courses dealing with chemical application e.g. the Farm Chemical Users Course or Chem Cert.



## Reducing pesticide concentrations In water storages and waste water

### Before waste water enters water storages and is discharged

Depending on the chemical, pesticides may travel either in a dissolved state or attached to particles moved by water, e.g. soil or growing media.

Particulate matter is trapped very easily by gravel beds, and organic matter such as compost fines in the gravel possibly can act as a site of pesticide degradation. The flow of water draining from gravel beds is slowed and subsequent runoff is substantially free from visible debris. For more information on this see Chapter 4 of this publication.

Pesticide residues not attached to eroding layers are greatly reduced if they enter soil profiles. The rate of their degradation depends on a range of soil conditions such as pH, drainage and organic content. Where there is suitable land on nurseries, you might give some thought to using it as a site for stripping pesticides (and nutrients) from waste water.

Particle gravitational traps and screens may be especially necessary for nurseries sited on ungravelled surfaces. For more details see Chapter 4 of this publication.

Land suitable for leach fields is not often available for nursery operations.

### Reducing volumes of waste water

This general topic is covered in other chapters of this publication. However, as pesticides are usually degradable, the longer a chemical has before being washed or leached from the site where it is applied the lower the concentration entering waste water. Also, the disadvantage of reducing runoff volumes of water after pesticide applications is that concentrations of the chemical may actually increase. A compensation is that reduced runoff volumes make it more feasible to store contaminated water on site and, if necessary and safe to the crops, use it there.

### Impounding runoff

Pesticides can be degraded in on site water storages and, if necessary, it can then be diluted enough before they are reused or discharged so they aren't a threat to the environment or nursery stock.

Effective impoundment will obviously depend on reducing volumes of runoff to meet available storage capacity. Major limitations are lack of space on site and the cost of impoundment where water storages do not already exist (this may include lost production areas).

### Recycling and reuse

Captured runoff water can have value if you are able to use it again on site. Some nurseries use it to irrigate inground crops on their own or even neighbouring properties.

Recycling implies that the same water is used again and again. If this is the case on your nursery you may have to deal with a number of significant problems. These are discussed more comprehensively in other chapters in this publication, however, there are some specifics about pesticide pollutants that you need to consider if you adopt this strategy.

#### For more info

**A review of pesticides in waste water and comments on implications to nursery production** (booklet), Bodman, K. (1997), Queensland Department of Primary Industries, Brisbane



### **For more info**

#### **A review of pesticides in waste water and comments on implications to nursery production**

(booklet), Bodman, K. (1997), Queensland Department of Primary Industries, Brisbane

**Pesticide waste water disposal: biological methods** (book), Craigmill, A.I. and Winterlin, W.I. (1988), in Bridges, J.S. and Dempsey, C.R. Pesticide Waste Disposal Technology, Moyes Data Corporation, Park Ridge, New Jersey

With constant recycling (or even on first reuse) concentrations of phytotoxic pollutants can build up. While many nursery operators have recycled water successfully, others have experienced crop or quality losses, particularly when total water storage levels have fallen or the ratios of used to unused mixtures have increased. The resultant effects can range from an easy to a difficult, lengthy diagnosis of an acute or chronic decline in crop performance.

Compared with most nutrient and other salt levels, pesticide pollutants are very expensive to monitor. Breakdown products may be as phytotoxic as their parent compounds and also may need assaying. Assays may indicate the presence and concentrations of pollutants, but little may be known about their relevance to crop damage when it occurs.

#### **Treating waste water on site**

Diluting stored waste water has already been mentioned, however, there are refinements to this where storages are connected in series. In this situation retention, degradation and dilution as water passes from one storage to another can be controlled.

A number of on site treatment possibilities have been researched, including activated carbon filters, ozonation, reverse osmosis and aeration. Slowly filtering waste water may be moderately effective in biodegrading pesticides. Coarse gravel has been used to do this, and compost filters can also degrade some insecticides and miticides.

These methods can be used if you know what the contaminants are. Some are untried in practice (they have been used in research projects only) and others are expensive to install and operate.

## **INDIVIDUAL PROPERTY WASTE WATER CODES OF PRACTICE**

Businesses need long term plans and goals. These plans need to incorporate financial provisions and strategies for risk management. Successfully reducing contaminants in waste water should be part of these risk management and financial plans.

To determine how a business will reach its goals it is first necessary to know where it currently is. In terms of pesticide use and contamination reduction, the long term plan begins with accurately assessing:

- quantities of pesticide currently being used
- the cost of their use
- losses solely due to failures in crop protection.

The aim should be to reduce all three when estimated annually.

To assess risk due to waste water contamination you should have analyses of waste water entering storage and being discharged from the nursery site. View discharge in the context of where the nursery is located in terms of environmentally sensitive situations, e.g. near edible crops, schools, watercourses etc.

As the goal is to reduce contamination levels these figures are your starting point. The result should be a permanent document with recorded achievements able to meet the scrutiny of external reviewers, if that is necessary. Enough information can be included to evaluate future investment needs and meet your future or current quality assurance documentation standards.



The pesticide use records most commonly kept at present under legal obligation will provide some useful information, however, if you do not already include it, expand these to take account of quantities of concentrate and dilutant use per unit area, the reasons for applying the chemical(s), and if it (they) did or did not work as well as expected.

## **FURTHER READING**

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**A review of pesticides in waste water and comments on implications to nursery production** (booklet), Bodman, K. (1997), Queensland Department of Primary Industries, Brisbane

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## APPENDIX 1

# CALCULATING COEFFICIENT OF UNIFORMITY, MEAN APPLICATION RATE AND SCHEDULING COEFFICIENT

### Overview

When selecting a system, you have three objectives:

1. Apply water evenly (Coefficient of Uniformity; Cu)
2. Apply water at the right rate (Mean Application Rate; MAR)
3. Apply water to the whole area, minimising dry spots (Scheduling Coefficient; Sc)

### Coefficient of Uniformity (Cu)

The Coefficient of Uniformity measures how evenly water application is distributed and takes both wet and dry areas into account and relates their application to the mean application rate. Cu is calculated as a percentage, with 100 % being the absolute ideal. A minimum value for fixed overhead systems is 85% and the closer you get to 100 % the better.

### Mean Application Rate (MAR)

To take full advantage of the water holding capacity of your growing media, the Mean Application Rate (MAR) should be less than the absorption rate of the growing media. The absorption rate will be governed by the composition of your growing media. Composted pine bark mixes commonly have an absorption rate of 10 – 12 mm/hour while medias with a significant proportion of coir can raise this rate to be as high as 15 – 20 mm/hour. Generally you should be looking at selecting an application rate of between 5 and 12 mm/hour. Lighter application rates should be considered for small plug containers and seedlings.

### Scheduling Coefficient (Sc)

Scheduling Coefficient is a measure of the extra time required to irrigate the area to ensure that the driest section (2 %) receives the required water application. It is expressed as a number greater than 1, with 1 being the ideal Sc.

For example, if we need to apply 5 mm of irrigation to a block with a Scheduling Coefficient of 2, the driest areas only receive 2.5 mm for a 5 mm application. Otherwise, to ensure the dry areas receive sufficient water, you would need to overwater the rest by applying 10 mm of water.

The Scheduling Coefficient has a significant impact on water consumption, fertiliser leaching, potential growth rates and consistency of product. A good Sc is 1.2 and the upper limit for most situations is 1.5.



$$\text{Coefficient of Uniformity} = \left[ 1 - \frac{(\text{average deviation from average catch})}{\text{average catch}} \right] \times 100$$

$$\text{Mean Application Rate} = \frac{\text{total volume per hour of catch containers}}{\text{No. of catch containers}}$$

$$\text{Scheduling Coefficient} = \frac{\text{average catch rate}}{\text{lowest catch rate}}$$

To achieve a Scheduling Coefficient of less than 1.5 it is necessary to ensure that all containers receive water from four full circle sprinklers.

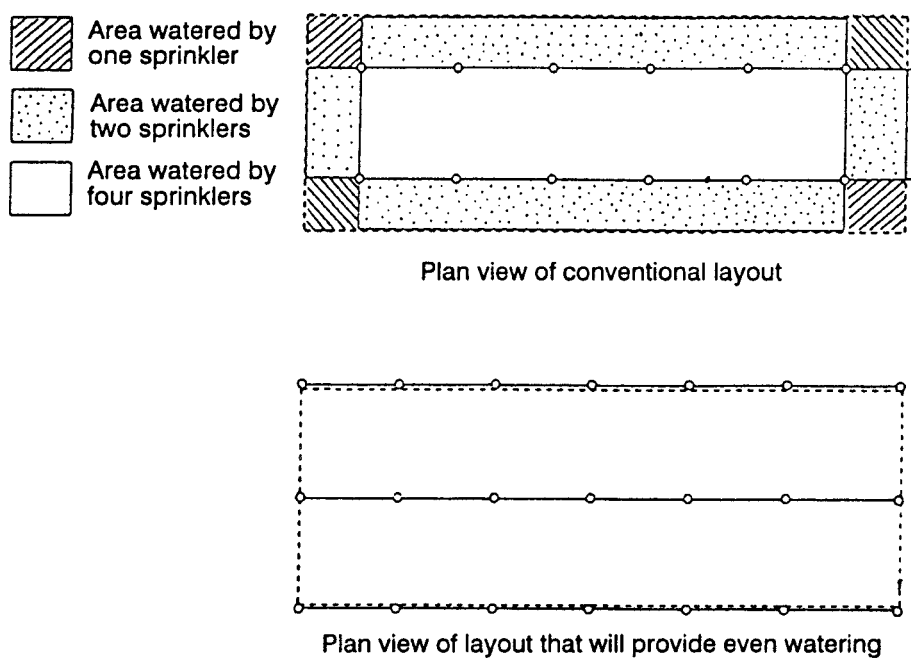
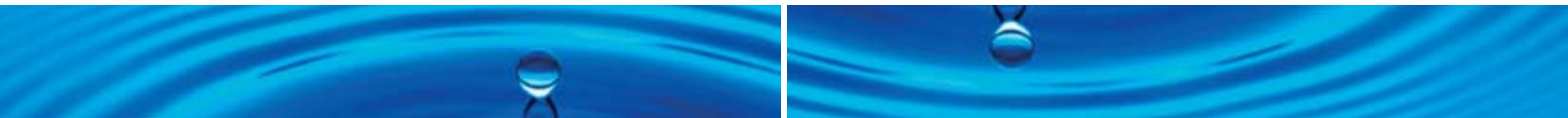


**Fig. 17 – Low Scheduling Coefficients can be achieved if each container receives water from four sprinklers**

Although the proposed layout has more sprinklers than the conventional layout, the low Scheduling Coefficient means the proposed layout will use less water, apply water more evenly and reduce excessive fertiliser leaching.



**Example**

Each block shown is fitted with sprinklers at 4 metre centres, applying 8 mm/hour with a Cu of 85 % discharging 130 litres/hour. The conventional layout has 12 sprinklers and a Sc of 2.2 with the driest areas at the comers. The proposed layout has 21 sprinklers and a Sc of 1.2.

**Comparing the two systems**

|                                                                                  | Conventional layout                                           | Proposed new layout                                           |
|----------------------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| Area watered                                                                     | $6 \times 22 = 132 \text{ m}^2$                               | $8 \times 24 = 192 \text{ m}^2$                               |
| Time to apply a 6 mm application                                                 | $\frac{6 \times 60 \times 2.2}{8}$ $= 99 \text{ minutes}$     | $\frac{6 \times 60 \times 1.2}{8}$ $= 54 \text{ minutes}$     |
| Volume of water applied                                                          | $\frac{128 \times 12 \times 99}{60}$ $= 2,534 \text{ litres}$ | $\frac{128 \times 21 \times 54}{60}$ $= 2,419 \text{ litres}$ |
| Translated to 200 such applications over a one hectare nursery, the volumes are: |                                                               |                                                               |
|                                                                                  | $19.2 \times 200 \times 10,000$ $= 38.4 \text{ megalitres}$   | $12.6 \times 21 \times 54$ $= 25.2 \text{ megalitres}$        |





## APPENDIX 2

# INPUT DATA FOR NURSERY PRODUCTION ECONOMIC MODEL

This model was developed to compare water savings; dollar returns and increase in business potential for nurseries that wished to retrofit the irrigation and drainage systems on their nurseries via a cost/benefit analysis. The model has been designed in Microsoft Excel.

This model takes the base data prior to retrofitting and the changed case after retrofitting and uses a standard discounted cash flow (DCF) investment analysis framework.

The DCF estimates the net Present value (NPV) or lump sum present value equivalent of the incremental cash flow stream over the term of the investment. It arises directly as a result of estimating the difference in the annual cash flow pattern for the business, with and without the proposed changes. Thus the NPV determines the present day value of any investment over the period of time at the quoted discounted rate.

The NPV result determines whether a proposed investment is likely to be viable or not. An investment is said to be viable if the NPV is positive at the quoted discount rate of 7 % over the investment time of 10 years for the generic economic model.

This generic economic decision model utilises a series of economic spreadsheets for the nursery industry to assess proposed changes to a business in regard to water saving technologies to allow growers to plan and implement water use efficiencies based on return on investment.

It will also provide estimates on other operational cost savings such as reduced electricity cost, plant throw outs, fertiliser and chemical usage.

For industry, the key to achieving a positive return on investment for upgrading irrigation systems is to first assess the existing irrigation system performance and the current costs of operating. Once data is established you can then compare the performance data to industry Best Management Practices in irrigation performance and determine the likely water use savings you would expect to achieve. The cost of any alternative water source and outlay to achieve the retrofit can then be assessed using the generic economic model to measure the net worth of the outlay.

The spreadsheet inputs are divided into the following sections

- Income (before and after retrofit)
- Capital costs
- Fixed costs (showing calculated cost savings for new system)
- Variable costs (showing calculations of new system savings)

The model then does a discounted cash flow analysis over ten years using

- Current system scenario
- New system scenario
- Benefits of new system.

It then prepares a cash flow summary which shows the pay back period for the investment, the benefit cost ratio which describes the return for every dollar invested.

Finally the model prepares an overall summary detailing the water savings in megalitres and the change in business profit.

Within the model, all yellow cells are data entry and the red cells are calculated by the model.

Typical inputs include:

#### **Income**

Sales  
Other  
Total sales  
Other sources  
Intellectual property  
Agency income  
Consulting  
Interest  
Diesel rebate  
Misc income  
Freight collected

#### **Capital costs**

Buildings and roads  
Office equipment  
Vehicles  
Nursery infrastructure and equipment  
Irrigation (both old and new)

#### **Fixed costs**

Accountant  
Advertising  
Bank charges  
Book keeping  
Broadband  
Cleaning  
Electricity  
First aid  
Hire plant & equipment  
Licenses and fees  
Motor tolls  
Motor vehicle expenses  
Pest control  
Rates  
Repairs and maintenance  
Security  
Technical books & journals  
Telephone  
Tool replacement  
Town water charges  
Wages  
Waste disposal  
Water testing  
Work cover  
Workplace health & safety

#### **Variable costs**

Bags  
Blades  
Cartons  
Chemicals  
Commissions  
Containers  
Freight  
Fungicide  
Herbicide  
Insecticide  
Labels  
Levies  
Payroll tax  
Plants  
Plastic trays  
Growing media  
Pots  
Seed  
Stakes  
Tape  
Ties  
Wax trays  
Weed mat

## APPENDIX 3

# CONSIDERATIONS WHEN DEVELOPING A DRAINAGE, SEDIMENT AND LITTER CONTROL PLAN

When designing for or operating at a particular site, consider the: physical limitations that affect the site and how to address them. This can reduce: both the: construction costs and the level of future maintenance. Integrating drainage, erosion and sediment control at the planning stage is more cost effective than establishing controls and undertaking remedial work once the nursery is completed.

Physical limitations can be divided into two categories, topographic limitations, which are summarised in Table 11 and soil limitations, summarised in Table 12. Terrain limitations are summarised in Table 13.

**Table 11. Topographic limitations**

| Topographic limitation | Considerations                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Slope                  | Gentle slopes generally impose little limitation to development, while steep slopes present problems because of increased runoff velocity and a greater requirement for cut and fill earthworks. The length of slope influences the volume and velocity runoff, while the shape of a slope can further influence the erosion potential through variations in vegetation cover and micro-climates. |
| Terrain                | The type of terrain can help identify unstable areas. Commonly occurring terrain types and considerations are in Table 13.                                                                                                                                                                                                                                                                        |
| Flooding               | If the drainage system cannot handle the volume of runoff then low lying areas will be flooded. Floodway obstructions such as buildings also increase flow velocity and turbulence.                                                                                                                                                                                                               |
| Shallow soils and rock | Rock surfaces and shallow soils reduce infiltration and produce high runoff rates.                                                                                                                                                                                                                                                                                                                |
| Sand dunes             | In their natural state they are usually stabilised with vegetation and development can destroy this protective vegetation. The most sensible approach is to leave them undisturbed.                                                                                                                                                                                                               |
| Wave action            | Land adjacent to water bodies, like lakes, can be affected by wind generated waves.                                                                                                                                                                                                                                                                                                               |
| Wetlands               | Wetlands provide natural detention storage for floodwater and filtration for sediment. Disturbing them will result in loss of these benefits.                                                                                                                                                                                                                                                     |
| Site drainage          | Poor drainage may lead to increased surface runoff, soil erosion, slope instability and flooding.                                                                                                                                                                                                                                                                                                 |
| Mass movement          | The movement of soil material down slopes is commonly triggered in infiltration, which reduces the soils shear strength.                                                                                                                                                                                                                                                                          |
| Streambank erosion     | The removal of soil materials from streambanks by the direct action of stream flow.                                                                                                                                                                                                                                                                                                               |

**Table 12. Soil limitations**

| <b>Soil limitation</b>                | <b>Considerations</b>                                                                                                                                                                                                                       |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Slope pH                              | Soils with extreme pH levels experience increased erosion and sediment problems, and are more difficult to revegetate.                                                                                                                      |
| Acid surface soils                    | These soils are poorly drained, restrict the growth of stabilising vegetation and area a major problem if exposed to the air. The most sensible approach is to leave them undisturbed.                                                      |
| Water repellent soils                 | Water repellent soils do not readily absorb water when they are dry and therefore have high rates of runoff. They are difficult to revegetate and are very prone to erosion.                                                                |
| Expansive and reactive soils          | these soils shrink and swell markedly with changes in moisture content. Soil movement can destroy or damage buildings, walls, dams, roads and paths leaving the soil exposed to erosive sources.                                            |
| Sodic soils                           | Sodic soils are extremely erodible. Plant germination and growth is usually poor. Try and avoid nursery development on these soils.                                                                                                         |
| Non-cohesive soils                    | Soils, such as sands, are extremely erodible. Steep cuttings or batters are not suited with these soils and retaining structures are usually required.                                                                                      |
| Low fertility                         | Low fertility soils are more likely to erode than more fertile soils as they are less likely to be stabilised with vegetation.                                                                                                              |
| Saline soils                          | Saline soils are often poorly drained and sodic. They are extremely erodible. Soil salinity problems may be triggered by development activities which raise saline water tables.                                                            |
| Toxic soils                           | Toxic soils predisposed to erosion are difficult to vegetate. Toxicity may be associated with extremes of pH, chemical pollutants, or soil pathogens.                                                                                       |
| Unconsolidated soils                  | Uncompacted fill and disturbed soils are extremely erodible. They are also prone to differential settlement, which may damage greenhouses and paths. For these reasons you should minimise cut and fill and ensure fill is compacted.       |
| Hardsetting and surface sealing soils | These soils become hard and compact when dry, making water infiltration difficult. The result is high runoff. Seedling germination is difficult and mulches or cover crops are recommended to help retain soil water and protect bare soil. |

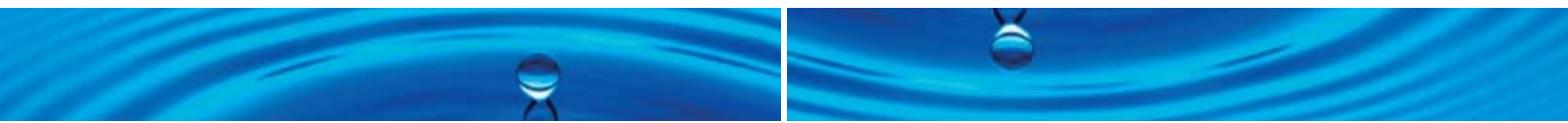
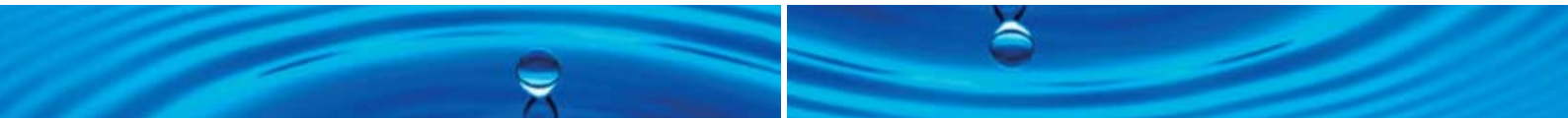


Table 13. Terrain types and considerations

| Terrain type  | Considerations for sediment and litter generation        |
|---------------|----------------------------------------------------------|
| Ridge crest   | Shallow soil; rock outcrops; poor drainage; high runoff  |
| Sideslope     | Mass movement                                            |
| Footslope     | Flooding from overland flow; seasonal waterlogging       |
| Floodplain    | Flooding; waterlogging                                   |
| Drainage line | Flooding; waterlogging; streambank erosion; saline soils |
| Dune          | Wave erosion; high permeability                          |
| Escarpment    | Shallow soils; rock outcrops; mass movement; high runoff |



## APPENDIX 4

### POUR-THROUGH TECHNIQUE

This test is normally done 1 to 2 hours after irrigation, when the moisture content of the mix is close to container capacity

The procedure is that water is slowly added to the surface of a pot until 50 to 100 ml of leachate has been displaced from the mix. As a general rule, no more than 100 ml of leachate should be obtained for each litre of mix.

This procedure should be repeated on five to ten randomly selected pots to cover possible variation in a growing area.

The electrical conductivity of the leachate is a guide to the salt/nutrient content of the soil solution. Values above 2 dS/m are considered high for some species. For further information on interpreting results, see Conover, Pool and Steinkamp's article in *Foliage Digest*.

#### REFERENCE

**Using the pour-through extraction procedure in production regimes: optimum fertiliser rates and associated leachate electrical conductivity levels of twelve foliage plants.** Conover, C.A.; Pool, R.T. and Steinkamp, K. (1992), *Foliage Digest* (December): 3–7



