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Review of soft chemical options and research for insect pest control

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Potatoes New Zealand

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Executive summary

A search of available information (internet, Web of Science, Navochem Manuals) was undertaken to identify “softer” chemicals as a complement to, or alternative for conventional insecticides currently used to manage tomato potato psyllid populations. The active ingredient, mode of action, and their use, along with results from studies undertaken in NZ or elsewhere, are listed below for a range of products including; minerals, mineral oils, horticultural/vegetable oils, botanicals (extracts/oils, derivatives), insecticidal soaps, and plant essential oils. Several products are identified that could warrant further investigation, particularly JMS-stylet oil, Eco-Oil and Excel-Oil.

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1 Introduction

Since the arrival of the tomato potato psyllid (*Bactericera cockerelli* (Sulc), Hemiptera, Triozidae) (TPP), and the identification of its role as a vector of the bacterial pathogen *Candidatus* Liberibacter solanacearum (Munyaneza et al. 2007), Integrated Pest Management (IPM) practices have been threatened due to the increased use of broad spectrum insecticides. An increased use of such insecticides can be costly and environmentally unsustainable, and can result in insecticide resistance, reduced populations of beneficial insects, and secondary pest outbreaks (Yang et al. 2010). A reduction in the threats to IPM posed by heavy use of persistent, broad-spectrum insecticides can be achieved by replacing these products with "softer" pest control products. In this study, soft chemicals are described as compounds that are either more targeted in their specificity and/or have a reduced environmental impact, and include; minerals, mineral oils, horticultural/vegetable oils, botanicals (extracts/oils, derivatives), insecticidal soaps, and plant essential oils.

The objective of this study was to identify potential alternatives to currently used synthetic insecticides for control of tomato potato psyllid in potatoes in New Zealand via a review of the existing literature on 'soft' chemical/alternative treatment options.

2 Methods

Internet (www.google.com), and literature searches (Web of Science) were carried out and the New Zealand Novachem agrichemical manual 2010 was consulted to establish current and potential 'soft' chemical/alternative treatment options. Relatively few studies have been carried out on the use of 'soft' chemical/alternative treatments for the control of the tomato potato psyllid, therefore products which have been shown to be potentially useful for other psyllids and insect pests have been included. Microbial insecticides and conventional synthetic chemicals have been excluded from this review. Previous industry correspondence linked to the Sustainable TPP Management SFF Project, Objective 6; Soft chemical options for the covered crops industry, was also consulted.

3 Results

The following reviews ‘soft’ chemical/alternative treatment options and research studies for control of psyllids and insect pests. Each ‘soft’ chemical/alternative treatment option is grouped by product type. For each product type, the active ingredient, mode of action, use, and a summary of recent research related to the product are documented. The advantages and disadvantages of each main group; minerals, mineral oils, horticultural/vegetable oils, botanicals (extracts/oils, derivatives), insecticidal soaps, and plant essential oils are also provided where information is available.

3.1 Minerals

3.1.1 Product: Surround WP

(Available in NZ, registered for use on Apples & Grapes, NZ Novachem Agrichemical Manual 2010).

Active ingredient: Kaolin Clay; platy aluminosilicate mineral that is chemically inert over a wide pH range.

Mode of action: Creates a protective physical or mechanical barrier. Repellent action by creating an unsuitable surface for feeding or egg-laying. May also disrupt the insect’s host finding capability by masking the colour of the plant tissue.

Use:

- Orchard pests including apple maggot, white apple leafhopper, pear psylla, codling moth, oriental fruit moth, tufted apple bud moth, lesser appleworm.
- On vegetables, field trials have shown potential for pepper weevil, cabbage aphid, and onion thrips.
- Some repellency to silver whitefly in laboratory studies.

Studies – NZ: No published studies to date.

Studies – overseas

Peng et al. 2010. Tomato Potato Psyllid on tomato. **Laboratory tests**; No choice tests showed reduced oviposition. Choice tests showed reduced adult infestation and oviposition. Differences depended on the ratio of untreated leaves and treated leaves available to the psyllids. **Field tests**. Caged choice tests showed fewer adults, eggs and nymphs on kaolin treated plants. Uncaged tests showed psyllid numbers fluctuated between sampling dates, differences between treatments for adults and eggs laid occurred on some sampling dates. TPP prefered to feed and oviposit on the lower leaf surface, therefore it may be difficult to prevent oviposition once adults move to lower leaf surface.

Reitz et al. 2008. Thrips and tomato spotted wilt on tomato. Essential oils and kaolin reduced insecticide use on tomatoes.

Hall et al. 2007. Asian Citrus Psyllid on citrus. Twelve month study showed adult and egg numbers were significantly reduced. Reductions in infestation levels of citrus psyllid in treated trees were attributed to the negative effects of the particle film on the ability of adults to grasp, move, and oviposit.

Saour 2005. Pistachio psyllid on pistachio. Some control.

Liang & Liu 2002. Lab tests; some repellency against silverleaf whitefly.

Heacox 1999. Apple maggot, white apple leafhopper, pear psylla were effectively controlled. Some control was noted for codling moth, oriental fruit moth, tufted apple bud moth, lesser appleworm.

Advantages

Adults appeared to try and escape tested leaf surface, although mouthparts were able to penetrate the leaf surface. Acts as physical barrier, repelling insects from landing, disrupts feeding and oviposition. Insects appear unable to recognise plants as their host. Acts as a mechanical barrier impeding insect movement and feeding. Other advantages; unlikely to develop resistance, non-toxic to humans, relatively safe to some natural enemies, easily applied, protects some microbial pesticides.

Disadvantages

Reported to promote occurrence of some pests, could affect predators and parasitoids, examples given in orchards, reduces diversity of generalist arthropod assemblages either due to repellent effect or lack of pest prey. Heavy use in orchards also thought to lead to a flare up of European red mites or San Jose scale. Continuous coverage required due to irrigation, rainfall, dew and new plant growth. Adequate coverage difficult on underside of leaves. Limited outdoor field studies on vegetables crops.

3.2 Mineral Oils

3.2.1 Product examples: SunSpray ®, Excel® Oil, Excel® Organic Spraying Oil

(Available in NZ, NZ Novachem Agrichemical Manual 2009, 2010).

Active ingredient: Emulsifiable concentrate containing 970 ml/L mineral oil.

Mode of action: Physical action by coating insect exterior and interfering with their metabolic processors. Control is mainly by suffocation when oil moves into the spiracles of the insect. Oils are sometimes applied to prevent transmission of viruses. Oils used to inhibit virus transmission are sometimes called “stylet oils,” a reference to the piercing and sucking mouthparts (stylets) of aphids that transmit these viruses.

Use:

- SunSpray used against Mites, scale, aphids, pear psylla.
- Excel Oil
    - On kiwifruit against scale,
    - On avocados against armoured scale, six spot and greenhouse thrips
    - On citrus, pip and stone fruit against scale, aphids and mites and,
    - On grapes against powdery mildew.

Studies – NZ:

Walker et al. 2010. Lab tests: Tomato Potato Psyllid on capsicum leaf discs. In a potted plant bioassay 48% of 3rd instar TPP nymphs mortality was recorded.

Shaw et al. 2000. San Jose scale on apple. Summer use of 2% mineral oil may give effective control of potential scale infestation in late summer.

Yang et al. 2010. Lab tests; Tomato Potato Psyllid on tomatoes. Sunspray oil significantly repelled TPP adults and deterred oviposition compared to untreated controls.

Studies – overseas

Erler & Cetin 2005. Pear psylla on pears. Pear psylla suppression by compatible combinations of insecticides and oils could be more effective than treatments with single insecticides.

Erler 2004. Pear psylla on pears. 1 % mineral oil had pronounced deterrent activity on pear psylla, preventing oviposition for approximately one month after application.

Al-Jabr 1999. Greenhouse tomatoes; Tomato Potato Psyllid. SunSpray oil significantly deterred TPP oviposition 1,2, 3 and 4 days after application.

Baxendale & Johnson 1990. Aphid, mite scale and other on ornamental species. Treatment with 3% oil proved to be highly effective against aphid, scale, mite and other pest infestations.

3.2.2 Product: JMS Stylet Oil (Available in NZ, Elliot Chemicals, Pukekohe)

Active ingredient: White mineral oil

Mode of Action: Protectant and curative contact product. Direct contact required, interferes with insect respiration. Controls harmful pests through suffocation and by modifying insect behaviours such as feeding and egg-laying. Interferes with the pest's ability to chemically communicate with a host plant. Interferes with virus transmission and behaviours of virus spreading pests such as aphids and whiteflies. Viruses can be transmitted from a virus-carrying pest to a healthy plant in less than 20 s, but JMS Stylet-Oil interferes with the transmission process thus preventing inoculation of healthy plants.

Use:

- On apples, avocados, citrus, kiwifruit, pears, stonefruit; range of insect pests.
- On grapes; powdery mildew, botrytis, mealy bug, mites.

Studies – NZ: No published studies to date

Studies – overseas

Umesh et al. 1995. Aphid transmitted viruses and melons. JMS Stylet Oil reduced the incidence and spread of aphid-transmitted viruses when inoculum pressure was low. However, when inoculum pressure was high, the oil did not reduce virus spread to tolerable levels, but delayed initial infection to some degree.

Advantages

Enhances efficacy of insecticide/pesticide and hence can reduce the dosage level by up to 25%. Biodegradable, phytotoxicity-safe, and insects do not build up resistance. Negligible detrimental effect on beneficial insects. Low phytoxcity.

JMS Stylet Oil – John Trumble (US) reported very good repellence of up to 4 weeks (Brian Smith, pers. comm.).

Disadvantages

Excel Oil – can leave residue on plants (Excel Oil – Stuart Atwood, pers. comm.). Currently not registered on potatoes, requires high volume spraying for maximum coverage.

3.3 Horticultural/Vegetable Oils

3.3.1 Product examples: Canola oil (Eco-oil®), Otec Oil
(Available in NZ, NZ Novachem Agrichemical Manual 2010).

Others oils; **Soybean oil, (Bionatrol-I)** (Not Available in NZ), **Rapeseed oil, Cottonseed oil**

Active ingredient: Refined vegetable oil obtained from the seeds.

- Eco-oil®; emulsifiable concentrate containing 851.5 g/L canola oil.
- Otec Oil, contains 835 g/L canola oil.

Mode of action:

- Canola: repels insects by altering the outer layer of the leaf surface or by acting as an insect irritant.
- Eco-oil®; miticide/insecticide.
- Otec Oil; adjuvant.
- Cottonseed oil is generally considered the most insecticidal of the vegetable oils.

Use:

- Canola oils: wide range of plants, including: citrus, corn, fruit trees, nut trees, sugar beets, soybeans, tomatoes, vegetables, figs, melon, olives, small fruits, alfalfa, bedding plants, ornamentals, and houseplants.
- Bionatrol-I (*not available in NZ)*: aphids, whitefly, mites, etc.

Studies – NZ: No published studies to date

Studies – overseas

Yang et al. 2010. Lab tests; Tomato Potato Psyllid on tomatoes. “BugOil” (canola oil) Significant repellency to adults and had strong deterrent effects on TPP oviposition.

Marcic et al. 2009. Spider mites, green peach aphid, pear psyllid. Field and greenhouse. Rapeseed spray oil an effective agent in control of European red mite on apple, two-spotted spider mite on cucumber, green peach aphid on pepper and the 1st generation of pear psylla.

Lee et al. 2004. Two spotted spider mites, aphid, whitefly on greenhouse cucumber. Bionatrol reduced all insect populations by 88–95% on greenhouse grown cucumber.

Cottonseed oil: Several commercial products are available that contain cottonseed oil; however, this oil is not generally available for wide spread use.

Advantages

Eco-oil is currently used by most greenhouse growers with Abamectin for TPP management as it gives good control, although there is potential for it and the inseciticde to be over used (Stuart Attwood, pers. comm.). The oil is biodegradable and leaves little residue and does not taint the crops.

Disadvantages

For greenhouse capsicums, formulations over 250 ml/100 L results in burning (Stuart Attwood, pers. comm.). Application of horticultural oils when temperatures are high (above 85–90^{o}F) and/or humidity is low may cause leaf scorch and interfere with plant respiration. Reapplication may be necessary depending on weather conditions. Nil/Limited outdoor crop studies.

3.4 Botanical extracts/oils/derivatives

3.4.1 Product: Neem 600 WP

(Available in NZ, registered outdoor tomatoes)

Active ingredient: Unknown, but contains 600 g/kg Neem seed kernel extract containing insect growth regulators and anti-feedant compounds in the form of a wettable powder.

Mode of action: Insect growth regulator

Use: Greenhouse Whitefly

Studies – NZ: No published studies to date

Studies – overseas: No published studies to date

3.4.2 Product: NeemAzal-T/S

(Available in NZ)

Active ingredient: Derived from the Neem tree kernel. Contains 10 g/L azadirachtin in the form of an emulsifiable concentrate. Also contains sesame oil and surfactant.

Mode of action: Broad spectrum biochemical insecticide. Slow acting naturally based anti-feeding insecticide. When used early, or prior to an increase in pest numbers, it leads to feeding inhibition and to moulting, and also to a reduction in fecundity and breeding ability. The oil and surfactant assist the transport of the active ingredient.

Use: Range of crops for a range of insect pests

Recent studies – NZ

Shaw et al. 2000. San Jose scale on apple. Neem significantly reduced fruit infestation by scale insects at harvest relative to untreated trees but not to the same extent as the

organophosphate insecticides, diazinon and chlorpyrifos.

Berry et al. 2009. Tomato Potato Psyllid. Lab. Studies. After 168 h applications of azadirachtin caused 100% mortality of 3rd instar TPP nymphs.

Recent studies – overseas

Ogbuewu et al. 2010. A review. Over 195 species of insects are affected by neem extracts and insects that have become resistant to synthetic pesticides are also controlled with these extracts.

Weathersbee & McKenzie 2005. Asian citrus psyllid on citrus. Lab studies. Psyllid nymphs were susceptible to azadirachtin at very low concentrations perhaps due to developmental inhibition. No mortality of adult psyllids was observed when exposed to plants treated with concentrations of 11–180 ppm azadirachtin. Adult psyllids demonstrated a small but significant repellent effect from treated plants in a choice experiment.

Musabyimana et al. 2001. Banana root borer. Lab studies. Fewer banana root borer adults settled under corms of banana when treated with 5% emulsified neem oil. Feeding damage by larvae on stem discs was significantly less than untreated discs.

Advantages

Had some success in reducing numbers of TPP with Neem 600WP when trialed on greenhouse tomatoes (Stuart Atwood, pers. comm.). Negligible detrimental effect on beneficial insects. Low phytoxcity.

Disadvantages

NeemAzal caused considerable plant burning when trialed on greenhouse tomatoes (Stuart Atwood, pers. comm.). Limited outdoor crop studies.

3.4.3 Product: Garlic based products

Garlic & Pyrethrum Concentrate
(*Available in New Zealand)*

PyGanic
(*Available in New Zealand)*

BioRepel
(*Available in New Zealand)*

Active Ingredient:

Garlic & Pyrethrum Concentrate is an organic insecticide that combines pyrethrum (a contact insecticide) and garlic oil.

PyGanic contains 13 g/L pyrethrins in an emulsifiable concentrate.

BioRepel contains garlic juice.

Mode of action: Acts as an insect repellent. Technical grade pyrethrum, the resin used in formulating commercial insecticides, typically contains from 20% to 25% pyrethrins. The insecticidal action of the pyrethrins is characterized by a rapid knockdown effect, particularly in flying insects, and hyperactivity and convulsions in most insects. These symptoms are a result of the neurotoxic action of the pyrethrins, which block voltage-gated sodium channels in nerve axon.

Use:

In organic production and home garden

- Garlic & Pyrethrum Concentrate is used on a wide range of pests, including aphids, thrips, leafhoppers and caterpillars.
- PyGanic
    - On avocados and citrus; Greenhouse thrips.
    - On kiwifruit; passion vine hopper,
    - On ornamentals; aphids, earwings, pear slug.

Studies – NZ: No published studies to date.

Studies – overseas: No published studies to date.

Advantages

Organic certified. Garlic exhibits antibacterial, antifungal, amoebicidal and insecticidal qualities. Nil/Limited studies.

Disadvantages

Toxic to bees and fish. Degradation rapid due to sunlight and ultraviolet light. Thorough plant coverage required. Although garlic oils kill pest insects and some pathogens, it also kills beneficial insects and microbes. Thus, it is not recommend as an all-purpose spray for outdoor use. Nil/Limited studies.

3.4.4 Product: Agri50 NF

(Available in NZ, registered on capsicums, tomatoes, cucumbers)

Active ingredient: A colloidal suspension of polysaccharides derived from plant extracts. Contains 28% propylene glycol alginate (hydrated).

Mode of Action: Forms a sticky layer able to trap small insect pests. Most effective against juvenile stages.

Use: unspecified

Studies – NZ: No published studies to date

Studies – overseas No published studies to date

Advantages

Biodegradable, phytotoxicity-safe, and insects do not build up resistance. Negligible detrimental effect on beneficial insects. Nil/Limited studies.

Disadvantages

Nil/Limited studies.

3.4.5 Product: AkseBio2

(Available in NZ?)

Active ingredient: Botanical natural product. Etheric oil of Thymbra spicata.

Mode of Action: unspecified

Use: unspecified

Studies – NZ: No published studies to date

Studies – overseas

Erler et al. 2007. Pear Psylla. Field study. A 2-y field study. 2nd and 3rd applications of AkseBio2 reduced numbers of psyllid eggs and young instars, causing up to 79.4 and 81.1% mortality respectively. Up to 52.7% mortality was achieved on older (third–fifth) instars.

Erler 2004. Pear Psylla. Lab studies. Strong oviposition deterrent effect for winterform and summerform females and caused a reduction in the total number of eggs laid in both choice and no-choice assays. Significant mortalities in freshly laid eggs (0–48 h) and various nymphal stages of the pest were recorded in toxicity assays.

Advantages

Biodegradable; insects do not build up resistance. Negligible detrimental effect on beneficial insects. Nil/Limited studies.

Disadvantages

Nil/Limited studies.

3.4.6 Product: Guava

(Available in NZ?)

Active ingredient: Guava leaf

Mode of Action: unspecified

Use: unspecified

Studies – NZ: No published studies to date

Studies – overseas

Zaka et al. 2010. Asian Citrus Psyllid. Lab studies. Fewer psyllids were found on citrus leaves in the presence of guava foliage than in its absence. Repellent affects were caused by Guava volatile compounds rather than physical factors.

Advantages

Limited information available.

Disadvantages

Limited information available.

3.4.7 Product: Sucrose octanoate
(Available in NZ?)

Active ingredient: Formulation of a synthetic analogue of the natural sugar ester (sucrose octanoate) from leaf trichomes of wild tobacco.

Mode of action: Disrupts the waxy outer layer (cuticle) causing the insect or mite to dry out and die.

Asian citrus psyllid. Mites and other soft-bodied insects

Use: unspecified

Studies – NZ: No published studies to date

Studies – overseas

McKenzie et al. 2005. Silverleaf whitefly. Lab studies. A tomato leaf bioassay showed that effective nymph and adult whitefly control can be achieved with sucrose octanoate at application rates 1% (4,000 ppm [AI]).

McKenzie & Puterka 2004. Asian Citrus Psyllid. Lab and field studies. Sucrose octanoate rates tested ranged from 400 to 8000 ppm (0.1–2% formulated product). Nymphal and adult *D. citri* as well as the mite complex tested were equally controlled to levels of >90% at the higher concentrations of sucrose octanoate .

Advantages

Some studies carried out on other psyllid species. Limited information available.

Disadvantages

Limited information available.

3.4.8 Product: Cis-jasmone
(Available in NZ?)

Active ingredient: A natural plant-derived organic product (semiochemical).

Mode of action: Induces production of plant volatiles that repel undesirable insect pests and also attract beneficial insects (insect predators and parasitoids).

Use:

- Cis-jasmone only;
    - On wheat and beans; aphids, whitefly
    - Cis jasmine plus synergist;
    - On tomatoes; whitefly
    - On peppers;, cotton, eggplant and potatoes; aphids

Studies – NZ: No published studies to date

Studies – overseas

Bruce et al. 2003. Grain aphid. Lab studies. In an olfactometer bioassay cis-jasmone was repellent to alatae of the grain aphid, *Sitobion avenae*. Also, wheat seedlings sprayed with formulated cis-jasmone 24 h previously were less susceptible to attack by *S. avenae* than control plants. In field simulator studies, significantly fewer alate *S. avenae* settled on cis-jasmone-treated plants over a 24-h period. In a series of small-plot experiments conducted over four years, cis-jasmone applications reduced cereal aphid populations infesting wheat in the field.

Birkett et al. 2000. *Aphid species. Lab and field studies.* (Z)-jasmone was found to be electrophysiologically active and also to be repellent in laboratory choice tests. In field studies, repellency from traps was demonstrated for the damson-hop aphid, and cereal aphid numbers were reduced in plots of winter wheat treated with (**Z**)-jasmone.

Advantages

Lab studies indicate that *cis*-jasmone, can "switch on" plant defence against insect attack. Limited information available.

Disadvantages

Limited information available.

3.4.9 Product: Requiem

(Not registered in NZ)

Active ingredient: Plant extract derivative from *Chenopodium ambrosioides* near *ambrosioides***.**

Mode of action: The active ingredient is lipophilic; attracted to the oily outer surfaces of target pests, and works to kill target pests in three ways.

1. Breaks down the insect's exoskeleton. This degradation of the body and joints causes a loss of fluid and inhibits the pest's ability to move.

2. Clogs the trachea, interrupting the insect's respiratory system, preventing respiration and causing suffocation.

3. Disrupts the insect's ability to navigate, blinding it from finding sources of food. Without the ability to locate food, the pest stops its destruction of crops and starves.

Use: Soft-bodied sucking pests including thrips, whiteflies, aphids, mites, leaf hoppers, leafminers, and psyllid. Controls whiteflies, aphids, mites, thrips and other sucking pests in high-value fruits and vegetables.

Studies – NZ: No published studies to date

Studies – overseas

Yang et al. 2010. Lab studies; Tomato Potato Psyllid on tomatoes. In a no-choice test and a choice test, Requiem had significant repellency to adults and deterred oviposition as compared with untreated controls.

Advantages

Resistance development reduced/unlikely due to three different modes of action. Active against all lifecycle stages – eggs to adults. Safe for workers, the environment, and neighbours.

Disadvantages

Good coverage is essential. Nil/Limited outdoor field studies.

3.5 Insecticidal Soaps

3.5.1 **Products: Nufarm Soap**, Yates Defender, PS2

(Available in NZ)

Active ingredient: Potassium fatty acid soaps, 2% solution. PS2 contains the active ingredient maltodextrin.

Mode of action: Direct contact. Fatty acids disrupt the structure and permeability of insect cell membranes. The cell contents are able to leak from the damaged cells, and the insect quickly dies.

Use: Soft body insects; aphids, thrips, scale, mites. PS2 was developed as a potential option for whitefly control (John Thompson (Bioforce), pers. comm.).

Studies – NZ

Berry et al. 2009. Tomato Potato Psyllid. Lab. Studies. After 168 h applications of PS2 caused 50% mortality of 3rd instar TPP nymphs.

Higher mortality has been observed in TPP 1st-2nd instar nymphs (John Thompson, pers. comm.).

Studies – overseas

Cloyd RA. 2009. Cotton/melon aphid, green citrus aphid. Spray applications of a 0.1% concentration of insecticidal soap led to 72% and 79% removal of the cotton/melon aphid and the green citrus aphid on *Pyracantha* spp. Shrubs. Immature stages of aphids were more susceptible to insecticidal soap than adults.

Butler et al. 1993. Sweetpotato whitefly. Greenhouse studies. 0.1% concentration of insecticidal soap caused over 85% mortality of sweetpotato whitefly nymphs compared with water controls on tomato leaves. 0.1% application of insecticidal soap applied to field infested cucumber leaves also caused a significant reduction in sweetpotato whitefly nymphs.

Koehler et al. 1983. Cabbage insect pests. Lab studies. Results indicated frequent application is necessary for effective control.

Advantages

Compatible with IPM programmes. Effective against a range of small pests. Fast acting. Safe to operators, crop workers and consumers. No pre-harvest interval or residues. Considered selective due to minimal adverse effects on beneficial insects. Soaps, alone or in combination with horticultural oils, are also valuable in the management of some plant diseases.

Disadvantages

Potential plant phytotoxic effects. Short residual action means repeat applications may be need at short intervals to control pests. Thorough coverage required. Control may be decreased if hard-water sources are used. PS2 was used by most greenhouse capsicum and tomato growers but results in significant reduction in production and is seldom used now (Stuart Attwood, pers. comm.). Reapplications may be needed depending on weather conditions. Nil/limited outdoor field studies.

3.6 Plant Essential Oils

3.6.1 Products with reported pesticide activity on crops.

Examples:

Cedar Oil
Peppermint Oil
Elder Oil
Thyme Oil
Sage Oil
Eucalyptus Oil.

Active ingredient: Cedar Oil; natural component of wood from the *Juniperus virginiana* L. tree.

Mode of action: Cedar Oil; Repellents and feeding depressants. Works on pheromone driven insects by disrupting the octopamine neuron receptors of these pests.

Uses: unspecified

Studies – NZ: No published studies to date

Studies – overseas

Walker et al. 2011. Tomato Potato Psyllid. Lab. studies. Cinnamon, Wintergreen, Rosemary, Patchouli and D-limolene oils significantly deterred TPP oviposition after 48 h as compared with untreated controls. Patchouli oil also showed significant repellency to female TPP adults compared with untreated controls 48 h after treatment.

Rosa et al. 2010. Lab. studies. Oils; *L. azorica*, *J. brevifolia*, *P. undulatum* leaves and fruits, and *H. gardnerianu*m all showed significant feeding deterrence to *Pseudaletia unipuncta* (Lepidoptera: Noctuidae). *L. azorica* and *J. brevifolia* oils showed strong moderate insecticidal effect on fourth-instar larvae.

Yao 2010. Asian Citrus Psyllid. Lab studies. Petitgrain oils on yellowish-green coloured cards in greenhouse studies showed that scented cars attracted more Asian Citrus psyllids than unscented cards.

Islam et al. 2009. Lab. studies. Bioassays showed the essential oil extracted from coriander, *Coriandrum sativum* L. had vapour toxicity and strong repellency towards all stages of the red flour beetle *Tribolium castaneum*. Oil fumigation yielded 100% mortality for *T. castaneum* larvae, pupae and adults at 0.08 ug/ml dosage.

Abivardi & Benz 1984 (in Endersby & Morgan 1991). Large white butterfly. Greenhouse studies. Peppermint, Angelica and Eucalyptus significantly reduced larval ceding in glasshouse experiments.

Lundgren 1975. Lab. Studies. Elder, Thyme and Sage were found to have oviposition deterrent effects on *P. rape* in laboratory bioassays.

Advantages

Overall, nontoxic to mammals, birds and fish.

Disadvantages

Adverse effects on pollinators and beneficial insects. Due to the volatility of essential oils they have limited persistence under field conditions. Mostly unavailable for commercial use. Nil/Limited outdoor relevant field studies.

4 Discussion

Insect pest control aims to reduce pest infestation to acceptable economic levels. Successful pest management requires the selection of appropriate control methods. A number of factors should be considered before a control method is determined. Examples include: insect mode of action, lifecycle of the insect, crop, crop age, application method requirements, timing, rate and number of applications, product, and human and environmental sustainability.

‘Soft’ chemicals and alternative treatment products such as minerals, oils, soaps, plant extracts, and plant essential oils have been used for many years and until the 1940s pest control chemicals were derived mainly from plants and inorganic compounds (Martin 2009). However, there have been relatively few documented studies on the use of ‘soft’ chemical/alternative treatments in outdoor vegetable crops.

As mentioned, tomato potato psyllid pest management practices in potatoes in New Zealand are unsustainable. The above review documents potential ‘soft’ chemical/alternative treatment options, which could be further evaluated for their use and integration into potato pest management programmes. The use of effective ‘soft’ chemicals/alternative treatments would be a useful complementary or alternative method to the use of traditional insecticides in potato crops. Studies are required on effective options for use in TPP control in potatoes. Options that should be considered include products which cause mortality, act as deterrents, and reduce feeding and oviposition activity. Further research is then required to determine suitability for use in potato crops, appropriate method of application and suitability for inclusion in an IPM programme. From the information above, several promising chemicals, JMS-stylet oil, Eco-Oil and Excel-Oil, could warrant future evaluation based on their efficacy, stability of efficacy, low impact on crop physiology, and low impact on beneficial insects.

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