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Evaluation of monitoring methods for thrips and the effect of trap colour and semiochemicals on sticky trap capture of thrips (Thysanoptera) and beneficial insects (Syrphidae, Hemerobiidae) in deciduous fruit trees in Western Australia

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ABSTRACT

Western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), plague thrips (*Thrips imaginis* Bagnall), and onion thrips (*Thrips tabaci* Lindeman) are pests of deciduous fruit trees in Australia. Yellow sticky traps and tapping buds and flowers for thrips are currently recommended for monitoring, but it is not known whether one method is more efficient than the other, or if selectivity could be optimised by trap colour, or addition of semiochemicals Thripline$^{®}_{ams}$ or Lurem-TR lures to traps. The number and species of thrips caught by trapping and tapping of flowers and leaves, on different trap colours (black, blue, green, red, yellow, white), including a control (clear) and thrips semiochemicals, were evaluated in a series of trials in commercial deciduous fruit orchards in the Perth Hills, Western Australia. There was poor correlation between thrips caught on traps and tapping samples ($R^2 = 0.00$ −0.05), with tapping less likely to trigger the action threshold and yielding less than 1% of the number of thrips caught on sticky traps. More thrips (*F. occidentalis*, *T. imaginis* and *T. tabaci*) were caught on blue, yellow and white bases, than on clear, red, green or black bases. On commercially available sticky traps, seven times more *F. occidentalis* were caught on 'Seabright blue' traps than yellow. The addition of semiochemicals increased capture of *F. occidentalis* by three times on baited compared to unbaited traps, on yellow and 'Seabright' blue traps. Thripline$^{®}_{ams}$ attracted *F. occidentalis*, but had no effect on the capture of *T. imaginis* or *T. tabaci*, whilst Lurem-TR attracted more *F. occidentalis* and also increased the capture of *T. imaginis*. More beneficial insects including brown lacewings (*Micromus tasmaniae* (Walker)) and hoverflies (*Melangyna viridiceps* (Macquart)) were caught on blue trap bases (1.6 times more) than other trap base colours. No beneficial insects were present during the Thripline$^{®}_{ams}$ experiment, whilst Lurem-TR increased trap capture of brown lacewings by 1.3 times. A monitoring system incorporating blue sticky traps in conjunction with Thripline$^{®}_{ams}$ would be more selective at detecting and monitoring *F. occidentalis* in deciduous fruit in Australia.

1. Introduction

Thysanoptera (thrips) are key pests of deciduous fruits in Australia, causing damage at flowering or fruit set (early season damage), or as fruits mature (late season damage) (Hardy et al., 2005), resulting in reduction in market value of crops. Native plague thrips (*Thrips imaginis* (Bagnall)) were first recorded as a pest of apples in the 1930s. Adult *T. imaginis* reduce pollination by feeding on the flower parts and fruit stalks (Evans, 1932; Brough et al., 1994). The larvae cause scarring, surface russeting and corkiness by feeding on, and scarring, the ovaries of peaches (*Prunus persicae* (L.) Batsch, Rosaceae), plums (*Prunus domestica* L., Rosaceae) and nectarines (*Prunus persica* variety nectarine, Rosaceae) from late bloom through to petal/shuck fall (Brough et al., 1994). Onion (*Thrips tabaci* (Lindeman)) and tomato thrips (*Frankliniella schultzei* (Trybom)) have also been recorded as sporadic pests of deciduous fruits (Steiner, 2008), attacking fruit 2–3 weeks before harvest. Silvering or whitening of the skin is caused by adults and larvae feeding on the fruit surface, with damage more apparent in protected areas where thrips shelter.

In the last decade, economic losses due to thrips damage has increased and is attributable to the spread of western flower thrips (*Frankliniella occidentalis* (Pergande)) into fruit growing areas (Broughton et al., 2011). First detected in Western Australia in 1993

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(Malipatil et al., 1993), *F. occidentalis* is now regarded to be a serious regional issue in Western Australia (Perth hills, Manjimup/Donnybrook), New South Wales (Central West Coast, Sydney Basin), Queensland (Granite Belt), and Victoria (Goulburn Valley) (Hardy et al., 2005). 'Pansy spots' or 'ghost spots' were first reported in 2000 from apples (cv. Granny Smith, Red Delicious) in south-eastern Queensland, and in 2003/04 from apples (cv. Granny Smith, Pink Lady) in the Perth hills. These spots result from oviposition sites over which scar tissue has developed (Cockfield et al., 2007; Steiner, 2008), and are often surrounded by a larger discolouration resembling a 'pansy' shape: red and green-skinned apples are most susceptible (Cockfield et al., 2007). Silvering of nectarines was first reported in the 2002/03 season in Forbes, Central Coast region of New South Wales, in 2002/03 in the Perth hills, Western Australia, and in the 2006/07 season in Swan Hill, Victoria (Mansfield and Lorimer, 2006).

In efforts to control insect pests in orchards, growers are encouraged to adopt Integrated Pest Management principles including the conservation of naturally occurring beneficial insects such as lacewings (*Micromus tasmaniae* (Walker), Neuroptera), ladybirds (Coccinellidae) and hoverflies (*Melangyna viridiceps* (Macquart), Syrphidae) which feed on aphids and mites (Malipatil et al., 2009). Growers can also release beneficials for the control of pests such as phytoseiid mites (*Phytoseiulus persimilis* (Athias-Henriot) and *Typhlodromus occidentalis* (Nesbitt)), for the control of two-spotted mite (*Tetranychus urticae* (Koch)).

Effective thrips control, however, relies on pesticide applications due to a lack of alternative control measures for field crops in Australia (Broughton and Herron, 2009). To successfully manage thrips, correct identification of the damaging species is critical due to the resistance of *F. occidentalis* to a range of insecticides from different chemical classes including synthetic pyrethroids, organophosphates, and carbamates (Herron and Gullick, 2001), and newer chemistries such as fipronil and spinosad (Herron and James, 2005). Insecticides applied at flowering to control *T. imaginis* such as tau-fluvalinate (synthetic pyrethroid), dimethoate (organophosphate), or methomyl (carbamate) are not as effective against *F. occidentalis*. Spinosad effectively controls *F. occidentalis* (if populations are not compromised by resistance), is regarded to be organic, is relatively safe to use with many beneficial insects, but is not effective against *T. imaginis*.

In plum orchards in South Africa, Allsopp (2010) found that blue traps caught more *F. occidentalis* and *F. schultzei* than yellow traps. Matteson and Terry (1992) have shown that *F. occidentalis* are attracted to the brightness of the blue wavelength in cotton, and blue traps have been reported to catch more *F. occidentalis* in glasshouse (Brødsgaard, 1989; Gillespie and Vernon, 1990) and field crops (broccoli, Chen et al., 2004; lettuce and onion, Natwick et al., 2007). White (Yudin et al., 1987) and yellow (Cho et al., 1995) traps have also been reported to catch *F. occidentalis* in open lettuce and tomato crops, respectively. Low ultra-violet reflecting white, blue and yellow water traps have been shown to catch more *T. imaginis* than green, red, black and high ultra-violet reflecting white (Kirk, 1984).

The few studies on the effect of trap colour on capture of beneficial insects suggest a variable response. Clare et al. (2000) and Wallis and Shaw (2008) evaluated the effect of red, green, white, yellow and blue traps on capture of beneficial species in New Zealand apple orchards. White attracted more honey (*Apis mellifera* L.) and native bees (*Lasioglossum*, *Hylaeus* spp.), blue attracted more bumble bees (*Bombus* spp.) (Clare et al., 2000), whilst yellow traps attracted more parasitic wasps (Wallis and Shaw, 2008). Yellow traps also attracted more seven-spotted ladybird, *Coccinella septempunctata* (L.), in alfalfa (Maredia et al., 1992), and aphidophagous hoverflies (Laubertie et al., 2006) including *Melangyna* spp. in water traps in wheat (Bowie et al., 1999). However, Chen et al. (2004) found that blue attracted more hoverflies (*Allograpta obliqua* (Say)) than yellow or white traps in their trials in broccoli. The green lacewing *Chrysoperla carnea* (Stephens) showed a variable seasonal response to orange, red, black hues and clear traps in alfalfa (Blackmer et al., 2008).

The development of thrips semiochemicals could further enhance trap selectivity. Thripline$^{®}_{ams}$ developed by Keele University, England (Hamilton and Kirk, 2003), and produced by Syngenta Bioline Ltd (also marketed by Biobest as ThriPher), is a synthetic version of a sexual aggregation pheromone produced by male *F. occidentalis*. Lurem-TR is a kairomone (interspecific) attractant derived from host plants and related compounds (Teulon et al., 2008b), developed by Plant Research International, the Netherlands and Crop and Food Research New Zealand (van Tol et al., 2007), and distributed by Koppert (2010). The semiochemicals differ in their attractancy to different thrips species. Thripline$^{®}_{ams}$ is species-specific, attracting male and female *F. occidentalis*, whilst Lurem-TR is interspecific, known to attract *F. occidentalis*, *T. tabaci* and *Thrips major* Uzel (Teulon et al., 2008a,b).

To minimise pesticide use and their effect on beneficial insects, growers should apply pesticides only when thrips are present. Current recommendations for monitoring thrips are yellow sticky traps and/or tapping buds or flowers (Hardy et al., 2005). The present study compares the effectiveness of tapping versus trapping at triggering the pesticide application action threshold for thrips in deciduous fruit trees; and aims to identify the optimal trap colour and semiochemical combination for monitoring thrips, particularly *F. occidentalis*, whilst being the least detrimental to beneficial insects.

2. Materials and methods

2.1. Field sites

Trials were conducted on commercial farms in the Perth Hills, southwestern Australia, which had previously sustained *F. occidentalis* damage (Table 1). This region has a Mediterranean climate with hot, dry summers (December–February) and cool, wet winters (June–August). Mean monthly daily air temperatures range from 16.2 to 18.2 °C (min) to 22.3–36.0 °C (max) in summer, and 8.5–13.6 °C (min) to 19.3–25.7 °C (max) in winter; most rainfall is received in June–August (>100 mm/month) (BOM, 2011). *F. occidentalis* are present all year, but are most abundant from October to April (Broughton unpubl. data). No control of *F. occidentalis* was carried out during trap trials, though control was carried out against other pests such as Mediterranean fruit fly (*Ceratitis capitata* (Wiedemann)) with organophosphate insecticides.

Table 1
Trap sites.

Orchard	Cultivars	Location	Latitude and longitude
A	Red Roy, August Red (nectarines)	Roleystone	S32° 01′390, E116°06′388
B	Rose Diamond/Spring Bright (nectarines)	Pickering Brook	S32° 01′725, E116°06.963
C	Arctic Star/Spring Bright (nectarines)	Karragullen	S32 06.101, E116 07.171
D	Pink Lady (apple), Rose Diamond (nectarine)	Karragullen	S32 06.673, E116 07.541
E	Sundowner (apple), Arctic Star (nectarine)	Karragullen	S32 05.435, E116 07.293