TOMATO POTATO PSYLLID

Potato

Enterprise management plan

CONTENTS

INTRODUCTION

Tomato potato psyllid (TPP) is a serious pest of potatoes. TPP is the vector of the bacterium *Candidatus* Liberibacter solanacearum* (CLso) which is associated with a range of symptoms collectively known as Zebra Chip disease. Zebra Chip can have a devastating impact on the production and economic performance of your crop.

TPP was first detected on mainland Australia in Western Australia (WA) in February 2017. This prompted a comprehensive biosecurity response to minimise the impact of TPP on Australian businesses.

After national agreement that TPP could not be eradicated, efforts focussed on developing the science, biosecurity and business systems to improve the capacity of growers and industry to manage TPP.

An essential component of transition to management is the development and implementation of enterprise management plans for affected industries. The plans outline measures to effectively control TPP and demonstrate industry commitment to minimising its spread and impact. They are critical in supporting ongoing efforts to renew and maintain market access, as well as underpin certification and assurance schemes.

Our aim is to build on current best practice to include the management of TPP, without creating unnecessary additional work.

ABOVE: Mature adult TPP in comparison to a 5 cent coin.

THIS PLAN INCLUDES FIVE KEY COMPONENTS:

1. UNDERSTANDING PEST AND PATHOGEN BIOLOGY AND THEIR IDENTIFICATION
2. IDENTIFYING RISK PATHWAYS
3. APPLYING CONTROL AND MANAGEMENT OPTIONS
4. BIOSECURITY AWARENESS AND IMPLEMENTATION
5. POST FARM GATE MANAGEMENT

TPP WAS FIRST DETECTED ON MAINLAND AUSTRALIA IN WESTERN AUSTRALIA IN FEBRUARY 2017.

** As at October 2018, surveillance confirms that CLso is not present in WA*

BELOW: TPP nymphs on underside of leaf.

1 UNDERSTANDING PEST AND PATHOGEN BIOLOGY AND THEIR IDENTIFICATION

What is TPP?

TPP (*Bactericera cockerelli*) is a tiny sap-sucking insect which feeds on tomato, potato, capsicum, chilli, tamarillo and sweet potato, and solanaceous weeds like nightshade, leading to loss of plant vigour and yield.

ABOVE: TPP life stages.

TPP life stages

TPP go through three stages of development – egg, nymph and adult. Adults and nymphs cause injury to plants by feeding with sucking mouth parts.

- **Adults** resemble a winged aphid and are about 3mm long. The body is brownish and has white or yellowish markings on the thorax and a broad white band on the abdomen. Wings are transparent and rest roof-like over the body.
- **Nymphs** are up to 2mm long, oval shaped, flattened and scale-like in appearance. Young nymphs are yellow with a pair of red eyes and three pairs of short legs. Older nymphs are greenish and fringed with hairs and have visible wing buds.
- **Eggs** are less than 1mm long and are attached to the plant by a short vertical stalk. They are usually laid on the lower surface of leaves or as a halo around the leaf edge. Eggs are white when first laid then turn yellow to orange after a few hours.

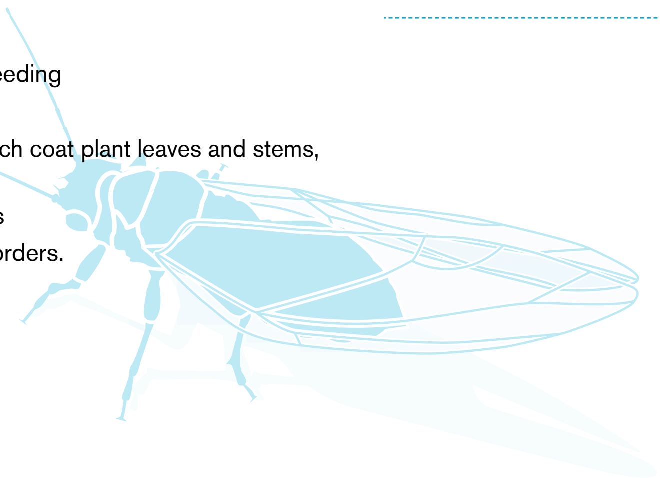
ABOVE: Damage to the foliage of a potato plant, caused by the TPP *(Bactericera cockerelli)*.
Photo: Whitney Cranshaw, Colorado State University

LEFT: Wax pellets excreted by TPP.
Photo: Whitney Cranshaw, Colorado State University

GROWERS SHOULD REGULARLY CHECK FOR SIGNS OF TPP IN HOST CROPS.

Symptoms of TPP infestation to look for:

- Look for damage on the underside of leaves
- Insects jumping from the foliage when disturbed
- Severe wilting of plants caused by high numbers of psyllids feeding
- Yellowing of leaf margins and upward curling of the leaves
- White sugar-like granules (excreted by adults and nymphs), which coat plant leaves and stems, and can lead to the development of sooty mould
- Ants on plants may be symptomatic of the presence of sugars
- Stem death symptoms similar to other potato and tomato disorders.



RIGHT: Symptoms of zebra chip (*Candidatus* Liberibacter solanacearum) on potatoes.
Photo: Plant Health & Environment Laboratory, Ministry for Primary Industries, Auckland, NZ

INSET: Symptoms of zebra chip (*Candidatus* Liberibacter solanacearum) on fried chips.
Photo: J.E. Munyaneza, USDA-ARS, Konnowac Pass (US)

Candidatus Liberibacter Solanacearum* (CLso)

TPP can carry a bacterium called *Candidatus* Liberibacter solanacearum (CLso) or Zebra Chip, which is associated with a range of symptoms, affecting yield and quality of potatoes.

It only takes 1–2 hours of feeding for the psyllid to infect a plant with Zebra Chip.

BELOW: Aerial tuber resulting from infestation of potato by TPP.
Photo: Whitney Cranshaw, Colorado State University

SYMPTOMS OF CLso

Symptoms of the CLso bacterium in potatoes may look similar to other plant conditions. Growers are urged to be vigilant.

- Plants may have shortened internodes and aerial tubers may develop in the leaf nodes
- Potato tops are likely to be smaller than normal
- The foliage turns yellow and may have a burnt or purplish appearance
- Stems may die completely but regrowth from the base may occur
- Tubers from affected plants may have small stalked tubers protruding from the main tuber (called ‘chaining’) and when cut may show internal browning of the vascular ring or brownish streaks along the medullary rays.

** As at October 2018, surveillance confirms that CLso is not present in WA*

IDENTIFYING RISK PATHWAYS

2

Where did the pest come from?

TPP was detected in Western Australia for the first time in February 2017, prompting a comprehensive biosecurity response. It had not previously been found on the Australian mainland and the origin of this detection is unknown. TPP is present on Norfolk Island and in other countries including USA, Canada, Central America and New Zealand.

It can spread through the movement of host plant material. It can also disperse through natural pathways such as flight, wind and human – assisted movement (movement of plant material).

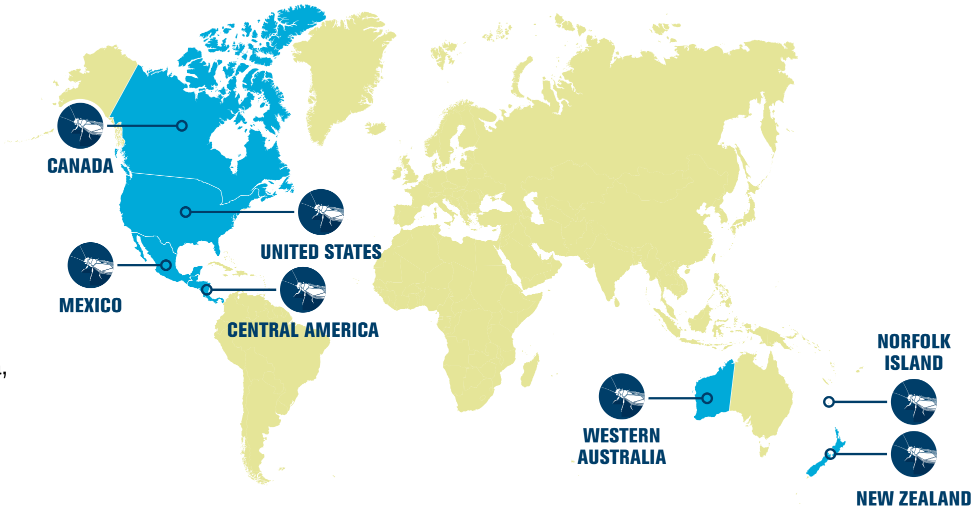


FIGURE 1: Distribution of TPP worldwide

What is being done to protect our industry?

A Quarantine Area Notice has come into effect in and around the Perth metropolitan area to limit the spread of TPP within the state.

In addition, New South Wales, Northern Territory, Queensland, South Australia, Tasmania and Victoria have all applied movement conditions to reduce the risk of TPP spreading interstate.

3 APPLYING CONTROL AND MANAGEMENT OPTIONS

1. FIND OUT STATUS OF TPP IN YOUR REGION
2. SET UP MONITORING PROGRAM FOR PROPERTY FREEDOM, EARLY DETECTION OR AS A CROP PROTECTION DECISION-AID SYSTEM (MONITOR THRESHOLDS)
3. DEVELOP A FARM BIOSECURITY PLAN FOR TPP
4. DEVELOP AND FOLLOW CROP PROTECTION/ IPM PLAN
5. BECOME FAMILIAR WITH INTERSTATE AND INTERNATIONAL MOVEMENT CONTROLS

EARLY DETECTION IS IMPORTANT IN ANY PEST MANAGEMENT SCENARIO.

Apply sound crop hygiene/biosecurity practices to prevent the entry, establishment and spread of pests and diseases.

- Check planting material you purchase are free of pests and don't bring infested plants into your property.
- Control host plants in a buffer around your cropping area.
- Regularly monitor your plants for any unfamiliar pests or diseases.

Monitoring for TPP

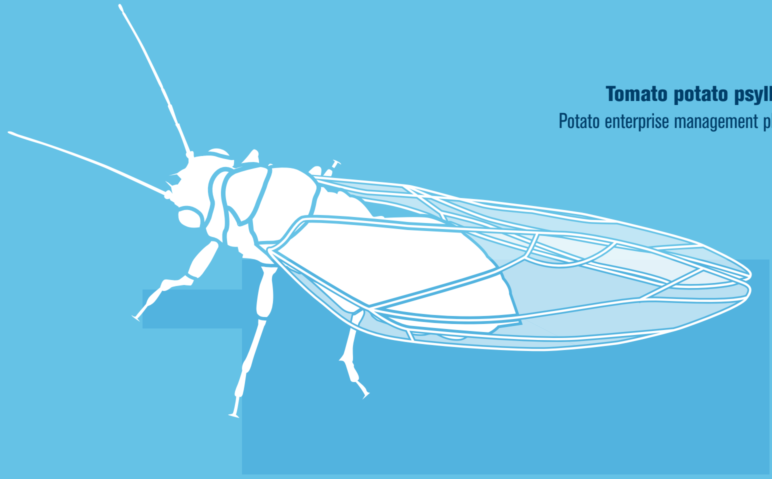
In addition to looking for TPP and symptoms in field, growers should install sticky traps to monitor for TPP. Remember early detection is important in any pest management scenario.

How many traps do I need on my property?

The number of traps you need will depend on the size of your property and the distribution of TPP host crops on farm.

If the property is 1-4 hectares and fully planted with host crops, 4 traps should be sufficient.

If the property is larger and host crops are scattered across the property, additional traps may be useful.



STEP 1	REMOVE COVERING FROM THE YELLOW STICKY TRAP TO EXPOSE THE STICKY LAYER
STEP 2	PLACE PROTECTIVE CAGE OVER TRAP
STEP 3	ATTACH STICKY TRAP TO POLE USING TWO BULLDOG CLIPS
STEP 4	PLACE TRAP WITHIN TWO METRES OF EDGE OF CROP, ONE TRAP PER SIDE OF CROP
STEP 5	PLACE POLE IN CROP SO THE BOTTOM EDGE OF TRAP IS LEVEL WITH THE TOP OF CROP CANOPY
STEP 6	LEAVE TRAP IN LOCATION FOR ONE WEEK
STEP 7	INSPECT TRAP AFTER ONE WEEK AND DETERMINE ACTION AS PER DEVELOPED PROCEDURE
STEP 8	CONTACT YOUR LOCAL INDUSTRY BODY OR STATE AGRICULTURAL DEPARTMENT FOR FURTHER ADVICE IF YOU SUSPECT TPP IS PRESENT

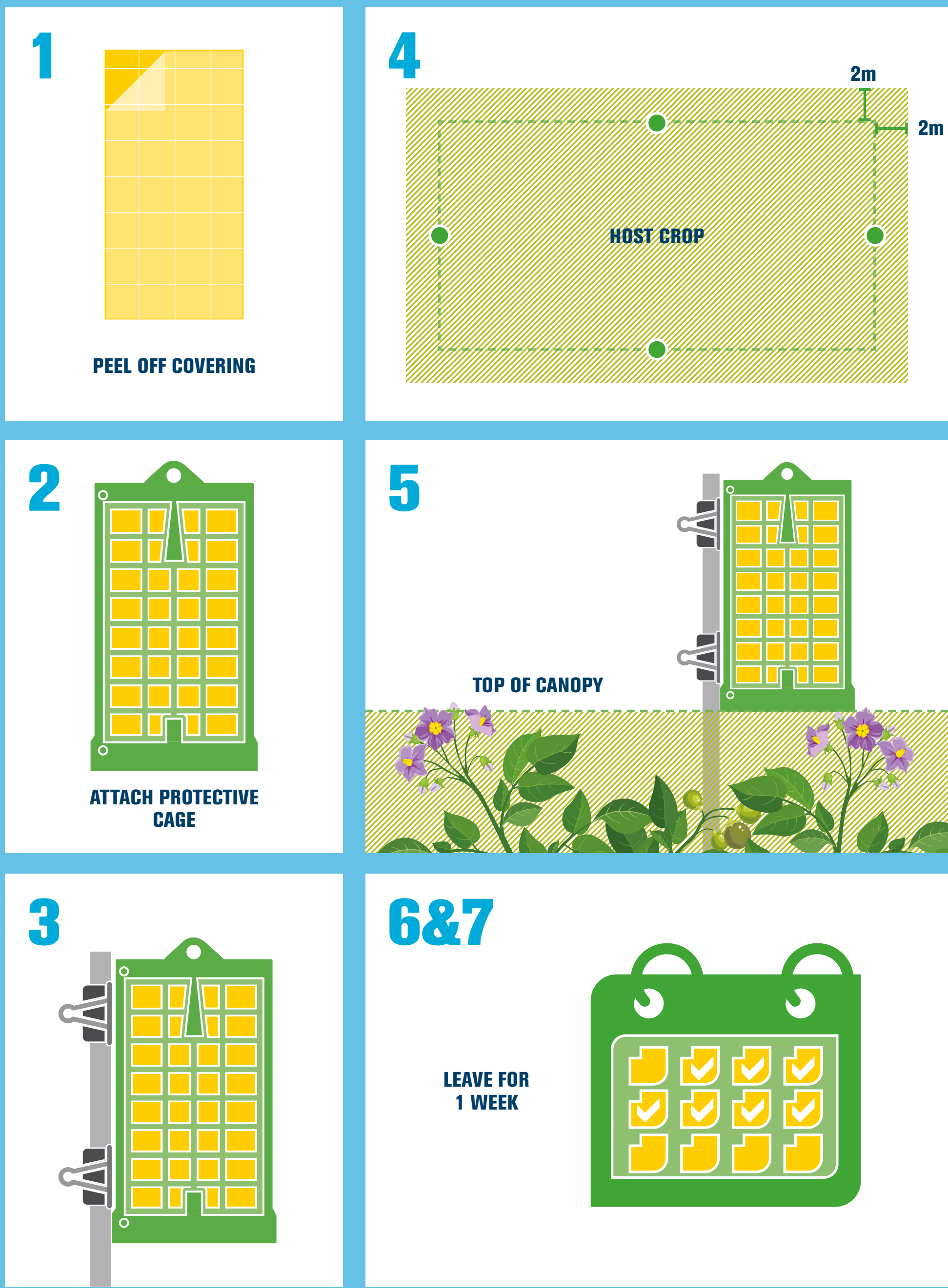


FIGURE 2: How to install sticky traps in potato crops

SCIENTIFIC R&D IS CRITICAL TO IMPROVING OUR UNDERSTANDING OF TPP IN AUSTRALIA, AND INCREASING MANAGEMENT OPTIONS AVAILABLE TO GROWERS.

Pest thresholds and control

Much of the local research is just beginning, therefore biological control and pest thresholds for TPP in Australia are yet to be defined. Until local trial data is validated, current best practice is to monitor and if no TPP is found, continue with your current pest control program.

The Department of Primary Industries and Regional Development (DPIRD) has led a program of R&D as part of the nationally-agreed TPP Transition to management plan. The plan aimed to develop the science, biosecurity and business systems to support growers and industry to manage TPP.

Key research activities and preliminary trial results are provided in a series of factsheets available in the Appendix of this plan.

Note: some insecticides have been made available through emergency permits for use in host crops (Table 1).

ABOVE: Ladybird feeding on adult TPP.

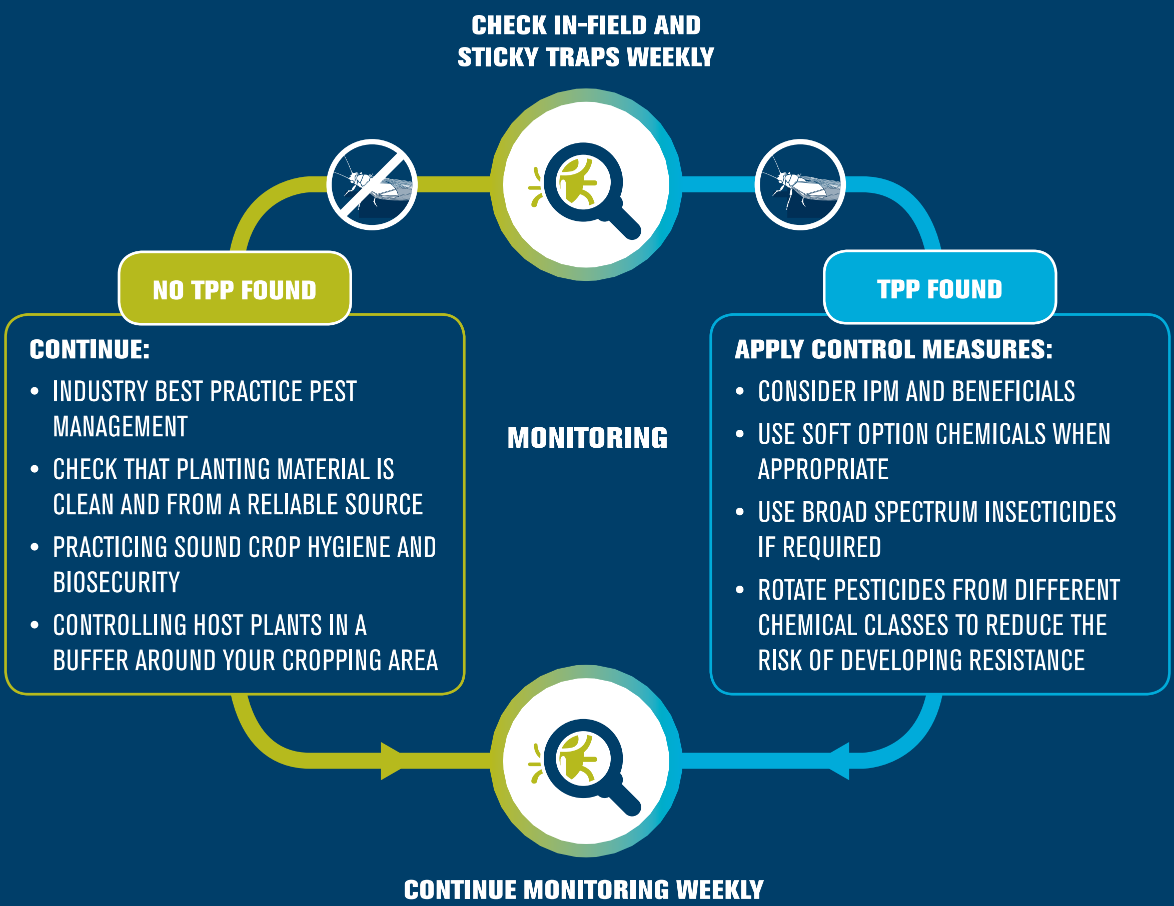


FIGURE 3: TPP action plan

TABLE 1: Summary of the available permits for potatoes. Growers should download the full permit and read in conjunction with the product label before using

Active Action Group	Permit No. Holder Expiry	Crops	Rates	WHP (days)	Jurisdiction	Comments
Abamectin **Contact/ingestion** **Group 6**	**PER84249** NSWDPI 31/07/2020	Potato and sweet potato	**18g/L product:** 600mL/ha **36g/L product:** 300mL/ha	14 days	All states except Victoria*	• DO NOT exceed a maximum of five (5) foliar applications, with a minimum 7–14 days between consecutive treatments.
Lambda-cyhalothrin **Contact/ingestion** **Group 3**	**PER84249** NSWDPI 31/07/2020	Potato	**250g/L product:** 24mL/ha	7	All states except Victoria*	• Apply only when numbers are excessive. • Monitor crop regularly for re-infestation and re-spray if necessary.
Methomyl **Contact/ingestion** **Group 1**	**PER84249** NSWDPI 31/07/2020	Potato	**225g/L product:** 2L/ha	NA	All states except Victoria*	• Apply as foliar spray when pest first appears. • Repeat if necessary, depending on infestation pressure.
Spirotetramat **Systemic** **Group 23**	**PER84245** NSWDPI 28/02/2020	Potato, sweet potato	400mL/ha or 40L/100L Plus Hasten Spray adjuvant as per label instructions	7	All states	• Apply by foliar application using calibrated boom sprayer. Ensure adequate penetration and coverage. • Apply as per product label instructions for each of the crops listed on this permit. • Spirotetramat is most effective on nymphs. • If pest pressure is high an initial knock down application of abamectin or bifenthrin may be required. • Apply with a minimum re-treatment interval of seven (7) days. • DO NOT apply more than three (3) treatments per crop. • DO NOT apply more than two (2) consecutive sprays of Spirotetramat before changing to an approved insecticide product from a different chemical (MoA) group.
Spinetoram **Contact/ingestion** **Group 5**	**PER84757** Hort Innovation 30/11/2020	Root and tuber vegetables	**120g/L product:** 400mL/ha **250g/kg product:** 200g/ha Apply with wetter as per label rates.	3	All states except Victoria*	• Apply as a foliar spray immediately upon discovery of the pest using boom spray. • Ensure thorough coverage of plants. • DO NOT make more than four (4) applications per crop with a minimum re-treatment interval of 7–14 days. • DO NOT apply consecutive applications of Group 4C insecticides. • DO NOT apply while bees are foraging on the crop to be treated.
Sulfoxaflor **Systemic** **Group 4**	**PER84743** Hort Innovation 31/10/2022	Root and tuber vegetables including potato and sweet potato	400mL product/ha	7	All states except Victoria*	• Apply as foliar cover spray immediately the psyllid pest is detected. • Apply a maximum of four (4) foliar applications per season, with a 7–10 day re-treatment interval between sprays. • DO NOT make more than two (2) consecutive applications per crop. • Apply in sufficient water volume to achieve through coverage of all plant foliage. • Apply using calibrated boom sprayer or equivalent equipment. • Sulfoxaflor is highly toxic to bees. DO NOT apply this product while bees are foraging in the crop to be treated (refer *Additional Conditions and product label*).

* Victoria is not included in this permit as their Control-of-Use legislation means that a permit is not required to legalise this off-label use.

4 BIOSECURITY AWARENESS AND IMPLEMENTATION

Good farm biosecurity procedures should be in place to prevent the entry, establishment and spread of pests and diseases. The Vegetable and Potato Biosecurity Program provides a range of resources available to potato growers **ausveg.com.au/biosecurity-agrichemical/biosecurity/**

TABLE 2: Generic farm biosecurity health check

Biosecurity practice	In place	In progress	No	N/A
Wash down facilities are provided on site for machinery, equipment and vehicles				
Visitor vehicle access is restricted to designated parking areas				
Only on-site vehicles are used to transport equipment and visitors around the farm				
Limit vehicle access and keep vehicle movement to a minimum				
Designated tracks are used to limit vehicle movement on growing areas				
Machinery and vehicles are cleaned before moving off property				
Footbaths and brushes are easily accessible and used				
Visitor clothing, footwear and tools are checked for soil and organic matter before entering the farm				
Staff are trained in biosecurity and farm hygiene practices				
Visitors are inducted in biosecurity expectations prior to moving around the farm				
Visitors sign a register to monitor on-farm movements				
Appropriate hygiene supplies are available to staff and visitors (hand sanitiser, gloves, foot baths, overalls)				
Contractor entry is conditional to a biosecurity induction and hygiene protocols				
Gate signs requesting phone-check in and providing owner/manager contact numbers are visible at main entrances				
Farm is divided into ‘zones’ with restricted or minimised people, machinery and equipment movement between zones				
Planting material for all crops grown are sourced from reputable suppliers				
Imported seed has been tested as per BICON conditions				
Symptom monitoring is regularly conducted in crops				
Staff are trained to recognise symptoms of disease infection				
Inspect the plants you purchase to ensure they are free of pests				
Activities and results of pest monitoring are recorded, including lack of observations				
A farm management plan is maintained for endemic pests				
Pallets are clean of organic material and soil				
Ensure that equipment, machinery and vehicles leaving the property meet industry biosecurity expectations				

5 POST FARM GATE MANAGEMENT

INTERSTATE MOVEMENT CONDITIONS CHANGE REGULARLY, CHECK THAT YOU HAVE THE LATEST REQUIREMENTS.

Interstate movement

Australia's states and territories can apply movement conditions to material that could pose a quarantine risk to their state/territory. These conditions may apply to the movement of fruit, vegetables, nursery stock, flowers, plants, and seeds, or other risk pathways such as soil, timber, vehicles and machinery.

Movement conditions are applied to manage the quarantine risk of any pests and diseases that may be present on the produce. They can include specified treatments (e.g. washing procedures or chemical treatments), inspection of produce, state or area freedom certification, or other requirements. If a suitable treatment is not available, produce may be prohibited entry into that state or territory.

When exporting quarantine risk material to another state or territory, it is the responsibility of the exporter to ensure they have met the movement conditions of the jurisdiction they are exporting to. If you intend to move produce into more than one state or territory, you must check the movement conditions for each.

Contact details and links to websites are provided on the Australian Interstate Quarantine plant quarantine regulator contacts page: **www.interstatequarantine.org.au/producers/committees/quarantine-regulators/**

TPP Quarantine Area in Western Australia

A Quarantine Area is in place to direct the movement and treatment of host plants within WA.

Prescribed treatment is required for host plants, such as seedlings or nursery stock, where they are moving from the Quarantine Area to specified local government areas in WA.

Growers should be familiar with the prescribed treatments outlined in the Quarantine Area Notice.

For full details including the published Quarantine Area Notice, additional treatment options and a list of areas in the Quarantine Area and specified local government areas, please visit **www.agric.wa.gov.au/tpp/tpp-quarantine-area**

APPENDIX 1 – Preliminary results

Department of
Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

Tomato potato psyllid

Research and development preliminary results

Factsheet

About Tomato potato psyllid (TPP)

Tomato potato psyllid (*Bactericera cockerelli*) was detected in Perth, Western Australia in February 2017.

TPP is a tiny sap-sucking insect which attacks a range of cultivated crops in the Solanaceae family including potato, tomato, eggplant, capsicum, chilli and tamarillo and weeds such as nightshade.

TPP damages plants by directly feeding on fruits with attached green material and leaves, and causes the disease psyllid yellows which can result in yellowing and stunting in tomato and potato plants.

TPP has also been identified as the vector of *Candidatus* Liberibacter solanacearum (CLso), the putative causal agent of Zebra Chip disease in potato. CLso has not been detected in Australia.

L–R: Tomato potato psyllid adults and nymphs on the back of a leaf. Mature adult TPP in comparison to a 5 cent coin.

TPP research and development

The Western Australian Department of Primary Industries and Regional Development (DPIRD) has completed a series of laboratory and glasshouse trials on the performance of insecticides and Biological Control Agents (BCA) on TPP.

An overview of preliminary trial results are outlined in this factsheet. Further research results are available in the TPP biological control and chemical control factsheets.

APPENDIX 1 – Preliminary results (cont.)

2 Tomato potato psyllid
Research and development preliminary results


© DPIRD

An Integrated Pest Management strategy (IPM) is recommended for the effective control of TPP.

What is IPM?

IPM is an approach to crop production and protection that combines the use of insecticides with other management techniques including chemical control, biological control, cultural control and physical control.

IPM provides benefits such as reduced risk of pesticide contamination, decreased production costs, reduced risk of insecticide resistance and helps preserve naturally occurring beneficials.

Monitoring and treatment decisions

- Yellow sticky traps placed at field edges near the tops of plants can be used as an indicator of psyllid movement in areas where TPP occurs.
- If adults are caught on traps, the leaves of host plants on the field edges should be examined for eggs and nymphs.
- If all life stages are present, an insecticide treatment may be warranted.
- It is recommended growers select insecticides that are compatible for use in IPM programs.
- To prevent insecticide resistance from developing in TPP populations, insecticides from different chemical classes need to be used in rotation.
- Growers should contact their chemical advisors to talk through an appropriate Insecticide Resistance Management strategy for their business.
- Insecticides are only effective against TPP and do not prevent the spread of the CLso bacterium.


© Whitney Cranshaw, Colorado State University

Preliminary research and development results

Biological control

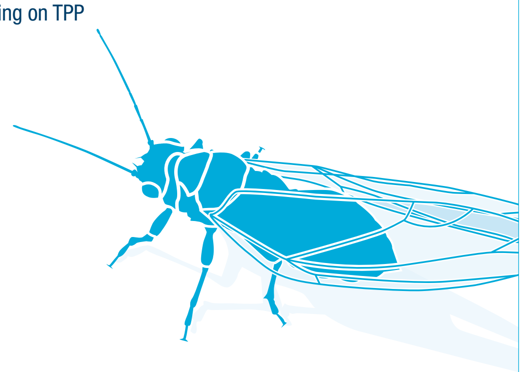
- In laboratory and glasshouse trials, several commercially-available BCA's were assessed for their performance against TPP in tomato, capsicum and potato.
- All BCAs tested are generalist predators and occur naturally in some commercial crops and regions.
- The efficiency of predators against TPP varied with host crop type.
- In laboratory trials, adult ladybird beetles *Harmonia conformis*, *Cryptolaemus montrouzieri*, and the larval stage of the green lacewing (*Mallada signata*), were most efficient predators of TPP in tomato, capsicum and potato.
- On capsicum, ladybird beetle species *H. variegata*, *H. octomaculata* and *Chlocorus circumdatus* were also effective predators of TPP.
- Three releases (at 21 day intervals) of the mirid bug *Nesidiocoris tenuis* effectively suppressed TPP populations in a glasshouse trial in tomato.

Figure 1. Most efficient predators of TPP in tomato, capsicum and potato, in laboratory trials: (A) *H. conformis* feeding on TPP eggs and foraging on capsicum leaf. (B) *C. montrouzieri* feeding on TPP nymph. (C) *M. signata* larva.

Chemical control

- Thirty insecticides from 11 chemical classes have been identified for use in Australia.
- These chemicals are registered in Australia for use against other sucking insect pests, but not currently registered for control of TPP.

  Please note: some insecticides have been made available through emergency permits for use in host crops and nursery stock.
- Resistance to imidacloprid, a neonicotinoid, and abamectin has been observed in populations of TPP in Texas and Mexico. However, resistance to these insecticides was not observed in laboratory and glasshouse trials in WA.
- Insecticides are only effective against TPP and do not prevent the spread of the CLso bacterium, associated with TPP in other parts of the world.



APPENDIX 1 – Preliminary results (cont.)

Insecticide toxicity — laboratory trials

- The toxicity of 15 pre-harvest insecticides with various modes of action were screened in capsicum, tomato and potato.
- Abamectin, spinetoram, methidathion, methomyl, chlorpyrifos, cyantraniliprole, DC-164 (experimental chemical) and sulfoxaflor caused 100% mortality to all life stages of TPP.
- Imidacloprid applied as a soil drench was toxic to TPP life stages causing significant mortality for up to 10 days post-drenching.

Insecticide efficacy — glasshouse trials

- In the glasshouse trial, three applications (at 21 day intervals) of abamectin, cyantraniliprole, and spirotetramat in capsicum, tomato and potato, and flonicamid in tomato, effectively suppressed TPP populations.
- Pymetrozine failed to suppress TPP populations in glasshouse trials in capsicum, tomato and potato.

Organically acceptable alternatives

- Azadirachtin, eco-oil, agri-50 and paraffinic oil were evaluated against TPP eggs, nymphs and adults.
- In lab trials, all plant-based derivatives (azadirachtin, eco-oil, agri-50 and paraffinic oil) were least toxic to TPP mature nymphs (3rd – 5th instar).
- Azadiractin was very toxic to TPP adults. Paraffinic oil, agri-50 and eco-oil in potato and capsicum were less toxic to TPP adults.
- Egg laying was observed with azadirachtin, agri-50, eco-oil, and paraffinic oil, though none hatched after 7 days.
- Of 13 chemicals tested against eggs, hatching was observed with spirotetramat, abamectin, methomyl, chlorpyrifos, eco-oil, paraffinic oil and azadirachtin, but none developed to adult.

SCIENTIFIC R&D IS CRITICAL TO IMPROVING OUR UNDERSTANDING OF TPP IN AUSTRALIA AND INCREASING MANAGEMENT OPTIONS AVAILABLE TO GROWERS.

Transition to management

TPP was detected in Western Australia in February 2017, prompting a comprehensive biosecurity response.

Following national agreement TPP could not be eradicated, a Transition to management plan was developed which aimed to improve the capacity of industry and growers to manage this pest and build confidence around the status of the CLso bacterium.

The TPP R&D program was a major component of the Transition to management plan.

Visit **agric.wa.gov.au/tpp** for more information on the signs and symptoms of TPP.

This factsheet is an initiative of the national TPP Transition to Management Plan.

STOP. CHECK. PROTECT.
Help limit the spread of the Tomato potato psyllid

agric.wa.gov.au/tpp

June 2018

APPENDIX 2 – Biological control results

Department of
Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

Tomato potato psyllid

Biological control results

Factsheet

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L–R: Tomato potato psyllid adults and nymphs on the back of a leaf. Mature adult TPP in comparison to a 5 cent coin.

TPP research and development

The Western Australian Department of Primary Industries and Regional Development (DPIRD) has completed a series of laboratory and glasshouse trials on the performance of insecticides and Biological Control Agents (BCA) on TPP.

Preliminary results of biological control trials are outlined in this factsheet.

APPENDIX 2 – Biological control results (cont.)

Biological control

Several commercially available beneficial insects have been identified for potential use in biological control of TPP. There were significant differences in TPP consumption between BCAs tested.

To preserve beneficials, it is recommended that growers select insecticides that are compatible for use in IPM programs.

Predators

Several species of generalist predators including lacewings, ladybirds, mirid bugs, hoverflies and predatory mites feed on nymphs and adult TPP (Table 1).

All predators feed on a range of crop pests and are naturally occurring in some areas in Australia.

Lacewings

Larvae of the brown lacewing, *Micromus tasmaniae*, feed on all stages of the psyllid and occur naturally in field crops in Australia. In New Zealand, M. *tasmaniae* has been reported to feed on TPP in unsprayed potato crops.

The larvae of the green lacewing, *Mallada signata* are predators of aphids, moth eggs and small larvae, scales and whiteflies. In laboratory experiments, late instar larvae and adults consumed all life-stages of TPP.

Nymphs appeared to be more efficient consumers of TPP than adults.

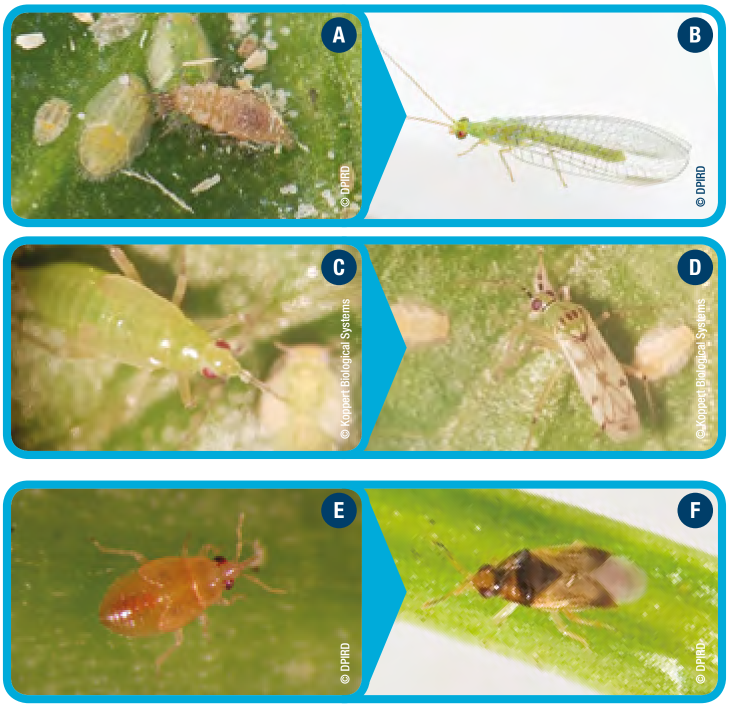


Figure 1. Green lacewing, *M. signata* (A) larva and (B) adult. (C) *N. tenuis* nymph and (D) *N. tenuis* adult. (E) *O. tantillus* nymph and (F) *O. tantillus* adult.

True Bugs

Nesidiocoris tenuis is a natural enemy of whiteflies, moth eggs and small grubs. The minute pirate bug *Orius tantillus* and *N. tenuis* are both used for control of thrips and whitefly species in greenhouse crops.

Lab experiments showed that they predated on TPP, though were not as voracious as some lady beetle species and green lacewing.

Parasitoids

Tamarixia triozae parasitises late instars of TPP and has been imported into New Zealand for further evaluation.

In Australia, no parasitoids are commercially available for the control of TPP. However, Australia is regarded to be a 'hotspot' of psyllid diversity and it is possible that naturally occurring parasitoids are present.

Table 1: A list of potential candidate BCAs present in Australia.

Scientific name	Common name	Classification	Present in Australia
Typhlodromalus limonicus (Garman & McGregor)	Mite	Acari: Mesostigmata: Phytoseiidae	Unknown
*Chilocorus circumdatus** Gyllenhal	Red Chilocorus	Coleoptera: Coccinellidae	Commercially available
*Coccinella transversalis** Fabricius	Transverse ladybird	Coleoptera: Coccinellidae	Commercially available, naturally occurring
*Cryptolaemus montrouzieri** Mulsant	Mealybug ladybird	Coleoptera: Coccinellidae	Native, commercially available
*Harmonia conformis** (Boisduval)	Large spotted ladybird	Coleoptera: Coccinellidae	Native; commercially available
*Harmonia octomaculata** (Fabricius)	Spotted ladybird	Coleoptera: Coccinellidae	Commercially available
*Hippodamia variegate** (Goeze)	Adonis ladybird	Coleoptera: Coccinellidae	Commercially available
Adalia bipunctata (L.)	Two-spotted ladybird	Coleoptera: Coccinellidae	Native to North America; naturalized in Australia
Cleobora mellyi (Mulsant)	Southern ladybird	Coleoptera: Coccinellidae	Native, wide spread in Australia
Coccinella undecimpunctata L.	Eleven-spotted ladybird	Coleoptera: Coccinellidae	Native to northern hemisphere; naturalized in Australia & New Zealand
Halmus chalybeus (Boisduval)	Steel-blue ladybird	Coleoptera: Coccinellidae	Native
Scymnus loewii Mulsant	Loew's ladybeetle	Coleoptera: Coccinellidae	Unknown
Melanostoma fasciatum (Macquart)	Small hoverfly (Fly)	Diptera: Syrphidae	Native
*Orius armatus** Gross	Minute pirate bug	Hemiptera: Anthocoridae	Native, Commercially available
*Orius tantillus** (Motschulsky	Flower bug	Hemiptera: Anthocoridae	Native, Commercially available
*Nesidocoris tenuis** Reuter	Mirid bug	Hemiptera: Miridae	Commercially available
Nabis kinbergii Reuter	Pacific damsel bug	Hemiptera: Nabidae	Native
*Mallada signata** (Schneider)	Green lacewing	Neuroptera: Chrysopidae	Native, commercially available
*Micromus tasmaniae** (Walker)	Brown lacewing	Neuroptera: Hemerobiidae	Native
Drepanacra binocula (Newman)	Hook-tipped brown lacewing	Neuroptera: Hemerobiidae	Native

* Indicates potential biological control agents present in Australia (preliminary laboratory and glasshouse study under TPP Transition to management program).

APPENDIX 2 – Biological control results (cont.)

Figure 2. Adult ladybird beetles: (A) *H. octomaculata*, (B) *H. variegata* feeding on TPP nymph (C) *H. conformis* feeding on TPP eggs and foraging on capsicum leaf, (D) *C. cirumdatus* feeding on TPP nymph, (E) *C. montrouzieri* feeding of TPP nymphs and (F). *C. transversalis* feeding on TPP nymph.

Ladybird beetles (Coleoptera: Coccinellidae)

Several species of commercially available ladybird fed on TPP adults and nymphs in lab experiments.

The large spotted ladybird *Harmonia conformis* and the mealybug ladybird *Cryptolaemus montrouzieri* were effective predators of TPP in capsicum, tomato and potato.

In addition *Hippodamia variegata*, *Harmonia octomaculata* and *Chilocorus circumdatus* also fed on TPP.

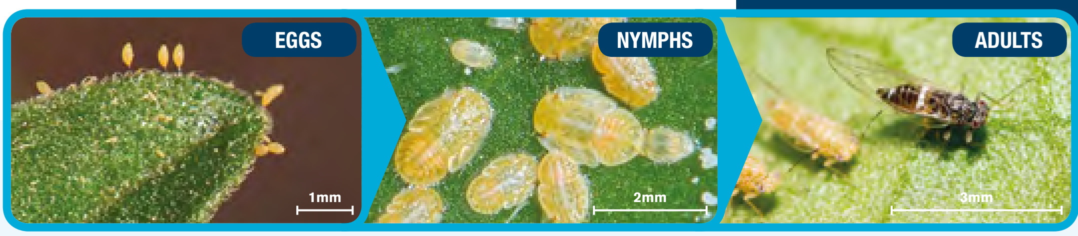
SCIENTIFIC R&D IS CRITICAL TO IMPROVING OUR UNDERSTANDING OF TPP IN AUSTRALIA AND INCREASING MANAGEMENT OPTIONS AVAILABLE TO GROWERS.

Transition to management

TPP was detected in Western Australia in February 2017, prompting a comprehensive biosecurity response.

Following national agreement TPP could not be eradicated, a Transition to management plan was developed which aimed to improve the capacity of industry and growers to manage this pest and build confidence around the status of the bacterium *Candidatus* Liberibacter solanacearum (CLso).

The TPP R&D program was a major component of the Transition to management plan.



Visit **agric.wa.gov.au/tpp** for more information on the signs and symptoms of TPP.

This factsheet is an initiative of the national TPP Transition to Management Plan.

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June 2018

APPENDIX 3 – Chemical control results

Department of
Primary Industries and
Regional Development
GOVERNMENT OF
WESTERN AUSTRALIA

Tomato potato psyllid

Chemical control results

Factsheet

About Tomato potato psyllid (TPP)

Tomato potato psyllid *(Bactericera cockerelli)* is a tiny sap-sucking insect which attacks a range of cultivated crops in the Solanaceae family including potato, tomato, eggplant, capsicum, chilli and tamarillo and weeds such as nightshade.

TPP damages plants by directly feeding on fruits with attached green material and leaves, and causes the disease psyllid yellows which can result in yellowing and stunting in tomato and potato plants.

TPP has also been identified as the vector of *Candidatus* Liberibacter solanacearum (CLso), the putative causal agent of Zebra Chip disease in potato. CLso has not been detected in Australia.

Chemical control

- In the USA, Mexico and NZ, chemical control is the most widely used technique to manage TPP/CLso.
- While conventional pesticides (all active ingredients other than biological pesticides and antimicrobial pesticides) may not kill TPP quickly enough to prevent CLso transmission, they may be useful for reducing the overall TPP population.
- A list of insecticides from different chemical classes have been identified for use in Australia, though are not currently registered specifically for control of TPP (Table 1). Note: some insecticides have been made available through emergency permits for use in host crops and nursery stock.

Continued on page 4

TPP research and development

The Western Australian Department of Primary Industries and Regional Development has completed a series of laboratory and glasshouse trials on the performance of insecticides and Biological Control Agents (BCA) on TPP.

Further research is needed to validate preliminary findings and support registration of insecticides for control of TPP by the Agricultural Pesticides and Veterinary Medicines Authority.

APPENDIX 3 – Chemical control results (cont.)

Table 1: Insecticides with potential use against TPP. Refer to the legend below this table for further information on toxicity ratings.

Active ingredient (trade name)	**Product mode of action**
Methomyl 225g/L (e.g. Lannate)	1A; Acetylcholinesterase (AChE) inhibitors
Oxamyl (Vydate L)	1A, AChE inhibitors
Methidathion 400g/L (e.g. Suprathion)	1B; AChE inhibitors
Chlorpyrifos 500g/L (Chlorpyrifos 500EC)	1B; Anti-cholinesterase compound
Alpha-cypermethrin 100g/L–250g/L (e.g. Alpha 100 Duo, Nufarm Astound Duo, BASF Fastac)	3A; Synthetic pyrethroids
Bifenthrin 250g/L (e.g. Bifenthrin 250EC; Astral™ 250EC)	3A; Synthetic pyrethroids
Deltamethrin 27.5g/L (e.g. Cropro D-sect, Decis, Deltamethrin Duo)	3A; Synthetic pyrethroids
Lambda-cyhalothrin 250g/L (e.g. Karate Zeon®)	3A; Synthetic pyrethroids
Taufluvalinate 240g/L (e.g. Mavrik®, Klartan®)	3A; Synthetic pyrethroids
Deltamethrin 20g/L and thiacloprid 150g/L (Proteus®)	3A/4A; synthetic pyrethroid, noenicitinoid
Imidacloprid 200g/L (e.g. Confidor® 200SC, Imidacloprid 200SC)	4A; NACHR competitive modulator
Sulfoxaflor 240g/L (Transform™)	4C; NACHR competitive modulators
Spinetoram 120g/L (Success Neo™)	5; NACHR allosteric modulators
Abamectin 18g/L (e.g. Vertimec®)	6; Avermectins; Chloride channel activation
Pymetrozine	9B; Chordotonal organ TRPV channel modulators
Flonicamid 500g/kg (Mainman®)	9C; Chordotonal organ modulators — undefined target site
Buprofezin (Applaud®)	16; Inhibitors of chitin biosynthesis, type 1
Spirotetramat 240g/L (Movento 240SC)	23; Acetyl choline esterase carboxylase inhibition
Cyantraniliprole 100g/L (Benevia®)	28; Ryanodine receptor modulatior
Agri-50NF	UN; MoA unknown; derived from plant extracts
Azadirachtin 10g/L (AzaMax™)	UN; uncertain MoA unknown
Emulsifiable botanical oils 850g/L (Eco-Oil®)	UN; MoA unknown
Paraffinic oil 815 g/L (Sacoa BioPest)	UN; blocks spiracles; inhibits feeding

Toxicity rating to TPP
■ Low <25%; ■ Slightly toxic 26–50%; ■ Moderately toxic 51–74%; ■ Highly toxic >75%
↓ decreases egg laying; [1] up to 7 DAT; [2] up to 14 DAT
* toxic to beneficials, but has a short residual life

Registered use	Eggs	Nymphs	Adults	Translaminar activity	IPM compatible
Tomato, capsicum				N	N
Capsicum, sweet potato, tomato	Unknown			N	N
Fruits, vegetables				N	N
Fruits, vegetables				N	N
Tomato			Unknown	N	N
Tomato, capsicum			Unknown	N	N
Outdoor tomato, sweet potato			Unknown	N	N
Tomato, potato			Unknown	N	N
Tomato			Unknown	N	N
Potato	↓[1]	Unknown		N	N
Vegetables				Y	N
Fruits, vegetables	↓[1]			Y	Y (may be toxic to parasitic wasps)
Vegetables, ornamentals	↓[1]			Y	?
Fruits, vegetables	↓			Y	N
Capsicum, eggplant, potato, tomato	↓		Unknown	Y	Y (although may not be compatible with predatory bugs and mites)
Potatoes				Y	Y
Tomato, capsicum	Unknown		Unknown	N	Y (slightly toxic to parasitic wasp; highly toxic to some lady beetles species)
Vegetables	↓[2]			Y	Y
Potato, field tomatoes	↓[2]			Y	Y
Fruits, vegetables				N	Y
Fruits, vegetables				N	Y
Vegetables, ornamentals		?		N	*
Fruits				N	*

APPENDIX 3 – Chemical control results (cont.)

- Efficacy against TPP life stages has been indicated where information is available from published literature, or laboratory and glasshouse trials. Note that insecticides may not be effective against all life stages.
- Good insecticide coverage, or translaminar activity, is important as TPP are usually found on the underside of the leaves.
- Insecticides with translaminar activity are absorbed by one side of the leaf surface so that the active ingredient is available to the untreated side.

Insecticide resistance

- Imidacloprid and abamectin are widely used to control TPP in potato and tomato crops in the USA and Mexico, with resistance in TPP populations observed in Texas and Mexico.
- Resistance to these insecticides was not observed in laboratory and glasshouse experiments in Western Australia.
- Apply at least two or three applications of each insecticide, 7–14 days apart to kill all the nymphs as most insecticides will not kill eggs.
- Follow the directions on the label.
- It is important to control psyllids on young plants as this stage is most affected by the psyllid yellows disease.
- Older plants are still vulnerable to infection by the bacterium, but the fruit that has set will still be harvestable.
- During the growing season, use insecticides from more than one insecticide group, always complete a cycle of applications with one insecticide before switching to another insecticide from a different chemical class.

Integrated Pest Management compatibility

- Many species of beneficial insects such as ladybird beetles, brown and green lacewings and hoverflies (syrphids) occur naturally.
- All are generalist predators and feed on a range of pests including aphids, whiteflies, thrips and caterpillars.
- Laboratory experiments indicate ladybird beetles and lacewings will also feed on TPP adults and nymphs.
- The compatibility of insecticides with potential use for TPP are indicated in Table 1. Note that the effect of insecticides can also vary with species and life stage.

Organically acceptable alternatives

- Azadirachtin, eco-oil, agri-50 and paraffinic oil are available commercially and have activity against TPP.
- Azadiractin was very toxic to TPP adults, paraffinic oil, agri-50 and eco-oil in potato and capsicum were less toxic to TPP adults.
- Azadirachtin, eco-oil, agri-50 and paraffinic oil were least toxic to mature nymphs (3rd-5th instar).
- Egg laying was observed with azadirachtin, agri-50, eco-oil, and paraffinic oil, though none hatched after 7 days.

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MY NOTES

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