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The phenology of, and efficacy of insecticides against, the Tomato/Potato Psyllid (*Bactericera cockerelli*) in tamarillos

Page-Weir NEM, Jamieson LE, Chhagan A, Curtis C

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Page-Weir NEM, Jamieson LE, Chhagan A, Curtis C

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This report has been approved by:

Lisa Jamieson
Scientist, Biocontrol & Northern Entomology
Date: 10 August 2010

Louise Malone
Science Group Leader, BioProtection – Applied Entomology
Date: 10 August 2010

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Executive summary

The phenology of, and efficacy of insecticides against, the Tomato/Potato Psyllid (*Bactericera cockerelli*) in tamarillos

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Background

The Tomato/Potato Psyllid (*Bactericera cockerelli*: TPP) was first identified in New Zealand in 2006. Both the adult and nymphal life stages of TPP cause damage to the host plants by feeding on the leaves, which results in 'psyllid yellows' as seen in tomatoes and potatoes. TPP transmits the bacterial pathogen *Candidatus* Liberibacter solanacearum, which is thought to be the causative agent of 'zebra chip' in potato tubers and stunted growth in fruit and leaves in tomatoes, capsicums and tamarillos.

Liberibacter infection not only reduces crop yield and impacts on the quality of the fruit but ultimately also leads to the decline and death of the infected plant.

This report outlines the progress so far of two ongoing investigations:

1. Phenology of Tomato/Potato Psyllid (*Bactericera cockerelli*) in tamarillo orchards
2. Susceptibility of different life stages of Tomato/Potato Psyllid (*Bactericera cockerelli)* to insecticides.

Methods

Phenology

Four blocks within two orchards in Whangarei with moderate to high numbers of TPP were identified. The numbers of different life stages of TPP on 10 tagged trees in each block were monitored fortnightly by two tamarillo growers from October to the present date. The incidence and severity of disease symptoms was recorded.

Insecticide trial

The following treatments were applied initially on infested tamarillo plants and later on capsicum plants. There were four plants per treatment.

1. Untreated control
2. DC-Tron® (1000 ml/100 L)
3. Oberon® (60 ml/100 L)
4. NeemAzal® (500 ml/100 L)
5. Ovation™ + oil (25 g + 500 ml/100 L)
6. Avid® + oil (70 ml + 500 ml/100 L)
7. Calypso® (60 ml/100 L)
8. Pyradym® + oil (50 ml + 25 ml/100 L)
9. Talstar® (20 ml/100 L on tamarillos and 40 ml/100 L on capsicums)
10. Delegate® (10 g/100 L)
11. Confidor® (0.1 ml in 100 ml per tree as a soil drench).

The residual toxicity of each insecticide against TPP adults was assessed by enclosing 40 adults on a leaf on each plant 3 hours after treatment. The numbers of live and dead adults in these bags were counted 3 days after treatment.

The number of live and dead TPP, and the life stages present on each plant were assessed 7 days after treatment and then fortnightly for 12 weeks. Fortnightly assessments are ongoing at the time of this report.

Results to date

Phenology

When monitoring began in October 2009, there was an average of 0.12 late instar nymphs and 0.03 adults per leaf. This may indicate that TPP overwinter as older nymphs and/or adults. Monitoring results showed four periods when eggs were found on leaves, from November to April, and an increase in the abundance of early instars on leaves in early February. However, numbers of late instars found on leaves remained low throughout this period.

The flight activity of adult TPP as measured by numbers caught on the sticky traps was highest between late January and early April, which correlated well with the increase in egg numbers and young nymphs seen on tamarillo leaves.

Disease symptoms progressed quickly over the summer months with some trees showing severe symptoms within 6 weeks. Early results have indicated that TPP were not found on plants with disease symptoms, indicating a reduced attraction of these plants for feeding or laying eggs.

Insecticide trial

Results reveal a difficulty in establishing and retaining TPP on tamarillo plants. In the insecticide trial, this resulted in a low rate of egg laying and high mortality in untreated controls and very low numbers of nymphs remaining after 2 weeks in any treatment. These nymphal data were too low for any meaningful analysis. The low numbers of TPP on tamarillos in the insecticide trial supports the low abundance data that have been collected from the field monitoring (phenology work, section 2).

Insecticide trial results conducted on both capsicums and tamarillos reveal that residues of Avid® +oil, and Talstar® were most effective at reducing live adult TPP up to 3 days after treatment.

Work for this study is set to conclude in September 2010 and the complete results will be presented and discussed in a final report in October 2010.

For further information please contact:

Lisa Jamieson
The New Zealand Institute for Plant & Food Research Ltd
Plant & Food Research Mt Albert
Private Bag 92 169
Auckland Mail Centre
Auckland 1142
NEW ZEALAND
Tel: +64-9-925 8630
Fax: +64-9-925 7001
Email: Lisa.Jamieson@plantandfood.co.nz

1 Introduction

The Tomato/Potato Psyllid (*Bactericera cockerelli:* TPP) was first identified in New Zealand in 2006 (MAF 2010). Since its discovery, TPP has spread throughout many regions of New Zealand, infesting plants in the Solanaceae and some species of Convolvulaceae. Examples of plants attacked include, tomato, potato, capsicum, tamarillo, egg plant, kumara, cape gooseberry and chilli (Liefting et al. 2009; MAF 2010).

Both the adult and nymphal life stages of TPP cause damage to the host plants by feeding on the leaves. This can result in 'psyllid yellows' as seen in tomatoes and potatoes (Sengoda et al. 2010; Brown et al. 2010). TPP transmits the bacterial pathogen *Candidatus* Liberibacter solanacearum, which is thought to be the causative agent of 'zebra chip' in potato tubers (Sengoda et al. 2010), stunted growth in fruit and leaves in tomatoes (Brown et al. 2010), and leaf curling and yellowing in capsicums (MAF 2008b). Tamarillos have tested positive for *Ca*. L. solanacearum (MAF 2008a) with plants exhibiting similar symptoms of yellowing, leaf curling and stunted growth.

Liberibacter infection not only reduces crop yield and affects the quality of the fruit but ultimately also leads to the decline and death of the infected plant (Sengoda et al. 2010). TPP has also been found carrying the phytoplasma *Ca.* Phytoplasma australiense; however, transmission of this phytoplasma by TPP has not yet been confirmed. Investigations are underway to understand the phenology of the TPP in various regions of New Zealand, its host range and transmission biology. This information, in conjunction with the development of spray programmes targeted to the susceptible life stages of psyllids, will help growers to make informed decisions about when to spray their crops and control TPP most effectively.

This report outlines the progress so far of two ongoing investigations:

- Phenology (seasonal abundance) of TPP in tamarillo orchards
- Susceptibility of different life stages of TPP to insecticides.

2 Phenology of TPP in tamarillo orchards

The aim of this project was to determine the seasonal abundance of the different life stages of TPP on tamarillo trees through field monitoring, and to relate this information to results from the potted plant insecticide trial (section 3), to determine the optimum timing of pesticide applications to control TPP.

2.1 Methods

2.1.1 Monitoring nymphs

Four blocks within two orchards in Whangarei with moderate to high numbers of TPP were identified. Within each block, 10 trees with TPP infestation were tagged (40 trees in total). The numbers of TPP eggs, early nymphs (first, second and third instars), late nymphs (fourth and fifth instars), and adults on five young and five mature leaves on each of the tagged trees, were examined and recorded. The same 40 trees were continuously monitored from October to the present date. These trees were monitored fortnightly by two tamarillo growers.

2.1.2 Disease monitoring

A rating scale from 1 to 5 was created in conjunction with tamarillo growers to monitor disease symptom development (Figures 1 & 2) on these 40 tagged trees, whereby:

1 = Juvenile leaf pinking and cupping. Tree otherwise normal.
2 = More pronounced pinking and cupping. Change in tree colour – paling.
3 = Juvenile leaves no longer pink – yellow and cupped. Scorching of leaf margins/leaf spotting.
4 = Juvenile leaves dropped/branch tips scorched.
5 = Attempted re-growth or total defoliation.

The first assessment of three blocks was conducted on 2 October 2009. An additional fourth block was added on 12 February 2010. Fortnightly monitoring is ongoing at the time of this report.

Figure 1. (Left) Early leaf pinking and cupping = score 1. (Right) Yellowing and cupping of tamarillo leaves = score 3.

Figure 2. (Left) Tamarillo branch tip scorching = score 4. (Right) Attempted re-growth, small leaves = score 5.

2.1.3 Monitoring seasonal flight activity of adults

In each block, five yellow sticky traps (19 x 18 cm) were hung in trees and replaced fortnightly. At the time of collection, these traps were covered with a single layer of clear plastic wrap and sent to Plant & Food Research, Auckland, where TPP adults were identified and counted using a microscope.

2.1.4 Data analysis

All data recording sheets and sticky traps were sent to Plant & Food Research, Auckland. Data management and calculations were conducted in Microsoft® Office Excel 2007

Graphs were produced using Origin 7.5 [(PC/Windows XP) Copyright 2004, OriginLab Corporation)].

2.2 Results to date

2.2.1 Psyllid monitoring

The abundances of different life stages of TPP from October 2009 to June 2010 are presented in Figure 3. Monitoring began in early October 2009 when late instars and adults were present on leaves. Eggs were found on leaves in mid November, mid December, mid February and mid April. Eggs were generally laid on the soft young leaves near the top of the plant. Young instars were found on leaves in mid October and again in mid February through to mid April. The number of adults found on the leaves remained low throughout the monitoring period.

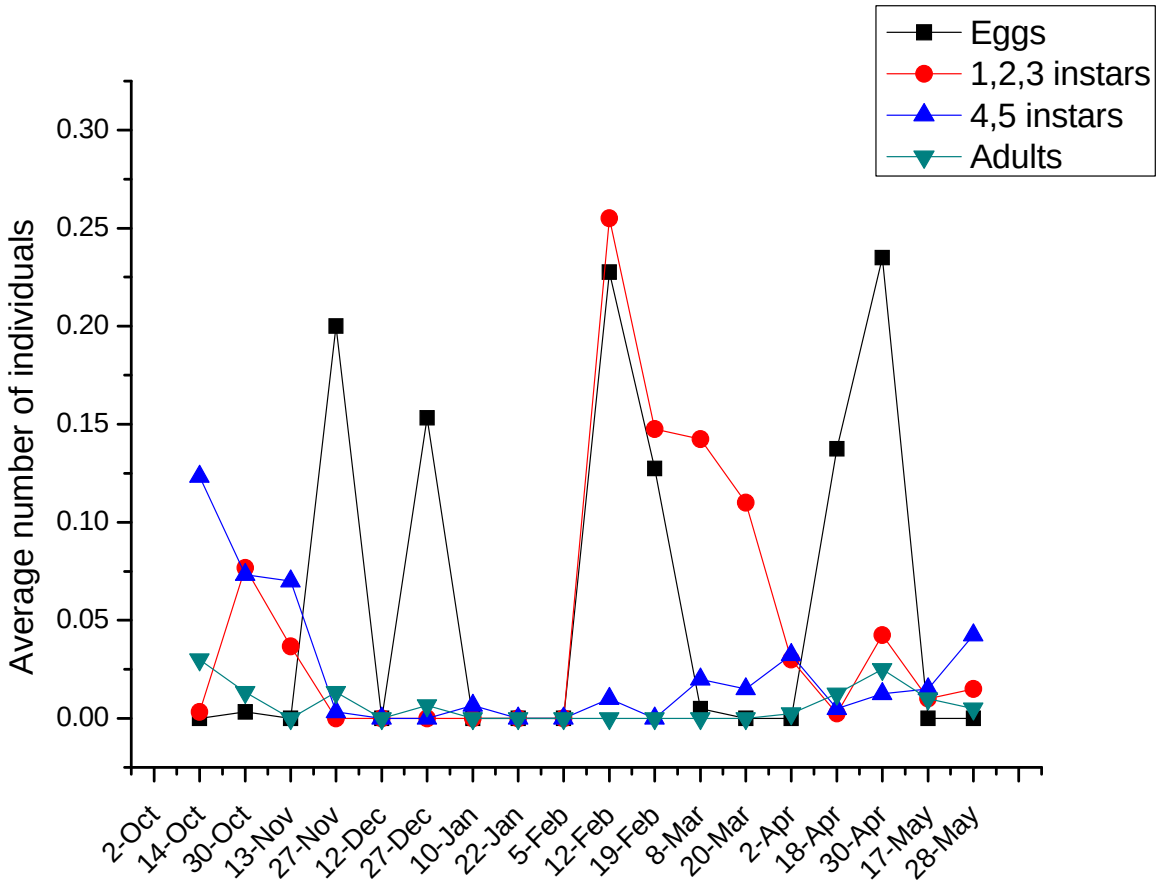

Figure 3. The seasonal abundance (mean number/leaf/fortnight) of various life stages of Tomato/Potato Psyllid (*Bactericera cockerelli,* TPP) on tamarillo plants in Whangarei from October 2009 to May 2010.

Adult flight activity as monitored on yellow sticky traps is presented in Figure 4. In late January numbers began to increase and peaked at an average of six adults per trap, per fortnight, in late March 2010. Flight activity did not decline until late April, when an average of one adult per trap, per fortnight was caught.

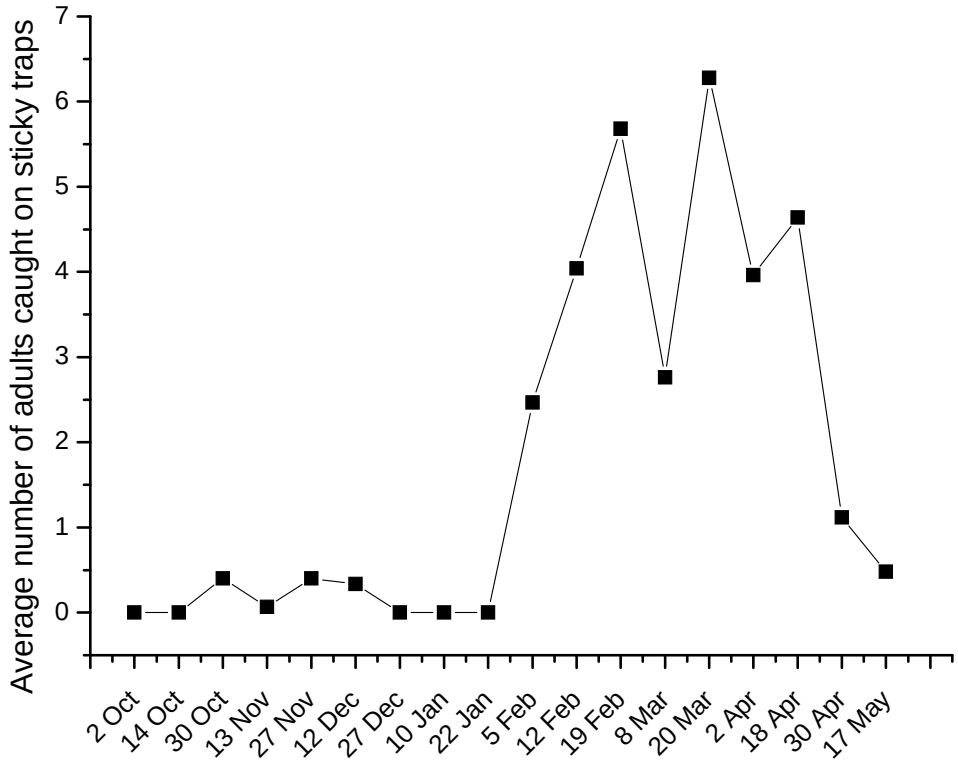

Figure 4. The seasonal abundance (mean number/trap/fortnight) of adult Tomato/Potato Psyllid (*Bactericera cockerelli*, TPP) caught on yellow sticky traps in Whangarei from October 2009 to April 2010.

2.2.2 Disease symptoms

Four of the 40 trees monitored developed disease symptoms. Three of the four affected trees had leaf drop, scorched stems and/or attempted re-growth or defoliation (disease scores of 4 or 5). One of the four trees currently shows early symptoms. From the time that infection was first noticed to trees reaching a score of 5 (most severe symptoms) was approximately 2 months.

Early disease symptoms are very similar to drought symptoms and are easily confused. During the summer months, there were several trees that were scored as showing early symptoms (score 1) that did not develop further symptoms, and eased once there was rain.

2.3 Main findings to date

When monitoring began in October 2009, there were an average of 0.12 late instar nymphs and 0.03 adults per leaf. This may indicate that TPP overwinter as older nymphs and/or adults. Monitoring results showed four periods when eggs were found on leaves from November to April, and an increase in the abundance of early instars on leaves in early February. However, numbers of late instars found on leaves remained low throughout this period.

The flight activity of adult TPP as measured by numbers caught on the sticky traps was highest between late January and early April, which correlated well with the increase in egg numbers and young nymphs seen on tamarillo leaves.

Disease symptoms progressed quickly over the summer months, with some trees showing severe symptoms within 6 weeks. Early results have indicated that TPP were not found on plants with disease symptoms, indicating a reduced attraction of these plants for feeding or laying eggs.

3 Susceptibility of different life stages of Tomato/Potato Psyllid (*Bactericera cockerelli)* to insecticides

The aim of this investigation was to determine the susceptibility of different life stages of TPP to insecticides in a potted plant trial.

Initially the insecticide trial was conducted on potted tamarillo plants, but because of insufficient psyllid numbers, the trial was repeated on capsicums, which are a preferred host for TPP. Methods and results for both tamarillos and capsicums are presented below.

3.1 Methods

3.1.1 Tamarillos

Small potted tamarillo plants (~10cm), grown from seed, were obtained from Craig Watson in late October 2009 and delivered to Plant & Food Research, Auckland. Plants were placed into a glasshouse cubicle until late January 2010 when they were approximately 60 cm high and moved to a shadehouse.

On 2 February, individual vials containing 20 TPP adults were collected from a TPP colony (Plant & Food Research, Auckland). Adults from each vial were placed into a small mesh bag, which was then placed over a young tamarillo leaf and closed with a twist tie. These bags were left undisturbed to encourage egg laying until the day of spraying.

On 11 February, two leaves per plant were tagged; each leaf either had young (first, second, third instars) or late (fourth, fifth) instars placed on it using a fine tipped paintbrush. Each leaf was then enclosed with a fine mesh bag. Plants were divided into groups of four trees each and labelled accordingly.

On 12 February, all bags were removed in preparation for spraying. On removal of the bags, it was discovered that most adults had not laid eggs on the tamarillo plants during the 10 preceding days.

On 12 February between 0630 and 1000 h, one of the following treatments was sprayed onto each group of trees:

1. Untreated control
2. DC-Tron® (1000 ml/100 L)
3. Oberon® (60 ml/100 L)
4. NeemAzal® (500 ml/100 L)
5. Ovation™ + oil (25 g + 500 ml/100 L)
6. Avid® + oil (70 ml + 500 ml/100 L)
7. Calypso® (60 ml/100 L)
8. Pyradym® + oil (50 ml + 25 ml/100 L)
9. Talstar® (20 ml/100 L)
10. Delegate® (10 g/100 L)
11. Confidor® (0.1ml in 100 ml per tree as a soil drench).

Four litres of each treatment was mixed and applied using a 5-L hand sprayer. Treatments were applied starting at the uppermost leaves and working towards the base of the tree, ensuring that each leaf was sprayed but that there was minimal spray run-off. Four replicates of each treatment were carried out.

Trees were left outside for approximately 2 hours to dry before 30 adults were enclosed in a mesh bag, which was secured over a leaf on each plant with a twisty tie to test residual toxicity of each insecticide. The numbers of live and dead adults in these bags were counted 3 days after treatment.

By 26 February, TPP numbers had decreased on all the plants and only seven nymphs remained on 48 plants. It was decided to repeat the trial on capsicums rather than tamarillos.

To establish any phytotoxic effect of the sprays, each plant was rated for the amount of necrosis and colour change of the leaves using the rating system below:

Necrosis
0 = no spots
1 = small area of stippling
2 = large area of stippling
3= stipling and patches of necrosis

Colour
0 = green
1 = green with small yellow patches
2 = green and yellow
3= mainly yellow.

3.1.2 Capsicums

On 1 March, capsicum seeds (McGregors 'Californian Wonder') were planted in propagation trays kept in a glasshouse cubicle. On 16 March small plants were pricked out and planted in individual pots and left to grow until May when they had reached ~40 cm in height.

On 18 May, 2000 TPP adults were released within the glasshouse cubicle to lay eggs on the capsicum plants; these eggs then hatched into early instars by the time treatments were applied.

On 2 June, 30 late instars were transferred onto each capsicum plant using a fine tipped paintbrush. Individual leaves on each plant were tagged and the number and life stages present recorded. Adults had continued to lay since their release 2 weeks earlier. A count of the total number of TPP and life stages per plant was also carried out. Plants were placed in groups of four and assigned one of the treatments listed in 3.1.1.

On 3 June, all plants were moved out of the glasshouse cubicle to a grassy area and spread so that spray drift would not occur. Untreated controls were placed outside the glasshouse and were separated from the treated plants by two glasshouses and a distance of approximately 100 m.

Spray application was carried out as described in 3.1.1. Application rates were as listed in 3.1.1, except for Talstar® applied at 40 ml/100 L.

Plants were left outside for approximately 3 hours to dry before 40 adults were enclosed in a mesh bag that was placed over a leaf on each plant to test residue activity. The numbers of live and dead adults in these bags were counted 3 days after treatment.

The number of live or dead TPP, and the life stages present on each plant were assessed seven days after treatment and then fortnightly for 12 weeks. Fortnightly assessments are ongoing at the time of this report.

3.1.3 Data analysis

The numbers of live TPP on each plant for all treatments were compared using Analysis of Variance (ANOVA). Least significant differences (LSDs) were calculated to separate treatments where the ANOVA demonstrated significant differences ($P<0.05$). Data were normally distributed and did not require transformation before analysis. The analysis was performed using GenStat (version 10) [(PC/Windows XP) Copyright 2006, Lawes Agricultural Trust (Rothamsted Experimental Station)].

Graphs were produced using Origin 7.5 [(PC/Windows XP) Copyright 2004, OriginLab Corporation].

3.2 Results to date

3.2.1 Tamarillo

Residues from Avid® + oil, Talstar® and Calypso®, significantly reduced the number of live TPP adults bagged on to treated leaves compared with controls when assessed 3 days after treatment ($P<0.05$) (Figure 5).

There was high mortality (62%) in the control treatment and high variability across treatments (Figure 5). These data, in conjunction with the low number of nymphs that remained on plants 2 weeks after treatment, resulted in the decision to repeat the trial using capsicum plants.

None of the treatments caused a significant increase in necrosis or colour change compared with the controls (Table 1).

Table 1. The average necrosis and colour scores of tamarillo plants 7 days after being sprayed with a range of insecticides.

Treatment	Necrosis score	Colour score
Untreated control	1.7	1.4
Confidor® (soil drench)	1.6	1.35
Pyradym® + oil	1.4	1.3
Calypso®	1.2	1.4
Avid® + oil	1.6	1.55
NeemAzal®	1.55	1.25
DC-Tron®	1.3	0.9
Delegate®	1.3	1.4
Ovation™ + oil	1.25	1.1
Oberon®	1.05	1.05
Talstar®	1.6	1.2
P-value*	NS (*P*>0.05)	NS (*P*>0.05)

NS = no significant difference

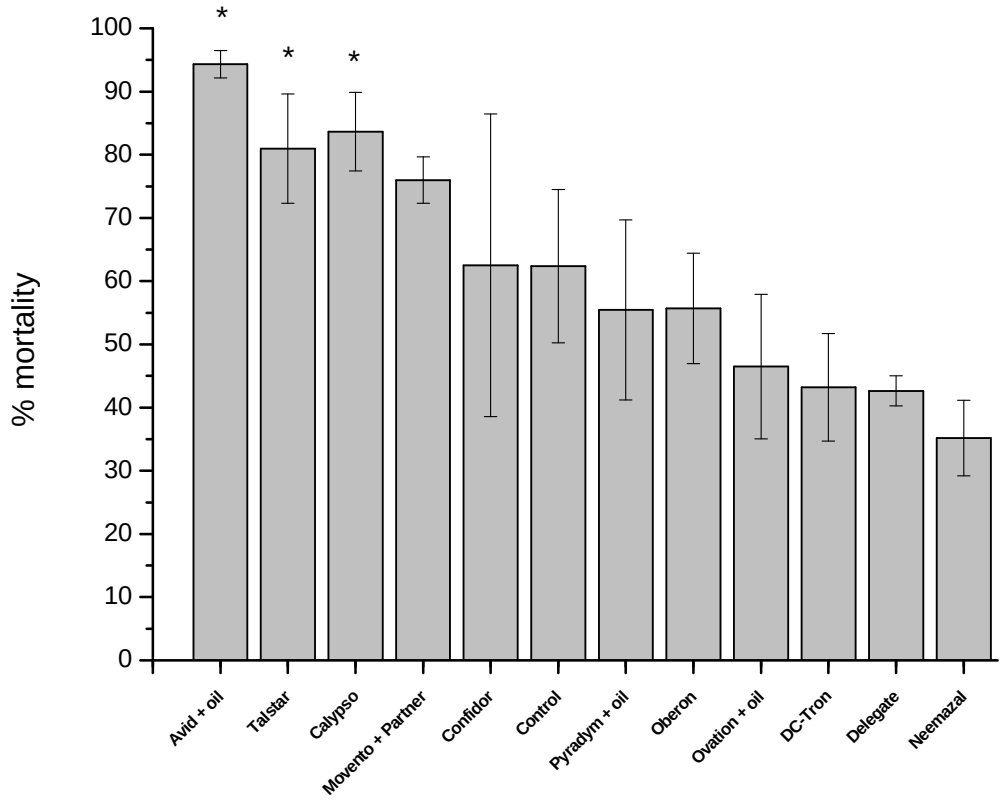

Figure 5. The percentage mortality of Tomato/Potato Psyllid (*Bactericera cockerelli*, TPP) adults, 3 days after treatment on tamarillos. Vertical lines represent the standard error of the mean. * indicates treatments that are significantly different from the untreated control.

3.2.2 Capsicums

Residues of Avid and Talstar resulted in significantly (P<0.001) higher adult mortality (85-93%) than residues from other treatments and no residues, with 85-93% of adults dead 3 days after treatment (Figure 6). Adult TPP mortality on leaves with residues of Pyradym®, DC-Tron® or Ovation™ was not significantly different from that on untreated leaves.

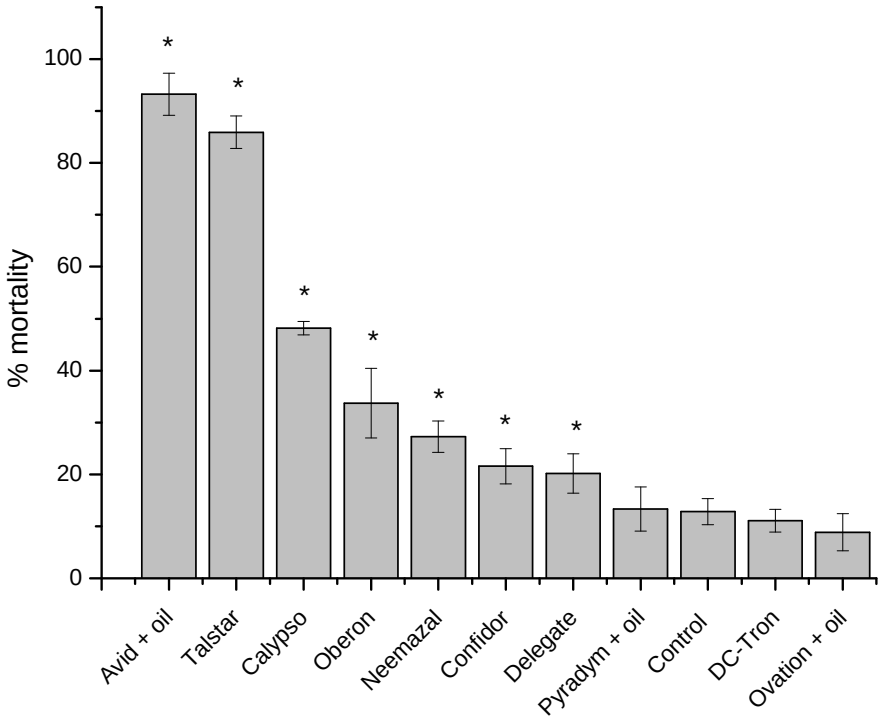

Figure 6. The percentage mortality of Tomato/Potato Psyllid (*Bactericera cockerelli*, TPP) adults 3 days after treatment on capsicums. Vertical lines represent the standard errors of the means. * indicates treatments that are significantly different from the untreated control.

Unlike the tamarillos, there was good establishment of TPP on the capsicum plants before treatment and the numbers on the untreated controls have continued to increase. Monitoring of the nymphal stages and egg hatch is ongoing and will be reported in full in the final report.

3.3 Main findings to date

Results reveal a difficulty in establishing and retaining TPP on tamarillo plants. In the insecticide trial, this resulted in a low rate of egg laying and high mortality in untreated controls, and very low numbers of nymphs remaining after two weeks in any treatment. These nymphal data were too low for any meaningful analysis. The low numbers of TPP on tamarillos in the insecticide trial supports the low abundance data that have been collected from the field monitoring (phenology work, section 2).

Insecticide trial results conducted on both capsicums and tamarillos reveal that residues of Avid + oil, and Talstar were most effective at reducing live adult TPP up to 3 days after treatment.

Work for this study is set to conclude in September 2010 and complete results will be presented and discussed in a final report in October 2010.

4 Acknowledgements

We wish to thank Craig Watson for providing young tamarillo plants, photographs of plants with disease symptoms, and for conducting fortnightly monitoring. Thanks also to Robin Nitschke for conducting fortnightly monitoring of psyllids in his orchards. Psyllids were kindly provided by Peter Workman, Frances McDonald and Ngaire Larsen of Plant & Food Research.

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