New Zealand Code of Practice for the Management of Tomato/Potato Psyllid (TPP) in Greenhouse Tomato and Capsicum Crops

Published by: Tomatoes New Zealand Inc. and Vegetables New Zealand Inc.

3rd Edition

October 2016

Table of Contents

1. Introduction

The tomato/potato psyllid (TPP), *Bactericera cockerelli* is now a widespread pest in New Zealand (first confirmed present by Biosecurity NZ, May 2006) and is the vector for *Candidatus* Liberibacter solanacearum (*Ca.* L. solanacearum), a bacterium which causes a disease of tomato, capsicum and other Solanaceous crops including potato.

This document is the tomato and capsicum industry's Code of Practice for its greenhouse tomato and capsicum growers to manage TPP and the associated disease causing organism *Ca.* L. solanacearum.

For further information contact the Business Managers:

Tomatoes New Zealand Inc.
Helen Barnes
DDI: 04 470 5666
Mobile: 021 348 948
Email: helen.barnes@hortnz.co.nz
Website: www.tomatoesnz.co.nz

Vegetables New Zealand Inc.
John Seymour
DDI 64 4 494 9973
Mobile: 0275 437 531
Email: john.seymour@hortnz.co.nz
Website: www.vegetablesnz.co.nz

1.1 Objective

The objective of this Code of Practice is to provide guidance to growers and others in the industry for the effective, safe and responsible control of TPP in order to minimise the impact of *Ca.* L. solanacearum on production and export market access.

1.2 Scope

The Code of Practice is aimed at all producers of greenhouse tomato and capsicum crops. Use of this Code of Practice will result in a number of benefits for the industry and consumers alike. Implementation of the Code of Practice will ensure:

a. Damage to individual crops will be minimised
b. Control of the pest will be effective and sustainable
c. Management of other pests of significance in these crops will not be unduly affected
d. Current IPM practices in place remain functional and the continued supply of high quality low residue fruit to the New Zealand public and our export customers is not compromised.
e. Continuation of export of these crops.

1.3 Relevant legislation and industry standards

All relevant legislation and industry standards should be followed or adhered to in the control of TPP. For further information, refer to the following:

- New Zealand (Maximum Residue Limits of Agricultural Compounds) Food Act 2014 (http://www.foodsafety.govt.nz/elibrary/industry/register-list-mrl-agricultural-compounds.htm)
- New Zealand G.A.P or GLOBALG.A.P

- GROWSAFE®
- Other Approved Supplier or Produce Trading Partners programmes

1.4 Information on the tomato/potato psyllid (TPP)

TPP is a small phloem-feeding, winged insect about 3mm in length and resembles a miniature cicada. This pest can sometimes vector ‘psyllid yellows’ disease to a number of host plants and vectors. A new species of bacterium causing disease in Solanaceous plants has been described as belonging to the genus *Candidatus* Liberibacter. A description of the insect is found in Appendix 1 along with additional sources of information and photos of life stages and typical host plant damage. Horticulture New Zealand Inc. has published sets of identification cards and a poster, and the Ministry for Primary Industries has a link with further information and images. Refer to Appendix 1 for the relevant web links.

2. Responsibilities, training and planning

2.1 Monitoring duties and responsibilities

Greenhouse growers or managers should:

- Identify a suitably trained person (or persons) to monitor the crop.
- Establish a crop monitoring plan based on section 3.3 including the use of maps of the greenhouse unit in which row numbers and bays can be easily identified.
- Set up a pest monitoring record system, and record pest numbers, life stages, location, and actions taken.
- Undertake monitoring at least weekly, increasing in frequency to daily monitoring during periods of high pest pressure.
- Ensure that monitoring is consistent between plants and between monitoring personnel.
- Make all greenhouse staff aware of TPP and *Ca.* L. solanacearum symptoms and encourage reporting to the crop monitor of any unusual or unhealthy symptoms in the greenhouse.
- Make identification factsheets/cards and posters available to all new staff.

2.2 Training requirements

- Crop monitoring personnel must be familiar with monitoring techniques and of TPP/ *Ca.* L. solanacearum symptoms or identification.
- All greenhouse staff should be familiar with TPP and the symptoms of the disease that it can sometimes cause.
- Use quality images and easy to understand descriptions of the disease vectored by TPP. Quality symptom images facilitate more informed feedback from staff because symptoms of feeding damage can resemble other disorders.
- Ensure sufficient copies of the TPP field identification factsheets/cards are available.

2.3 Pre-planting requirements

- Only source seedlings from a supplier implementing TPP control measures during the nursery phase:
  - TPP control on young plants can be achieved by spraying or drenching with an IPM compatible insecticide. Avoid substantial run off in the days following application. Repeat if required.
- Inspect the area surrounding the greenhouse for host plants, both weeds and ornamentals (see Appendix 2). Remove and destroy host plants where possible.

2.4 Planting

- Only plant seedlings that are free of pests. If TPP are found on seedlings, destroy infected seedlings before they are introduced into the greenhouse.
- Check all other seedlings in the batch to ensure they are not infested.
- TPP control on young plants can be achieved by spraying or drenching with an IPM compatible insecticide. Repeat if required.

2.5 Crop removal and actions between cropping cycles

- Before the end of a crop, pests should be contained within the building and eliminated before the old plants are removed. This prevents pests from being spread into the environment around the outside of the greenhouse. Apply a high volume pesticide spray together with a surfactant or mineral spraying oil. Keep the greenhouse closed to ensure maximum pesticide effect before opening for plant removal.

- Remove the infected plants in a secure manner such as in covered bins to land fill or covered composting.
- Clean and disinfect the greenhouse ensuring all plant material including weeds and volunteer plants are removed and destroyed.
- Check all flying insect pests have been eradicated by hanging yellow sticky traps (at least 10/ha) and inspect regularly, preferably weekly. Fog or spray insecticide if pests are present.
- Where possible, set up a double door system at the greenhouse entrance using insect mesh (this is not practical for many settings). This is to prevent flying insects from easy access to the crop. Hang one yellow sticky trap at least every $10m^2$ in this area.

3. Key aspects of crop protection

To successfully control TPP over an extended period, various methods must be employed or control will not be reliable.

3.1 Control methods

3.1.1 Cultural practices

Cultural aspects of crop protection involve considering all of the basic growing best practice concepts to ensure optimum growing conditions for maintaining a healthy crop which has maximum resistance to pests and diseases. Consider as many of these as possible; e.g. temperature, irrigation, pH and fertility, plant spacing.

3.1.2 Hygiene

Preventing pests from entering the crop should always be a key consideration in crop management. This commences before the end of a crop to ensure low carry over of all pests and diseases refer sections 2.3-2.5, above). All crop debris should be removed from the greenhouse and immediate environment. Weed and volunteer plant removal is required to ensure no green bridge remains for hosting pests. Adequate sanitation is essential before the new crop arrives. During the cropping period ensure good hygiene practices are observed at all times. Infestations must be dealt with promptly and appropriately, and diseased plants should be removed promptly and disposed of in a secure manner.

3.1.3 Biological agents

Research on a number of new natural enemies of TPP is underway and the biocontrol organism *Tamarixia trioaze* has now been approved for use in New Zealand (2016). If agrichemicals are carefully managed, non-introduced beneficial insects found in the crop such as, predatory mites, lacewings, ladybirds, parasitic wasps and other arthropods and entomopathogenic fungi will contribute to controlling pests (their impact on TPP is not extensively researched at this stage). Refer to Appendix 4 on side effects of chemicals on natural enemies and identify the least damaging options if it is determined that spraying is required.

3.1.4 Physical methods

Exclusion of pests by screening vents and doors is not practical for many properties. However certain spray options with a physical mode of action should be considered whenever possible. Several essential oils; e.g. cedar wood and neem, deter psyllids from selecting plants for egg laying. Care should be taken when trialling oils as many are phytotoxic. Yellow sticky traps placed near vents and entranceways can be used to reduce TPP populations migrating into the greenhouse.

3.1.5 Chemicals

Pesticides (mainly insecticides) registered for use in tomato and capsicum crops are listed in section 3.5, these may not be specifically registered for the control of TPP. Care is required in selecting chemicals so that a minimum of damage is done to beneficial organisms and resistance to the pesticide is prevented. Adhere strictly to specific product advice at all times to ensure pesticide resistance is minimised. Consult crop protection specialists for advice on selection, application guidelines and rotation of products with different modes. Always ensure compliance with New Zealand Maximum Residue Limits and if exporting, those of the importing country.

Resistance management

When using agricultural chemicals growers should be aware of managing resistance. Resistance in a pest, disease or weed population can develop from repeat use of an agricultural chemical. Resistance can become an issue because of high selection pressure exerted on a pest, disease or weed population over several seasons. This is generally the result of repeated use of the same or several agricultural chemicals with the same or similar mode of action.

In order to reduce the risk of resistance the majority of agricultural chemicals have a designated IRAC/FRAC/HRAC code. This coding system is based on the mode of action of the biochemical process through which the pesticide disrupts a pest, disease or weed's biology, generally resulting in the death of the pest, disease or weed.
These codes are used as part of a resistance management strategy. By using different modes of action growers can make decisions about rotating products to avoid or delay resistance developing. The mode of action of most agricultural chemicals is generally on the label.

For further information, refer to:
http://resistance.nzpps.org/
www.irac-online.org
www.frac.info
www.hracglobal.com

3.2 Management of alternative host plants

Check plants in the area surrounding the greenhouse are not hosting TPP. Remove known host plants where possible. The host range of the TPP is said to include the plants listed in Appendix 2.

Check regularly to ensure a buffer zone remains free of host weeds. If TPP lays eggs on ornamentals that are to be maintained and cannot be removed or replaced, control these populations by selecting sprays from the list in section 3.5. Continue the practice of rotating pesticides by their mode of action groups.

3.3 Crop monitoring

It is necessary to monitor TPP populations in order to make informed decisions for their control. Monitoring TPP populations on the plants in the greenhouse is the most reliable and effective method. Yellow sticky traps may give some indication of TPP activity but currently there is insufficient information to relate trap catches with TPP populations in greenhouse crops. Yellow sticky traps can give background information on TPP activity. Yellow sticky traps if hung near vents can be used to reduce TPP populations migrating into the greenhouse.

3.3.1 Monitoring for tomato/potato psyllids (TPP)

(a) Scheduled crop monitoring

The method outlined below is based on a 4m x 8m (5 rows per 8m span) structural module common in many multispan Venlo style greenhouses, but can readily be adapted to suit other structures for example, capsicum greenhouses have 5 or 6 rows per bay. The 4m sections between poles along the row are a designated sampling unit. Each sampling unit will contain approximately 15 tomato stems or >40 capsicum stems.

Monitoring is based on searching for TPP eggs, sugars or excretions as a way of detecting infestations:

- Monitor at least weekly – more frequent monitoring is recommended during times of high pest pressure.
- Each week, sample 1 row per 4-8 metre bay and alternate the rows (1 through to 5) between weeks so that all rows are monitored over a 5-week period. Alternatively, whole rows may be inspected so that each plant in the facility is visited 5 times in a 2-week period.
- Monitor the plant between poles which is showing eggs or the most TPP sugars.
- If no eggs or sugars are seen, monitor a plant at random within a 4m bay or row.
- Concentrate on monitoring the top section of capsicum plants and middle section of tomato plants. TPP outbreaks are easily identifiable by eggs on the leaf lamina or at advanced stage of infection by the sugars.
- Score the TPP infestation:
  0 no TPP present
  1 adults only
  2 adults and eggs
  3 adults, eggs and nymphs (on 1 -5 leaves)
  4 adults, eggs and nymphs (on > 5 leaves)
  5 TPP infestation on adjacent plants
- Using the 4 metre section method approximately 1 in 60 - 65 plant stems should be examined in each monitoring period.
- Not all plants infected with Ca. L. solanacearum show disease symptoms, however these may be detected during scheduled crop monitoring.
  - Record and then remove all plants showing yellowing symptoms associated with the *Ca.* L. solanacearum disease in each sampling section.
  - Any plants showing *Ca.* L. solanacearum symptoms anywhere in the greenhouse should also be removed.
- If the symptoms are not expressed strongly, plant samples may be sent for testing for Ca. L. solanacearum.
- Make control action decisions as described in section 3.3.2.

(b) Monitoring yellow sticky traps

Yellow sticky traps are not a formal part of the monitoring programme, as there is currently not enough information to relate trap catches with action thresholds. However, they can be useful for giving a quick assessment of comparative TPP activity in greenhouses for given periods.

It is suggested that sticky traps are monitored and replaced weekly inside and outside the greenhouse in north, south, east and west positions (See sections 2.5). Caution is required in interpreting results from sticky yellow traps from outside the greenhouse as other psyllid species may also be present and these may be difficult to distinguish from TPP adults.

(c) Monitoring by staff while working the crop

In addition to specific crop monitoring activities, described in 3.3.1. (a), all greenhouse staff should be trained to look for and recognise TPP and their symptoms while working the crop. It is suggested that a reward system be instigated as an incentive for extra vigilance.

All staff working in the crops must be able to recognise all the life cycle stages of TPP and to report suspected TPP infestations to crop monitors. This is extremely important at the initial stages of the TPP infestation when numbers of TPP in greenhouses may be very low.

This informal monitoring by crop working staff is a very important component of crop monitoring and should be incorporated into the monitoring programme.

(d) Monitoring for other pest and diseases

TPP monitoring can be incorporated into the other pest and disease monitoring. It is suggested that each plant that is selected to be monitored for TPP is also used for monitoring whitefly and other pests and biological control agents.

3.3.2 Guidelines for action thresholds for TPP control

The guidelines for action thresholds are described below and are only indicative – they are based on grower experience and have not yet been scientifically validated.

Monitoring will give growers two values: the proportion sample infested with TPP and a value from 1 - 5 indicating the severity of the infestations. Both values need to be taken into account when defining the required action. In general growers should take the action that applies to the highest of the value or percentage. For example, if the percentage value is <1% but the level of infestation is >1.8, then a full insecticide application should be made.

Table 1: Suggested action thresholds

Percentage of sample infested with TPP	Value indicating level of TPP infestation	Action
0	0	No action
<1%	<1.5	Remove infected leaves
1-2%	1.5-1.8	Spot spray insecticides
>2%	>1.8	Full insecticide application

Note: These guidelines are only indicative and will require adjustment by individual growers to meet their particular requirements.

3.3.3 Control actions

Removal of infected leaves

At very low infestation levels, TPP may be controlled by removing infested leaves. These leaves should be placed directly into plastic bags, sealed and disposed of in a safe manner.

Spot spraying

When spot spraying is to be undertaken further monitoring of plants and rows around the identified infested area should be undertaken to more accurately define the section of greenhouse that needs to be treated by spot spraying.

Monitoring hot spots

Experienced growers can often determine areas in their greenhouse where the initial TPP infestations occur. Extra monitoring in these areas will give additional information. It has been reported that TPP preferentially attack plants that have previously been infested with TPP. Marking and monitoring these plants may also give additional information.

3.3.4 Records - TPP/ Ca. L. solanacearum summary sheet

Monthly data sheets can be used to summarise: TPP monitoring, control actions and *Ca.* L. solanacearum infestations (see Appendix 3 for an example of a monthly recording sheet, note a nil detection must still be recorded). A separate sheet should be used for each greenhouse on the property. This summary sheet records:

Weed hosts:

Surveying the property for weeds that are host plants for TPP and recording actions to remove these alternate host plants (See Appendix 2 for list of weed host plants).

Neighbouring crops:

The location of neighbouring crops that host TPP and control strategies.

Yellow sticky traps:

Total TPP caught on sticky traps inside and outside the greenhouse.

Plant monitoring for TPP

Counts of the number of plants monitored, percent of plant infested with TPP, the mean TPP score and the control actions taken in response to the monitoring for each period.

Plant monitoring for *Ca.* L. solanacearum

Counts of the number of plants showing *Ca.* L. solanacearum symptoms and the response including the number of plants removed.

Insecticide application

Record all insecticides applied for both the control of TPP and other pests. This data will include product used, active ingredient, concentration, water rate and method of application.

3.4 Consideration of other pests, pollinators and natural enemies.

Many methods of controlling plant pests are not selective to the pest and can kill beneficial insects. Consideration the role of pollinators in a crop and the importance of maintaining populations of natural enemies such as parasitic wasps and predators. If bumblebees or biological control agents are being caught on yellow sticky traps in substantial numbers, either reduce trap density or change the trap position relative to the height of the crop.

Sprays with a contact mode of action should also be used with care as these can also reduce the role beneficial organisms' play in the control of TPP and other important pests (See Appendix 4).

3.5 Plant protection products

Adult and nymphal life stages of TPP cause damage to the host plants and transmit the bacterial pathogen '*Candidatus* Liberibacter solanacearum'. This leads to reduced crop yield and ultimately the premature decline and death of the infected plant.

TPP has numerous natural enemies in New Zealand in the form of predators, parasites and pathogenic fungi. Long term control of this pest will be best accomplished by utilising as many deterrent options as possible and supported by chemical use when required.

At all times adhere to pest management best-practice including:

- Seek up-to-date advice on pest management options.
- Implement cultural and biological control options where available.
- Utilise non-chemical methods to suppress pests as part of the management.
- Use sound monitoring procedures and action thresholds.
- Apply insecticides only when necessary.
- Use appropriate, adequately maintained spray equipment.

- Spot spray infested areas whenever feasible. Commence spraying from a low infestation area and progress towards the ‘hot spot’ or towards a greenhouse wall to avoid dispersing the pest.
- Preserve natural enemies of plant pests by using selective products when possible. Refer to Appendix 4 for side effects of chemicals on beneficial organisms.
- Report poor control of an insecticide to a crop protection advisor.
- Do not use the same spray on successive generations of the pest.
- Rotate active ingredients with different Mode of Action Classifications.
- Ensure that the relevant MRL is not exceeded at time of harvest (Table 2).

Many insecticides act on the nervous system of the pest but do not necessarily target the same site within the nervous system. Thus there are different groups affecting the nervous system, some inhibiting metabolic processes, others are feeding blockers or inhibitors of cuticle synthesis. For more detailed information, refer to IRAC website: www.irac-online.org.

Insecticides registered for use in greenhouse crops (capsicums and tomatoes) and off-label in New Zealand are included in Table 2. Some of the listed chemicals do not have a label claim for TPP. Off-label use is legal in New Zealand and the Food Act requires that all crops produced in New Zealand comply with the MRL standard and it is considered illegal to sell food with residues above the MRL.

Note: Residue compliance information for Tomatoes NZ Inc.
Tomatoes NZ Inc. requested Market Access Solutionz develop industrywide residue compliance guidelines. This compliance information is intended to benefit both domestic and export growers by ensuring easily accessible (and current) MRL (maximum residue limit) and WHP (with-holding period) information is available. These guidelines also indicate where WHP information is not known. Where this is the case, growers are encouraged to exercise caution around the use of these products (in terms of application timing etc). This information is specific to fresh tomatoes grown under glass and excludes field grown tomatoes. It is the grower’s duty to read and follow labels and controls and meet to meet the required domestic and export MRLs. Some NZ MRLs for older pesticides have been set to cover "vegetables or fruiting vegetables" in general and may no longer reflect current Good Agricultural Practice. For some compounds, greenhouse tomato label claims do not exist and efficacy, phytotoxicity / plant safety etc need to be considered when using these products, off label uses are not illegal unless registration conditions state otherwise and provided residues comply with the NZ MRL.

References:

- ACVM Label database: https://eatsafe.nzfsa.govt.nz/web/public/acvm-register
- MPI MRL Standard: www.foodsafety.govt.nz/elibrary/industry/register-list-mrl-agricultural-compounds.htm
- MRLs: https://pxmrl.maf.govt.nz/Default.aspx
- EPA controls database: www.epa.govt.nz/search-databases/Pages/controls-search.aspx

Table 2: Insecticides used by tomato and capsicum greenhouse growers (not necessarily efficacious for TPP unless indicated by a label claim)

The information contained in this table was correct at the time of collation (April 2016) and has been modified to include indoor capsicums. This document should be read in conjunction with the NZ G.A.P document 'Guideline for off label use of agrichemicals in Horticulture'.

Active Ingredient	Trade name examples	Agrichemical group	IRAC	Registered on indoor tomato?	Tomato / crop group NZ MRL (mg/kg)	Registered for indoor capsicums?	Capsicum NZ MRL (mg/kg)	NZ WHP (days)
ABAMECTIN**	Apostle, Avid, Verdex	Avermectin***	6	Y	0.1{48}	N	0.10	3 (Toms) (Caps -unknown)
ACRINATHRIN & ABAMECTIN**	Tripsol	Synthetic Pyrethroid and Avermectin***	3A and 6	Y	0.10	N	0.10	3 (Toms) (Caps -unknown)
ALPHA-CYPERMETHRIN	Bestseller 100EC, Cypher, Dominex PC100	Synthetic Pyrethroid***	3	N (Y – outdoor)	0.10	N	0.10	off-label
AZADIRACHTIN	Naturally Neem, Neem Azal-T/S; Neem 600 WP	Biological***	n/a	Y	exempt	Y	exempt	not required
BEAUVERIA BASSIANA	Contego BB, Beaugenic, Beaublast	Biological	n/a	Y	exempt	Y	exempt	not required
BIFENTHRIN	Disect 100 EC, Talstar 80SC, Venom	Synthetic Pyrethroid***	3	N (Y – outdoor)	0.05	N	0.10	off-label
BUPROFEZIN	Applaud 40SC, Buprimax, Mortar, Ovation 50 WDG, Pilan 25WP	Thiadiazine***	16	Y	0.50	Y	0.50	3 (Toms and Caps)
CYANTRANILIPROLE**	DuPont Benevia insecticide, DuPont Exirel insecticide	Anthranilic diamide***	28	N (Y – outdoor)	0.10	N	0.10	off-label
DELTAMETHRIN	Ballistic Insecticide, Decis Forte, Deltaphar 25EC, Proteus	Synthetic Pyrethroid***	3	N (Y – outdoor)	0.05 {7}	N	0.10	off-label
DICHLORVOS	Divap, Nuvos	Organophosphate***	1	Y	2.00	Y	2.00	3 (Toms and Caps)
ESFENVALERATE	Sumi-alpha	Synthetic Pyrethroid***	3	N (Y – outdoor)	0.20 {63}	N	0.10	off-label
FATTY ACIDS (K SALTS)	Mite Killer, Natures Way Insect & Mite Spray, Protector	Fatty acids***	n/a	N	exempt	N	exempt	not required
FENPYROXIMATE	Fenamite	METI acaricide and insecticide	21A	N	0.10	N	0.10	off-label
FIPRONIL	Albatross 200 SC Insecticide, Ascend, Kalas, Recoil	Phenyl pyrazole***	2	N	0.10	N	0.10	off-label
HEXYTHIAZOX	Nissuron	Tetrazine	10A	N	0.10	N	0.10	off-label

IMIDACLOPRID	Acclaim, Confidor, Gaucho, Gaucho Clear, Kohinor 350 Insecticide, Nuprid 350SC, Nuprid 600 FS, Pilarking, Sombrero 600 Seed Dressing	Chloronicotinyl***	4	N	0.10	N	0.10	off-label
LAMBDA-CYHALOTHRIN**	Cyhella, Dovetail, Halex, Karate, Zeon	Synthetic Pyrethroid***	3	N	0.10	N	0.10	off-label
LUFENURON**	Match, Nuron	Benzoylurea***	15	N	0.10	N	0.10	off-label
METHOMYL	Orion Methomyl, Lannate L	Carbamate***	1A	Y	0.50 {35}	Y	0.50 {35}	2 (Toms and Caps)
MINERAL and NON MINERAL OILS	Caltex D-C Tron Plus Spray Oil, Caltex D-C-Tron NR (Spray Oil), D-C-Tron Plus (Organic) Spray Oil, Excel Oil, Excel Spring Oil, NO Insects Super Spraying Oil, NO Insects Super Spraying Oil Ready-To-Use, Watkins Insect Spraying Oil, Eco-oil, Addit	Natural and mineral oil***	n/a	N	0.10	N	0.10	off-label
OXAMYL	Vydate L	Carbamate***	1	N	0.10	N	0.10	off-label
PERMETHRIN	Ambush, Attack (+pirimiphos methyl), Permigas (+pyrethrin) [1]	Synthetic Pyrethroid***	3	Y	0.50 {7}	Y	0.50 {7}	3 (Toms and Caps)
PIRIMIPHOS-METHYL	Actellic 50EC, Actellic Dust, Actellic Smoke Generator, Target (Attack, Ambush see Permethrin)	Carbamate ***	1 and 3	Y[1]	1.00	N	1.00	3 (Toms) (Caps-unknown)
POLYSACCHARIDES-PLANT EXTRACTS**	Agri-50NF	n/a	n/a	Y	exempt	Y	exempt	not required
PYMETROZINE	Chess WG	Pyridine azomethine***	9	Y	0.50	N	0.10	3 (Toms) (Caps-unknown)
PYRETHRIN	Garlic & Pyrethrum Insecticide Concentrate, Floragas, Greenseals Pyrethrum, Key Pyrethrum, Permigas (refer to Permethrin), Pestigas, Pyganic, Pyradym, Yates Natures Way Pyrethrum	Pyrethroid***	3	Y	1.00	Y	1.00	1 (Toms and Caps)
SPINETORAM””	Sparta	Spinosyn	5	N (Y – outdoor)	0.02 {62}	N	0.10	off-label
SPINOSAD**	Entrust Naturalyte Insect Control, Nursery Success Naturalyte, Success *Naturalyte* Insect Control, Yates Success Naturalyte, Yates Tomato Dust	Spinosyn***	5	N (Y – outdoor)	0.05 {60}	N	0.10	off-label
SPIROMESIFEN**	Oberon	Tetronic and Tetramic acid derivatives***	23	Y	0.50	Y	1.0	1(Toms and Caps)
SPIROTETRAMAT**	Movento	Tetronic and Tetramic acid derivatives***	23	N (Y – outdoor)	0.30 {90}	N	0.10	off-label

[1] Refer to label claim for Ambush or Attack

THIACLOPRID**	Alpasso, Calypso, Proteus, Topstar	Chloronicotinyl***	4	N	0.10	N	0.10	off-label

Disclaimer: This document is not a legal instrument or advice. This information is solely based on domestic and internationally sourced data. While this information is based on the best data available, and has been collated with care, it is not possible to guarantee the accuracy of this information and is intended for reference only. For this reason, and because of variations in G.A.P, climatic conditions etc, Market Access Solutionz does not accept any responsibility or liability in respect of loss or damage arising from the use or misuse of information contained in this document. Growers must ensure that their use of agrichemicals is in accordance with NZ regulations including MRLs. It is the responsibility of exporters to comply with importing country legal requirements. Market Access Solutionz strongly recommends growers verify this information through residue tests before harvest. In addition, MRLs can be changed or updated without notice. No guarantees can be given that export MRLs will not be exceeded in all instances. It is therefore strongly recommended that this information be used in conjunction with residue monitoring to try and avoid residue breaches.

Key	
Off-label	use is off label as no WHP has been assessed
Not required	WHP is not required as the active is exempt from MRLs
Exempt	active is exempt from the requirements to set an MRL
IRAC	Insecticide Resistance Action Committee is a specialist technical group of the industry association CropLife International who provide insecticide resistance management guidelines. Further information can be found here: www.irac-online.org/modes-of-action/ (refer to the resistance management tab).
**	label claim for TPP or psyllids – may not be for tomatoes or capsicums.
***	used by Solanaceous crop growers for TPP control (MAS, 2016)
Notes: The residue definition notes below are taken directly from the MPI website - see explanatory text tab	
7	Sum of isomers or enantiomers or diasteriomers
48	Sum of parent B1a, B1b components and their 8,9-Z isomers
60	Sum of spinosyn A and spinosyn D
62	Sum of spinosyn J and spinosyn L
63	As fenvalerate (sum of isomers), any ratio of RR, SS, RS & SR isomers
90	Sum of parent and its -enol metabolite

3.6 Advice on effective application of insecticides

One of the most important factors in psyllid control is ensuring thorough coverage of the plants. TPP are usually found at the base of the plant, and often on the undersides of leaves throughout the canopy. This means that it can be difficult for agrichemicals to reach TPP on mature crops.

Whenever insecticides are applied attention to equipment set up is crucial to achieving good control. As an example, for targeting both sides of the leaf surface a boom spray with fan nozzles (03F80) 30cm apart, 45^{o} upward from horizontal at a pressure setting of 2.5 – 3.0 bar and ground speed of one metre per second is efficient. For targeting underside of leaves only, a cone nozzle angled under the leaf may be more appropriate. Use spray sensitive paper placed in target ones to confirm adequate insecticide coverage.

To ensure thorough spray coverage of plants growers should **use sufficient water rates.**
The **addition of appropriate adjuvants** and the use of products with trans-laminar or systemic properties (i.e. products which spread through the leaf) should help to improve control. It is also important to **check the pH of the tank water** to ensure agrichemicals do not lose activity due to hydrolysis.

3.7 Insecticide application records (information on Appendix 5 - auditable section for export to Japan)

Record all details of spray applications for TPP in a spray diary (also note a nil detection must be recorded in Appendix 3 – plant monitoring for psyllids, if none are detected). These may include the operator's name, chemical used, dilution rates of active ingredients and additives, total volume, pressure, temperature and other relevant environmental data (Appendix 5). Obtain comments from the crop monitor after spraying, on efficacy of each spray and be guided by past results when deciding on conditions for a repeat spray if required.

3.8 Best practice where vectors are involved

- Work with neighbours, where applicable, to achieve low TPP numbers in the greenhouse vicinity.
- Control TPP in the crop to low levels using IPM best practice.
- Aggressive management of infected plants reduces the risk of disease spread within the crop. Rouge out infected plants, place in plastic bags and bury or burn them promptly.

4. Summary of recommendations for minimising TPP and other insect levels in crops

- Ensure all staff and visitors are instructed in compulsory growing-site hygiene practices.

- Plant good quality pest-free seedlings.

- Use pest resistant cultivars where possible.

- Ensure growing best practice in plant care, irrigation, plant nutrition and environmental control.

- Use biological control options for pest and disease management whenever possible.

- Choose spray options that have a non-toxic physical mode of action where available.

- Ensure as many staff as possible can recognise key pests and diseases so that prompt remedial actions can be taken to minimise impact on yield and quality.

- Maintain robust crop monitoring procedures with strict routines and evaluation of records.

- Take pest control actions in accordance with pest monitoring records and/or recommended thresholds.

- Choose agrichemicals with care targeting least side effects on beneficial insects including bumblebees and adequate rotation of classes of mode of action to prevent insecticide resistance. Ensure withholding periods can be realised before the next harvest day. Keep records of all treatments.

- Check the selection of spray equipment is appropriate, settings, calibration and active ingredient dilution rate. Ensure good target coverage is achieved during each spray session. Moisture sensitive paper can be used to confirm coverage.

Appendix 1: Life cycle and pest ID

The tomato/potato psyllid (TPP), *Bactericera cockerelli* (Homoptera: Psyllidae) is a Hemipteran insect measuring 2-3 millimetres (mm) with piercing-sucking mouthparts that enables this pest to feed on the phloem of its host plants. It undergoes incomplete metamorphosis: egg, nymph and adult.

Eggs are oval, small and attached to the leaves by a short stalk which would require magnification for identification but quite noticeable when on the leaf edges. Eggs are yellow when first laid and turn orange prior to emergence of the first nymphal stage. Eggs are hatched between 4 to 5 days after being laid.

The nymph passes five scale-like nymphal stages requiring between 12-21 days. The nymph looks much like a scale insect or a large whitefly scale and grows to 2 mm. It is flat and has a fringe of spines around the edges. Within this stage, it changes from light yellow to tan then to greenish brown. However, wing buds appear at the 3rd nymphal stage and becomes very apparent at the 4th and 5th stages. The wing buds of the psyllid nymph distinguish it from the whitefly nymph.

Adult psyllids are winged and resemble tiny cicadas. They are yellowish or greenish as they emerge and turn dark green or brown as they mature with white stripes on the thorax and head after 5 days. The psyllids are seen in aggregates feeding and mating on the leaves of host plants and mate more than once. After mating, female psyllids lay eggs on any part of the leaves. A single female is capable of laying up to 510 eggs in its lifetime.

Psyllid total development occurs between 15.5^{o}C and 32.2^{o}C with optimum development occurring at 26.6^{o}C. In a greenhouse environment averaging at 18^{o}C, psyllid takes 33 days to complete its life cycle.

Sources of additional information:

http://www.biosecurity.govt.nz/pests/potato-tomato-psyllid

http://www.biosecurity.govt.nz/pests/potato-tomato-psyllid/photos

http://www.tomatoesnz.co.nz/hot-topics/sff-psyllid/

Insecticide research notes:

Note:
The efficacy of 11 insecticides was tested against nymphal and adult stages of TPP on capsicum plants (Page-Weir, 2010). Residues of abamectin + oil and bifenthrin were the most effective at reducing adult TPP up to 3 days after treatment, while thiacloprid, spiromesifen, imidacloprid, spinetoram and azadirachtin were slightly toxic. Residues of buprofezin + oil, pyrethrin + oil and mineral oil had no effect on adult mortality. Nymphal life stages were best controlled with abamectin + oil, spirotetramat, bifenthrin and spiromesifen. (some of these chemicals are not registered for use on either tomatoes and/or capsicums) https://www.nzpps.org/journal/64/nzpp_642760.pdf

Note:
In 2011, some research was conducted on the efficacy of essential oils (Walker, 2011).

The repellency and oviposition deterrent effects of 10 essential oils (Cedarwood. Lemongrass, Cinnamon, Wintergreen, Rosemary, Peppermint, Clove, Patchouli, D-limolene and Neem), to female TPP adults were tested on capsicum leaves in a no-choice laboratory bioassay. One hour after treatment, Neem and Cedarwood had significantly repelled female TPP adults compared with the untreated controls. Twenty-four hours after treatment, Peppermint, Clove, Patchouli, Wintergreen and Neem showed some repellency to female TPP adults compared with the untreated controls (but this was not significant). By 48 h, Neem and Patchouli had shown significant repellency to female TPP adults and all oils except Peppermint, Clove and Lemongrass had significantly deterred oviposition by female TPP adults as compared with the untreated controls. Further tests of these oils, including their antifeedant properties, are required to determine their effectiveness in reducing crop damage caused by TPP/*Ca*. L. solanacearum and their suitability for incorporation into an IPM programme.

http://www.tomatoesnz.co.nz/hot-topics/sff-psyllid/

Note:
In 2010, a potted plant bioassay was carried out to determine the efficacy of four selected soft chemicals (PS2, Agri-50 NF®, Eco-oil® and Excel Oil ®) applied at the manufacturer's recommended field rate, to control tomato/potato psyllid nymphs (Walker, 2010). The recorded mortality of tomato/potato psyllid nymphs 168 h after spraying with Ecooil, PS2, Excel Oil and Agri-50NF, was 58%, 50%, 48% and 33%, respectively. Further tests may be required to determine the efficacy of these chemicals under greenhouse conditions.
http://www.tomatoesnz.co.nz/hot-topics/sff-psyllid/

Appendix 2: Host plants for the tomato/potato psyllid (TPP)

Adult TPP can be found on many plants, especially in summer when they are migrating. Although they may be able to feed on a wide range of plants they can only reproduce only on some members of the Solanaceae and Convolvulaceae families.

In addition to the host plants listed in the table, the psyllid probably breeds on chilli. Overseas it has been found breeding on field bindweed (*Convolvulus arvensis*) and morning glory (*Ipomoea purpurea*) (Convolvulaceae) and tobacco and black nightshade (*Solanum nigrum*) (Solanaceae). However, overseas information must be confirmed locally. For example, we have found that black nightshade (sometimes called deadly nightshade) in not a breeding host plant in New Zealand. Adults may lay eggs on the plant, but all nymphs die.

Table: Plants on which TPP can breed in New Zealand. Plants that support large populations of the psyllid are indicated with an asterisk.

Family Name	***Crop/weed***	***Common name***	***Scientific name***
Convolvulaceae	Crop	Kumara	*Ipomoea batatas*
Solanaceae	Crop	Capsicum*	*Capsicum annuum*
	Crop	Eggplant*	*Solanum melongena*
	Weed	Poroporo	*Solanum aviculare* and probably *S. laciniatum*
	Crop	Potato*	*Solanum tuberosum*
	Crop	Tamarillo	*Solanum betaceum*
	Crop	Tomato*	*Solanum lycopersicum*
	Weed	Thorn apple	*Datura stramonium*
	Weed	Apple of Peru	*Nicandra physalodes*

Appendix 3: Monthly TPP / *Ca.* L. solanacearum record summary sheet example.

(Spray records for TPP are auditable for export to Japan, see Appendix 5)

Date	
Greenhouse/unit	
Size	
Crop	
Cultivar	
Number of plants	
Planted	
Pull out	
Export/no export	

Weed host survey		
	Found	Action
Apple of Peru		
Thorn apple		
Bindweed		
Nightshade*		
Other host		

Presence of alternative crop host in locality			
Crop	Stage	Location	Strategy
Potato			
Tomato			
Capsicum			
Tamarillo			
other			

Yellow sticky traps - psyllids			
Outside	Total 1-4	Inside	Total 1-4
Week 1		Week 1	
Week 2		Week 2	
Week 3		Week 3	
Week 4		Week 4	

Plant monitoring for psyllids**								
	Number sampled	% plants infested	Total score	Mean score per Plant sampled	Response		Spray action	
					No action	Leaf cull	Spot	House
Week 1								
Week 2								
Week 3								
Week 4								

Plant monitoring for Ca. L. solanacearum			
	Number plants showing symptoms	Response	
		Plants removed	Other
Week 1			
Week 2			
Week 3			
Week 4			

Full house insecticide applications (link to spray records for TPP Appendix 5)							
	Applied for psyllids	Applied for other pests	Product	Active ingredient	Concentration	Water rate	Application method
Week 1							
Week 2							
Week 3							
Week 4							

**A nil detection must be recorded

Appendix 4: Toxicity of specific chemicals to natural enemies

Insecticide active ingredient	Bumble Bees (2)		Predatory Mites (1)						Parasitoids (1)			
			Amblyseius cucumeris		*Phytoseiulus persimillis*		*Hypoaspis miles*		*Aphidius* spp.		*Encarsia formosa*	
	Tox	**Per**	**Tox**	**Per**	**Tox**	**Per**	**Tox**	**Per**	**Tox**	**Per**	**Tox**	**Per**
Abamectin	B	72 h	2	5d	4	1w	2	5d	4	1w	3	5d
Alpha-cypermethrin	C	-	4	>8W	4	>8w	3	-	4	-	4	>8w
Buprofezin	A	-	1	-	2	-	1	-	1	1w	1	-
Deltamethrin	B	72h	4	>8w	4	>8w	4	>8w	4	>8w	4	>8w
Dichlorvos	B	36h	4	3d	4	1w	4	-	4	-	4	1w
Fenpyroximate	B	36h	4	-	4	>8w	3	>8w	3	-	1	-
Imidacloripid	C	-	4	-	3	-	4	-	4	-	4	-
Lamba-cyalothrin	C	-	4	>8w	4	>8w	4	>8w	4	>8w	4	>8w
Methomyl	B	72h	4	-	4	1w	4	-	4	-	4	-
Oxamyl	C	-	4	8w	4	>8w	3	-	4	>8w	4	>8w
Permethrin	C	-	4	>8w	4	>8w	4	>8W	4	>8w	4	>8W
Pirimicarb	B	24h	3	3d	2	3d	1	-	1	-	2	3d
Pirimiphos-methyl	C	-	3	3d	2	3d	1	-	1	-	2	3d
Pymetrozine	A	-	1	-	2	-	2	-	2	-	1	-
Pyriproxifen	A	-	1	-	2	-	1	-	1	-	1	-
Spinetoram	-	-	-	-	-	-	-	-	-	-	-	-
Spinosad	B	24h	1	-	1	-	1	-	3	-	3	1w
Spiromesifen	A	-	2	-	3	-	1	-	-	-	-	-
Spirotetramat	-	-	-	-	-	-	-	-	-	-	-	-
Thiacloprid	B	24h	-	-	3	2w	3	-	3	-	3	-

Note 1: The side effects of insecticides are classified into four categories according to IOBC/WPRS classification:

Class	Toxicity	Percentage death or reduction of parasitism capacity
1	Non-toxic	<25 death
2	Slightly toxic	25-50% death
3	Moderately toxic	50-75 death
4	Toxic	> 75% death

Pesticides residual effects:
For beneficial organisms, the residual period or persistence (Per) is given in days (d), weeks (w), or Hours (h). A hyphen (-) signifies that the information is not available. "More than" (>) signifies that the indicated residual period is a strict minimum.

Note 2: The side effects on bumblebees (*Bombus spp*.) are described in 3 classes:

Class	Advice
A	Can be used in combination with bumblebees
B	Remove the bumblebees hive before product application and until after the indicated persistence period
C	Do not use in combination with bumblebees

Bumblebee hives must be removed from the greenhouse before the application and not returned until after the indicated persistence period for class B. Hives can be removed for a maximum period of 72 hours before tomato pollination is affected.

Sources of additional information:

www.iobc.ch/2005/IOBC_Pesticide Database_Toolbox.pdf
www.koppert.nl/e0110.html
www.biobest.be
www.goodbugs.org.au

Appendix 5: Spray records for TPP (refer section 3.7 and Appendix 3) (This appendix only is auditable for export to Japan)

(Production sites may have differing spray record formats but should contain the criteria outlined in the two example records and a nil detection outcome of monitoring must also be recorded in the comments section of the spray record e.g. monitoring as per CoP – no TPP detected)

Example 1

SPRAY RECORD											
Block ID___				Crop variety___			Other comments: e.g. monitoring as per CoP – no TPP detected___				
Date	Operator Name	Chemical plus additives	Active ingredient	Dilution rate liters/100L or grams/100L	Spray Rate (L/ha)	Nozzle Selection & set up	Total volume of spray	Spray Pressure (kPa)	Air Temp (°C)	Air Humidity (%RH)**	Effect on Pest

**only if a requirement of application as stated on pesticide label

Example 2

SPRAY RECORD												
Target Details e.g. monitoring as per CoP – no TPP detected					**Application Rate & Sprayer:** ___ **Technical Authorisation:** ___						**CCP Chemical Name & Number**	
Date	Product Name	G/H sprayed	Pest targeted	Time	Product Rate per 100 Litres	Litres of Water used	Spray Unit & Tank Number Used	Sprayers Name	Supervisors Signature	W/H Period - Days	Chemical Name	UN #
							Tank#, Spray Unit					