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Evaluation of selected soft chemicals as potential control options for tomato/potato psyllid

Walker MK, Butler RC, Berry NA

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Walker MK, Butler RC, Berry NA

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THE NEW ZEALAND INSTITUTE FOR PLANT & FOOD RESEARCH LIMITED
Private Bag 92 169, Auckland 1142, New Zealand

This report has been prepared by The New Zealand Institute for Plant & Food Research Limited (Plant & Food Research), which has its Head Office at 120 Mt Albert Rd, Mt Albert, Auckland.

This report has been approved by:

Melanie Walker

Senior Research Associate, Applied Entomology

Date: 11 June 2010

Louise Malone

Science Group Leader, Applied Entomology

Date: 11 June 2010

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Executive summary

Evaluation of selected soft chemicals as potential control options for tomato/potato psyllid

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The tomato/potato psyllid (*Bactericera cockerelli* (Sulc), Hemiptera, Triozidae) (TPP) was first recorded in New Zealand in 2006 and is now a significant pest of solanaceous crops in both glasshouses and fields. Given the impact of this insect pest and its associated pathogen(s) on crop yields, immediate control options are required. 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. The recorded mortality of tomato/potato psyllid nymphs 168 h after spraying with Eco-oil, 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.

For further information please contact:

Melanie Walker
The New Zealand Institute for Plant & Food Research Ltd
Plant and Food Research Lincoln
Canterbury Agriculture & Science Centre
Private Bag 4704
Christchurch 8140
New Zealand
Tel: +64-3-325 6400
Fax: +64-3-3252074
Email: melanie.walker@plantandfood.co.nz

1 Introduction

The tomato/potato psyllid (*Bactericera cockerelli* (Sulc), Hemiptera, Triozidae) (TPP) was first recorded in New Zealand in 2006 and is now a significant pest of solanaceous crops in both greenhouses and fields. The arrival of TPP in New Zealand and the recent identification of its role as a vector of the bacterial pathogen Liberibacter (Munyaneza et al. 2007) have presented a considerable challenge to the New Zealand greenhouse vegetable, tomato and potato industries. Damage to crops caused by this pest insect through direct feeding is believed to be associated with ‘psyllid yellows’ in tomatoes and potatoes (Teulon et al. 2009). The bacterial pathogen Liberibacter (vectored by TPP) has also been identified as the cause of the disease ‘zebra chip’ in potatoes.

Before the arrival of TPP, New Zealand greenhouses used Integrated Pest Management (IPM) practices based on biological control and pollination requirements (Martin 2008; Zonda Resources Ltd 2009). Currently, in greenhouse crops there are no biological control agents or IPM-compatible insecticides available for control of TPP. The arrival of TPP has threatened the use of previously established IPM practices because of an increase in the use of pesticides that are incompatible with the use of biological control agents. The increased use of pesticides also threatens resistance management strategies for key insect pests and is environmentally unsustainable. Given the potential impact on IPM practices in these crops, IPM-compatible control options are preferred.

A number of softer chemical options used for other pests such as scale (Cating et al. 2010; Shaw et al. 2000), whitefly (Martin 2001), thrips (Martin 2001; Reitz et al. 2008), spider mites (Martin 2001), flat mites (Cating 2010), aphids (Martin 2001), and Asian citrus psyllid (*Diaphorina citri*) (Srinivasan et al. 2008) have been identified as potential control options for TPP (van Toor et al. 2008). These products include horticultural soaps (e.g., PS1 and PS2), spraying oils (e.g., minerals oils and plant-based oils), botanical insect growth regulators (e.g., Neem products), Agri-50NF, Sucrose octanoate, kaolin (aluminium silicate), AkseBio2 and organosilicone surfactants. In general, these ‘soft’ pest control products are considered ecologically sustainable with low toxicity towards humans (workers), other mammals and non-target species, have no or very short withholding periods, and could be incorporated into IPM programmes (Smith 2009). These products can be used on their own or in conjunction with selected insecticides to provide dual modes of action when spraying. Enhanced insecticide efficacy and efficiency may be achieved by improving their spread and penetration of the insect exoskeleton, increasing the chance of contact with and control of sessile insect stages (HortNZ 2008; Martin 2001; Smith 2009).

After consultation with industry representatives, four soft chemical options were selected for testing. These were PS2, Agri-50 NF®, Eco-oil® and Excel Oil®. PS2 (similar to Eradicoat, registered by BCP Certis UK, for control of spider mites) is a horticultural soap containing the active ingredient maltodextrin. This compound has a mechanical/physical mode of action formulation that coats and dries on the target pest, causing entrapment, blocking of the spiracles and leading to death by suffocation. PS2 was developed as a potential option for whitefly control using a low toxicity spray (John Thompson (Bioforce) pers. comm.; Smith 2009). It is effective against a range of small pests, is fast acting, safe to operators, crop workers and consumers, and has no pre-harvest interval or residues. PS2 is compatible with IPM programmes, as its physical mode of action and absence of any residual effect enables beneficial species to re-colonise, or be re-introduced, immediately after spraying (Anon 2010a; Jones 2010).

Agri-50NF is an insecticide formulated from a colloidal suspension of polysaccharides derived from natural plant extracts. This compound has a physical mode of action forming a sticky layer to entrap small insect pests. Agri-50NF is exempt from food tolerances, is compatible with IPM and biological control programmes because of its lack of residual effect. Agri-50NF is most effective against the juvenile stages of pest outbreaks including aphids, scale, whitefly, psyllids and two spotted mite (Anon 2006; Anon 2008).

Eco-oil is a non-toxic botanical oil based miticide/insecticide, used to control two-spotted mite, aphids, whitefly and scale in commercial tree, vine and vegetable crops, ornamentals, covered crops and home gardens. Eco-oil contains a blend of three botanical oils: canola oil, teatree oil and eucalyptus oil, emulsified in a surfactant system. This compound has three modes of action: (1) it penetrates the exo-skeleton and spiracles of insects, reducing their ability to expel carbon dioxide, resulting in carbon dioxide poisoning; (2) the thin protective membrane of insects and their eggs is denatured, causing dehydration and death; and (3) it acts as a mild insect repellent on leaf surfaces, reducing the chance of re-infestation. The benefits of using Eco-oil include no potential for spray resistance from overuse; a lower potential to burn plants compared with other horticultural oils; no withholding periods or re-entry restrictions; that it can be used within IPM programmes and is registered as organic with the Biological Farmers of Australia (Anon 2008; Anon 2010b).

Excel Oil is a horticultural spray oil for control of scale on kiwifruit, armoured scale, six spot and greenhouse thrips on avocados, scale, aphids and mites on citrus, pip and stonefruit, and powdery mildew on grapes. The active ingredient (mineral oil) creates an impervious layer suffocating target pests, by coating and blocking the trachea and spiracles. Excel Oil is biodegradable, has negligible toxicity to humans and other vertebrates, has no resistance build-up and is compatible with natural enemies because of its physical mode of action, and has no residual effect (Anon 2004; Anon 2008).

The aim of this study was to carry out a potted plant bioassay to determine the efficacy of PS2, Agri-50 NF, Eco-oil and Excel Oil in controlling tomato/potato psyllid nymphs.

2 Methods

2.1 Insect rearing

TPP nymphs used for testing were obtained from a laboratory colony at Plant & Food Research, Lincoln, Canterbury. This colony was originally established from adult TPP collected in greenhouse tomatoes in Auckland. TPP were reared on tomato plants ('Moneymaker') in a controlled temperature room at 23ºC, 40% humidity, 16:8 light:dark photoperiod.

2.2 Trial design

A potted plant bioassay using capsicum plants was conducted within a controlled temperature growth room (23ºC, 40% humidity,16:8 light:dark photoperiod) to determine the efficacy of four soft chemicals, PS2, Agri-50NF, Eco-oil and Excel Oil, to control TPP nymphs (third-fourth instar). Capsicum seedlings ('E Viper') at 3-true leaf stage were obtained from Zealandia Horticulture Ltd and were planted singly into potting mix in separate plastic pots (100 mm x 85 mm x 85 mm). Chemical treatments were applied to the capsicum plants (when plants were approximately 250-300 mm high, 15 true leaves) as direct sprays. In addition to the four chemical treatments, a water control and an untreated control were also tested.

Six replicates (potted capsicum plants) were used for each chemical treatment, water control and untreated control (36 capsicum plants in total). Capsicum plants were laid out on two adjacent benches (3 x 6 plants per bench) within the controlled temperature room, with plants arranged according to a Latinized Resolvable Block design (CycSoftware 2009) (Figures 1 & 2).

Figure 1.Capsicum plants were laid out on two adjacent benches (3 x 6 plants per bench) within the controlled temperature room.

Bench 1

Rep 1	1 X	2 E	3 W	4 A	5 P	6 U
Rep 2	7 P	8 A	9 U	10 X	11 E	12 W
Rep 3	13 U	14 W	15 P	16 E	17 A	18 X

Bench 2

19 W	20 U	21 X	22 A	23 E	24 P	Rep 4
25 E	26 X	27 P	28 U	29 A	30 W	Rep 5
31 P	32 A	33 E	34 W	35 U	36 X	Rep 6

Figure 2. Latinized Resolvable Block design. P = PS2, A = Agri-50NF®, E = Eco-oil®, X = Excel Oil®, W = water only, U = unsprayed control.

TPP nymphs were applied to capsicum plants 24 hours before chemical treatment. Two clip cages of 10 psyllids were attached to each plant. The numbers of live and dead psyllids per cage were counted at 72 and 168 h after treatment.

2.3 Application of TPP to capsicum plants

TPP nymphs were applied to capsicum plants 24 h before chemical treatment. Ten third-fourth instar nymphs were placed on the underside of two capsicum leaves per plant using a fine paintbrush (Figure 3). Clip cages (Figure 4) were then placed over the leaves and psyllids were left to settle on the plants for 24 h before spraying (Figure 5).

Figure 3. Tomato/Potato Psyllid (TPP) nymphs were placed on the underside of capsicum leaves using a fine paintbrush.

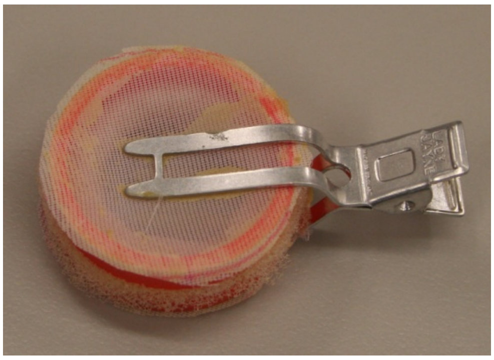

Figure 4. Clip cage.

Figure 5. Clip cages were placed over the capsicum leaves, and psyllids were left to settle for 24 h.

2.4 Chemical treatments

Four chemicals were each tested at the manufacturer's recommended field rate (Table 1).

Table 1: Chemical treatments used in the Tomato/Potato Psyllid (TPP) bioassays.

Trade name	Active ingredient	Chemical group	Formulation	Field rate
PS2	Maltodextrin	Horticultural Soap	Mechanical mode of action formulation	350 ml/10 litres
Agri-50NF®	Polysaccharides	Natural Plant Extract	Colloidal Suspension	175 ml/100 litres
Eco-Oil®	Canola Oil	Botanical Oil	851.5 g/litre EC	7.5 ml/litre
Excel Oil®	Mineral Oil	Horticultural Spray Oil	843 g/litre EC	1 litre/100 litres

2.5 Application of chemicals

Potted capsicum plants were removed from the controlled temperature room and placed outside on a grass lawn for spraying. Spraying was carried out between 1000 h and 1200 h, under warm temperatures (approximately 20ºC) and low wind conditions. Chemical treatments (and water controls) were applied as a fine mist to runoff, ensuring complete coverage of all leaf area, using a 2-L Handpump Pressure Sprayer (M^c^Gregor's®) (Figure 6). Each capsicum plant was sprayed individually after the two clip cages had been removed. After spraying (approximately 10 minutes), clip cages were placed back on the leaves and left for 7 days. Capsicum plants were placed back into the controlled temperature room after spraying, for the duration of the trial.

Figure 6: 2-L Handpump Pressure Sprayer (M^c^Gregor's®).

2.6 Assessment of mortality

Psyllid mortality was assessed 72 h (3 days) and 168 h (7 days) after chemical treatment. Clip cages were removed from individual leaves one at a time and numbers of live and dead psyllids were counted. A psyllid nymph was recorded as dead if it did not move one body length when slightly prodded with a fine paintbrush. Different brushes were used for each chemical or control and then discarded.

2.7 Statistical analyses

Data for 72 and 168 h were analysed separately. The importance of spatial trends on the mortality was explored (details not shown). There was some evidence of trends relating to the replicates (rows of 6 pots per bench). However, since the estimated treatment effects from these spatially adjusted analyses were essentially the same as those from a more straightforward analysis, the results of the simpler analysis only are presented. Mortality was analysed with a binomial generalized linear model with a logit link (McCullagh & Nelder 1989). Treatments were compared with the water and untreated controls using contrasts within the analysis. Estimated mortality and associated 95% confidence limits were obtained on the transformed (logit) scale and back transformed to percentages. All analyses were carried out with GenStat v.12 (GenStat Committee 2009).

3 Results

3.1 Mortality at 72 hours

The estimated percentage mortality of TPP nymphs 72 h (3 days) after spraying is shown in Table 2 and Figure 7. After 72 h, mortality was slightly higher with water than for the untreated control, but this difference was not significant (P=0.175). Mortality for all chemical treatments was higher than for water or untreated control. Of the chemical treatments, mortality with Agri-50NF was the lowest, at just over twice that for the water control (P=0.153), and more than six times the mortality for the untreated plants (P=0.012). Mortality for PS2, Eco-oil and Excel Oil was significantly higher than for both water and the untreated control (P<0.004 or smaller), with the highest mortality found with Eco-oil (48%), followed by PS2 (39%).

3.2 Mortality at 168 hours

The estimated percentage mortality of TPP nymphs 168 h (7 days) after spraying is shown in Table 2 and Figure 7. By 168 h, mortality had increased noticeably from 72 h for all chemical treatments, and had increased for water and the untreated control by proportionately similar amounts. Patterns of mortality between the chemical treatments were similar to those found at 72 h. However, the significance of most differences had increased (P<0.001 for all comparisons between chemical treatments and water or untreated control), as had the difference between the water and untreated control (P=0.059). Of the chemical treatments, mortality was highest for Eco-oil (58%), followed by that for PS2 (50%), Excel Oil (48%) and lowest for Agri-50NF (33%).

Table 2. Mortality (%) of tomato/potato psyllid nymphs 72 or 168 h after spraying (95% confidence limits in parentheses).

Chemical	72 h	168 h
PS2	39.0 (27.4,52.0)	50.0 (39.3,60.7)
Agri-50NF®	15.6 (8.0,28.0)	33.3 (23.5,44.8)
Eco-oil®	48.0 (35.4,60.7)	58.2 (47.1,68.4)
Excel Oil®	29.0 (18.8,41.8)	48.0 (37.4,58.8)
Water Control	6.9 (2.7,16.9)	9.9 (5.1,18.5)
Untreated Control	1.8 (0.3,9.9)	2.6 (0.8,8.8)

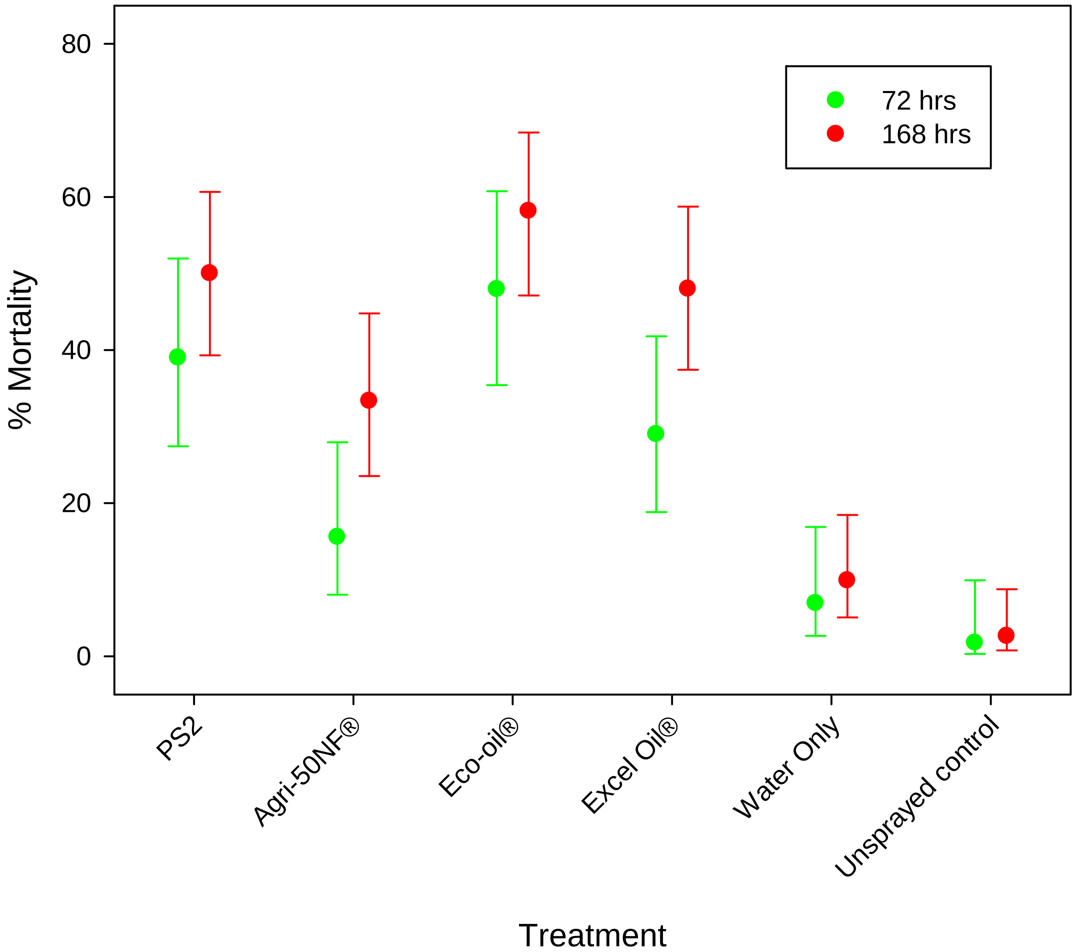

Figure 7. Mortality (%) of tomato/potato psyllid nymphs 72 or 168 h after spraying. Error bars are 95% confidence limits.

4 Discussion

In the present study, the soft chemicals; Eco-oil, PS2, Excel Oil and Agri-50NF, when applied at the manufacturer's recommended field rate, gave 58%, 50%, 48% and 33% mortality of TPP third-fourth instar nymphs after 168 h, respectively.

Despite the low mortality rates of third-fourth instar TPP nymphs, it is expected that higher rates of mortality would be achieved against first and second instar TPP nymphs (John Thompson (Bioforce) pers. comm., 2010). In a commercial greenhouse, several life stages of TPP occur over the same time period, and thus the use of soft chemicals could allow effective control of the more susceptible life stages of TPP (first and second instar nymphs), while reducing populations of third and fourth instar TPP nymphs.

Recommendations

We see three main options for soft chemical trials in Year 2:

1. Test the two or three most promising soft chemicals from Year 1 (Eco-oil, PS2, and Excel Oil) in the greenhouse

2. Test one or two of the most promising soft chemicals from Year 1 (Eco-oil, PS2) in combination with a selective insecticide such as pymetrozine, to give a dual mode of action when spraying, with the objective of enhancing the efficacy and efficiency of the selective insecticide to control TPP. This would be tested in a laboratory potted plant bioassay similar to that used in Year 1

3. Test other soft chemicals in a laboratory potted plant bioassay. These may include contact sprays (in addition to those tested in Year 1), and/or deterrents such as cedar oil, which may cause feeding and oviposition repellency (John Thompson (Bioforce) pers. comm., 2010).

These potential options will be discussed with the Sustainable TPP Management SFF Project Team at the meeting planned for mid June; a decision will then be made on the most appropriate option for soft chemical trials in Year 2.

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