CONTROL OF PESTS WITH A PYRETHRUM FORMULATION AND IMPACT ON PARASITOID AND PREDATORY SPECIES IN GREENHOUSE TOMATOES

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Summary

A synergized pyrethrins formulation (Py-Zap) was assessed for its efficacy on the pest species, *Trialeurodes vaporariorum* (Westwood) (greenhouse whitefly) and for its impact on the beneficial species, *Encarsia formosa* (Gahan) (parasitoid of whitefly). Trials were conducted on tomato plants in a polyhouse at Coldstream, Victoria. The pyrethrins formulation was highly effective at controlling greenhouse whitefly nymphs with the greenhouse whitefly population on tomato plants being reduced by about 90%. The effect of direct spray contact of Py-Zap on juvenile whitefly with developing Encarsia parasitoids was dependent on the stage of development of the Encarsia. Juvenile Encarsia at a mid-stage of development were not greatly affected by Py-Zap, however, a high proportion of Encarsia that were close to emergence were killed by the Py-Zap residues at the time of emergence. The trials showed that Py-Zap is effective at controlling greenhouse whitefly and that strategies can be employed to minimise the impact of Py-Zap on the beneficial species, by timing application to coincide with less vulnerable stages of their development.

Keywords. *Encarsia formosa,* pyrethrins, *Trialeurodes vaporariorum*, greenhouse tomato

INTRODUCTION

T*rialeurodes vaporariorum* (Westwood) (greenhouse whitefly, GHW) is a serious pest worldwide of crops grown in protected cropping systems.In Australia *T. vaporariorum* is a significant pest of greenhouse grown tomatoes. Symptoms of *T. vaporariorum* infestations on tomatoes include yellowing of leaves and sooty mould outbreaks. *T. vaporariorum* is also a vector of viruses including Tomato torrado virus (Gambley 2010).

Recommended management of *T. vaporariorum* is by using integrated pest management principles, including biological and chemical control (Jelinek 2010). *Encarsia formosa* (Gahan) was introduced into Australia between 1934 and 1936 (Wilson 1960) and is the most commercially abundant biological control agent for *T.vaporariorum*.
With regard to 10 insecticidal active constituents, there are some 100 products registered for use against GWF (APVMA PUBCRIS database; as at May 2014). These active constituents include, acetamiprid, bifenthrin, chlorantraniliprole, dimethoate, vegetable oils, imidacloprid, pyriproxifen, sulfoxaflor, synerigised pyrethrins and thiamethoxam.

Of interest to this study was the use of synergized pyrethrins for the control of *T. vaporariorum* and the potential detrimental effect of pyrethrins on the predatory wasp *E. formosa*. (Simmonds 2002, Masheva 2012).
Pyrethrins are insecticidal esters extracted from the daisy-like plant *Tanacentum cinerariaefolium* (Trevir.). The pyrethrins are broad spectrum insecticides with known efficacy on a wide range of insect pests (Casida and Quistad 1995). However, pyrethrins are quickly degraded in UV Light and by oxidation (Chen and Casida 1969) and therefore are perceived to have have low residual activity.

Pyrethrins are commonly formulated with the synergist piperonyl butoxide. Piperonyl butoxide is an important synergist that enhances the activity of pyrethrum (Yates and Lindquist 1950) and many other insecticides. More lately, piperonyl butoxide has been demonstrated to overcome esteratic metabolic resistance pathways in several insect species (Gunning et al 1998). The judicious use of synergised pyrethrin formulations may therefore have benefits, specifically; in insect resistance management and a short re-entry period, aiding the re-establishment of specific beneficial insect species.

The aim of this study was to determine if a synergized pyrethrum formulation may be useful in controlling *T. vaporariorum* in protected cropping without adversely damaging populations of the predatory wasp, *E. formosa*.

MATERIALS AND METHODS

Test Procedure

All trials were conducted on potted tomato plants (variety 'Ilanto') in a 36 m^2 ventilated polyhouse at Coldstream, Victoria from January to March 2012. Tomato plants were grown from seed and obtained from Yarra Valley Hydroponics, 3 Boundary Rd, Lilydale, Victoria, 3140. No plant protection products were applied to the plants prior to the trial. Daily watering of the plants was by direct watering to the soil, and the plants received an application of commercial fertilizer (Osmocote®) at the recommended rate prior to commencement of the trials. There were sufficient plants to allow selection of six plants (replicates) each for the treatment and control. All trial results were statistically analysed using StatsDirect Statistical Software Version 2.7.8 to separate treatment means at the 95% level of significance.

Insecticides

The synergized pyrethrum formulation, Py-Zap Insecticide with Natural Pyrethrum, APVMA Approval number 60610, was the only insecticide used in this study. Py-Zap is a 40g/L Pyrethrins, 160 g/L Piperonyl Butoxide micro-emulsion formulation. Py-Zap in this trial was used in accordance with the directions for use table at a rate of 2.0 mL product per L of water (80mg pyrethrins / L). Treatment and control plants were then sprayed twice (once each on consecutive days) with Py-Zap or water. For each trial, the application of Py-Zap to tomato plants was made in the morning of the 11th or 12th of February 2012. The control treatments were sprayed with tap water only. Treatments were applied by a portable pressurised sprayer.

Greenhouse whitefly

The whitefly used in this study was *T. vaporariorum. T. vaporariorum* was obtained as a commercial culture (Biological Services, Loxton, SA, 5333). Cultures were reared on host plants grown under ambient greenhouse conditions.

Emerging adult greenhouse whiteflies were released into the polyhouse so that they could infest young tomato plants (800 mm height). The tomato plants with whiteflies were maintained for 96 hours to allow the adult females to lay eggs on the undersides of the leaves. The majority of adult whiteflies were removed from the plants after 96 hours by temporarily placing the plants outdoors and suctioning whiteflies with a portable vacuum, leaving a discreet generation of whiteflies (present as eggs) on the underside of the leaves.

The plants were then maintained in the polyhouse for 11 days, by which time the juvenile whiteflies were at the nymph stage. The plants containing the whitefly nymphs were then thoroughly sprayed twice (once each on consecutive days) with Py-Zap or tap water on the upper and lower leaf surfaces. Plants were then maintained in the polyhouse throughout the assessment period.

Mortality of greenhouse nymphs was assessed to determine treatment effects at four and six days after first treatment (4DATand 6DAT). A single leaf from each plant was randomly selected and examined under a binocular microscope. Dead nymphs appeared dehydrated and flattened whereas live nymphs were clearly more turgid and exhibited raised setae. Mortality was recorded and statistical analysis of the data separated treatment means at the 95% level of confidence.

Encarsia

The beneficial insect used in this study was the parasitoid of greenhouse whitefly *E. formosa. E. formosa* were released by hanging single cards of 100 Encarsia pupae on the petioles of each of twelve tomato plants.
(Encarsia cards were obtained from Biological Services, PO Box 501, Loxton, SA, 5333).

A discreet generation of greenhouse whiteflies was established on the underside of tomato leaves by using the same method as for the whitefly trial. The plants were maintained in the polyhouse for 15 days, by which time the juvenile whiteflies were at the nymph stage. *E. formosa* emerged from pupae on cards within 48 hours and females had opportunity to parasitise the whitefly nymphs. The plants with developing *E. formosa* were maintained in the polyhouse until the parasitised whitefly turned black (approx. 14 days DAT) and until the emergence of *E. formosa* adults at 18-22 DAT. The successful emergence of adult *E. formosa* for the treatments and control was determined by examination of pupal cases under a binocular microscope. Results were compared statistically.

Parasitoid laboratory bioassay

In addition to the polyhouse trial on plants, a bioassay of *E. formosa* was performed in the laboratory. The bioassay purpose was to assess successful emergence of adult Encarsia from pupal cases following application of Py-Zap shortly before emergence was expected, compared to the polyhouse trial where emergence was 18-22 days after Py-Zap treatment. A short time period between treatment application and emergence was not possible in the polyhouse trial because the time of emergence could not be accurately predicted. The laboratory trial therefore provided additional data on the effect of Py-Zap on development of *E. formosa*.

The trial consisted of spraying parasitised whitefly pupal cases less than 72 hours prior to emergence of *E.formosa* adults from the pupal cases. The parasitised whitefly pupal cases containing *E.formosa* were located on cards provided by the commercial insectary. There were five replicates (cards,) each of approximately 100 parasitised pupae. Cards were sprayed with the recommended rate of Py-ZAP.

The treated cards were incubated at 22-25°C until the emergence of adult *E. formosa*, which was completed within 72 hours of treatment application. Successful emergence of adult *E. formosa* for the treatment and control was determined by examining a random sample of 50 pupal cases on each card and results were compared statistically.

RESULTS

Throughout the duration of the trials, the tomato plants grew from approximately 800 mm height to 1.5 m height, producing new green growth and appearing healthy and vigorous.Plants were examined regularly following application of treatments, and no phytotoxicity was observed at any time on leaves, flowers or fruits.

Greenhouse whitefly

The applications of Py-Zap to tomato plants infested with greenhouse whitefly caused high mortality of nymphs when assessed at four and six days after the initial application (Fig. 1). Mortalities were very significantly higher than control mortalities (($P<0.001$) and when adjusted for control mortality using Abbott's Formula (Abbott 1925), mortalities for 4DAT and 6DAT were 92.5% and 87.1%, respectively.

Encarsia

The application of Py-Zap to plants with developing juvenile *E. formosa* wasps on the undersides of the leaves caused a slight reduction in emergence of adult wasps from pupal cases, relative to untreated *E. formosa*, when the application was made 18-22 days prior to emergence (Fig. 2). The difference in percentage emergence was significant ($P=0.038$). In comparison, when Py-Zap was applied to *E. formosa* pupal cases shortly before emergence of adults (<72 hours), there was a more dramatic impact on emergence. Only 24.4% of adult wasps successfully emerged from pupal cases when treated with Py-Zap, compared to a successful emergence rate of 98.4% for the untreated group (Fig. 2). This difference was highly significant ($P<0.0001$). In the Py-Zap-treated group, it was observed that adult wasps died during eclosion, that is, whilst they were emerging from the pupal case. At emergence, the wasps cut a hole in the pupal case with their mandibles and it appears that they contacted a lethal dose of pyrethrins at this stage. The lower mortality observed when Py-Zap was applied at the mid-development stage would be due to break-down of the active ingredient over the longer time frame.

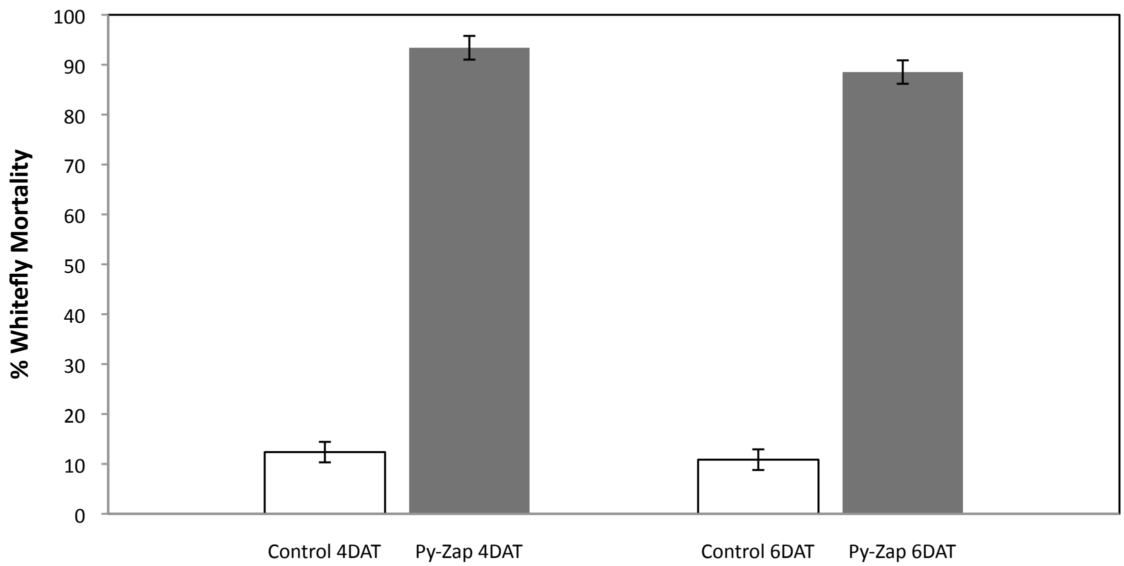

Figure 1. Effect of Py-Zap applications on mortality of *Trialeurodes vaporariorum* nymphs on tomato leaves in polyhouse trial. Error bars indicate one standard error of the mean.

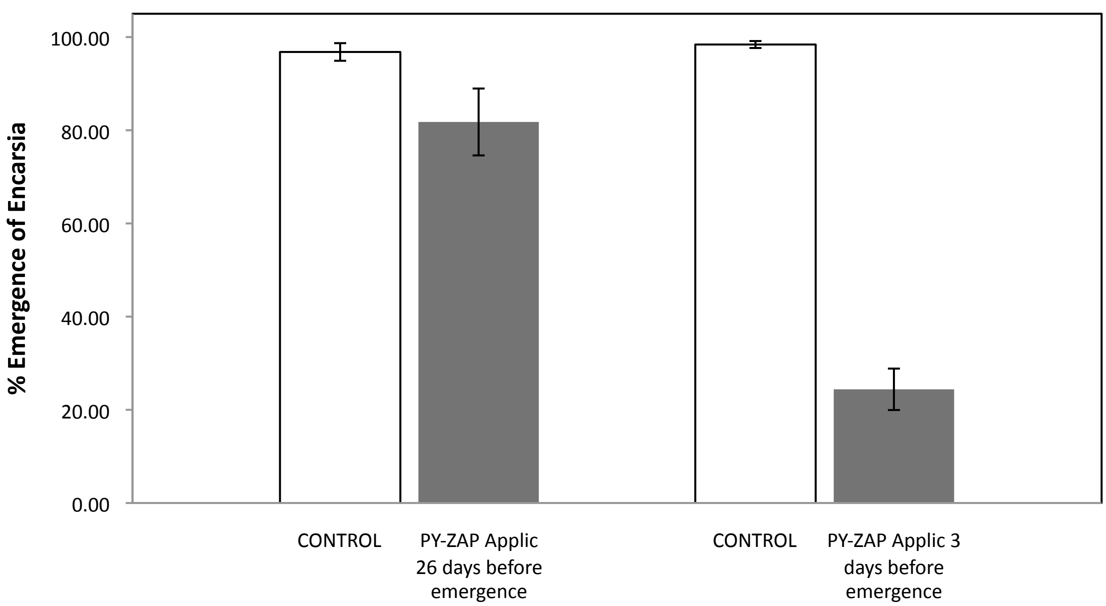

Figure 2. Effect of Py-Zap applications on emergence of *Encarsia formosa* adult wasps when applied to tomato plants 18-22 days and 3 days prior to emergence in polyhouse trial. Error bars indicate one standard error of the mean.

DISCUSSION

This series of trials assessed the efficacy of Py-Zap Insecticide with natural pyrethrum on the pest species *T. vaporariorum* by application to tomato plants in a polyhouse. The impact of Py-Zap on the beneficial species, *E. formosa*, a parasitoid of whitefly, was also tested. Some additional laboratory bioassays were performed to provide extra information that could not be obtained in the polyhouse trials.

Py-Zap was highly effective in controlling *T. vaporariorum* nymphs. About 90% of nymphs were killed in the Py-Zap treatment. The small number that survived may have been due to imperfect spray application coverage of the treatment rather than by tolerance to pyrethrins. Py-Zap efficacy on *T. vaporariorum* was in general agreement to work conducted by other authors where pyrethrum had been used as an active (Simmonds 2002, Masheva et al 2012).

Given previous published work (Simmonds 2002) demonstrated pyrethrum had shown high mortality on *E. formosa*, in the present work, the effect of Py-Zap was evaluated at a mid-development stage (about 12 days after parasitism occurred) and just prior to emergence of adult wasps. For both of these stages, the whitefly pupal cases had turned black, indicating development of *E. formosa* parasitoid inside. The results showed that Py-Zap had a high impact on *E. formosa* when applied just before (<72 hrs) emergence, but it had only a low impact when applied at an earlier developmental stage (18-22 days before emergence of *E. formosa*). Where Py-Zap was applied less than 72 hours in advance of *E. formosa* emergence, the adult wasps developed to emerge from greenhouse whitefly, but then died. The difference in mortality is likely to be due to the breakdown of pyrethrins over time. An application close to the emergence time of the wasps had a higher impact than an application at an earlier stage. It was anticipated before collation of results, that degradation of pyrethrins would have been more rapid than 72 hours. Data on photodegradation of pyrethrins indicates that pyrethrin degradation by light is rapid in direct sunlight. Chen and Casida (1969) found that less than 1% pyrethrin I remained after 5 hours exposure to direct sunlight. However in this trial, no attempt was made to quantify effects of wavelength filtration from the greenhouse structure or formulation type, both of which may conceivably increased pyrethrin stability in this trial.

The implication for the use of Py-Zap in crops where *E. formosa* is also released as a control strategy for greenhouse whitefly is that there is a window of opportunity for the application of Py-Zap that will have minimal impact on the parasitoid wasp. In situations where *E. formosa* has been released, the ideal time to apply Py-Zap to further knockdown a population of greenhouse whitefly would be at the mid-developmental stage of the *E. formosa*, which is when the pupae have just turned black. This would ensure that most of the juvenile *E. formosa* survive the application of Py-Zap. The situation would be more complex, however, if *E. formosa* had been previously released into the crop on more than one occasion and would therefore have more than one life-stage present. Another option could be to apply Py-Zap prior to release of *E. formosa*, although the impact of dried residues on *E. formosa* was not examined in this study.

Py-Zap was therefore shown to be a useful product for pest control in tomato protected cropping. Although direct applications of Py-Zap were harmful to the beneficial species *E. formosa* the results showed that strategies can be employed to greatly reduce impact. If used judiciously, Py-Zap may be employed as a useful tool in integrated pest management in protected cropping environments.

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