INSECTICIDE RESISTANCE IN AUSTRALIAN POPULATIONS OF WESTERN FLOWER THRIPS, *FRANKLINIELLA OCCIDENTALIS* (PERGANDE) (THYSANOPTERA: THRIPIDAE)

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Summary

Insecticides are the main method of Western Flower Thrips (WFT) control in Australia and their effective management is underpinned by resistance monitoring of field populations. Surveys conducted between 2003 and 2006 did not detect resistance to acetamiprid, dimethoate, methamidophos or thiamethoxam but, low level resistance was detected against abamectin, acephate, chlorpyrifos, dichlorvos, endosulfan, fipronil, malathion, methidathion, methiocarb and methomyl. Worryingly, high level resistance was detected to α-cypermethrin (25x) and spinosad (87x). Spinosad is now the most widely used registered product for WFT control. Loss of spinosad would jeopardise the WFT control strategy so it is imperative that the resistance is effectively managed.

Keywords: chemical control, resistance, Western Flower Thrips

INTRODUCTION

Western Flower Thrips (WFT) (*Frankliniella occidentalis* (Pergande)) was first detected in Australia in 1993 (Malipatil *et al.* 1993). It is a serious pest of a wide range of horticultural crops where adults and nymphs can cause crop loss by direct feeding (Kirk 2002) or by spreading virus disease (Broadbent and Allen 1995).

In Australia, insecticides are the main method of WFT control (Herron *et al.* 1996). However, Australian field collected populations of WFT are resistant to a number of chemicals used for that purpose (Herron and Gullick 2001, Herron and Cook 2002, Herron and James 2005). Low-level (1.8x) spinosad resistance was first detected in 2002-2003, but subsequent laboratory selection with spinosad demonstrated that resistance could quickly increase (Herron and James 2005). With spinosad now the most widely registered insecticide for WFT control, its loss due to resistance would jeopardise the current WFT control strategy including the newly emerging WFT integrated pest management (IPM) strategies (Jones *et al*. 2005).

Here we present crop-specific insecticide resistance monitoring data in field-collected populations of WFT for seasons 2003-2004 to 2005-2006.

MATERIALS AND METHODS

Insecticides

Chemicals trialled including their common name, trade name, formulation and supplier are given in Table 1.

Thrips maintenance

Thrips were placed in ventilated, thrips-proof containers and forwarded by overnight courier from their point of collection to our laboratory at Menangle in New South Wales. Prior to culture establishment thrips were confirmed as WFT using the diagnostic guide of Palmer *et al*. (1992).

Thrips were cultured on potted dwarf French bean (*Phaeseolus vulgaris* L.) using methods given in Herron and Gullick (2001). Briefly, WFT were reared in purpose-built rearing cages on potted bean plants with cumbungi (*Typha domingensis* Pers.) pollen and honey as a supplementary food source. Thrips were transferred onto fresh plants in a new cage on a six-weekly cycle and maintained at 25±1 °C under a 16:8 hour L: D regimen.

Bioassay method

The bioassay procedure was that of Herron *et al*. (1996). Briefly, WFT were lightly anaesthetised with CO_2 and then tipped onto French bean leaf discs embedded in agar in 35 mm diameter Petri dishes. The leaf discs with anaesthetised thrips in place were sprayed with a susceptible discriminating concentration (SDC)(Table 1) of insecticide (4 mL aliquot) or with water (control) via a Potter spray tower producing a deposit of 3.2 ± 0.08 mg cm^{-2}. Some strains with survivors at the SDC were further tested against serial insecticide concentrations to yield full log-dose probit responses. Once sprayed each Petri dish was covered with taut plastic cling-wrap film perforated with 40-50 fine ventilation holes. The dishes were stored for 48 h at 25 ± 0.1 °C under a 16:8 hour L: D regimen. The numbers of live and dead thrips were counted with the aid of a stereo-microscope. Each test was replicated at least once. Control mortality did not exceed 15%.

Data analysis

SDC results were corrected for control mortality (Abbott 1925). Probit regressions were analysed using GENSTAT 5 statistical software (Anon. 1988). The LC50 plus its 95% fiducial limits were calculated using the probit method outlined in Finney (1971). The LC50s were used to calculate resistance factors (RF50s) as outlined in Robertson and Preisler (1992).

Table 1. Common name, trade name, formulation, susceptible discriminating concentration (SDC) and supplier of insecticides.

Common name	Trade name	Formulation	SDC[1]	Supplier
abamectin	Vertimec	18 g L^{-1} EC	0.3 g L^{-1}	Syngenta Crop Protection
acetamiprid	Mospolan	225 g L^{-1} SL	0.5 g L^{-1}	Dupont (Australia) Ltd.
acephate	Orthene Xtra	970 g kg^{-1} SG	3.0 g L^{-1}	Arvesta Corporation
α-cypermethrin	Dominex Duo	100 g L^{-1} EC	0.01 g L^{-1}	FMC (Chemicals) Pty. Ltd.
chlorpyrifos	Lorsban 500 EC	500 g L^{-1} EC	0.1 g L^{-1}	Dow AgroSciences Aust. Ltd.
dichlorvos	Dichlorvos 1140	1140 g L^{-1} EC	0.6 g L^{-1}	Nufarm Aust. Ltd.
dimethoate	Dimethoate	400 g L^{-1} EC	1.0 g L^{-1}	Nufarm Aust. Ltd.
endosulfan	Endosulfan	350 g L^{-1} EC	1.5 g L^{-1}	Nufarm Aust. Ltd.
fipronil	Regent 200 SC	200 g L^{-1} SC	0.005 g L^{-1}	Nufarm Aust. Ltd.
malathion	Hy-mal	1150 g L^{-1} EC	0.3 g L^{-1}	Crop Care Australasia Pty. Ltd.
methamidophos	Nitofol	580 g L^{-1} EC	0.4 g L^{-1}	Bayer CropScience Pty. Ltd.
methidathion	Supracide 400	400 g L^{-1} EC	1.0 g L^{-1}	Syngenta Crop Protection
methiocarb	Mesurol 750 WP	750 g kg^{-1} WP	0.06 g L^{-1}	Bayer CropScience Pty. Ltd.
methomyl	Lannate L	225 g L^{-1} SC	0.3 g L^{-1}	Crop Care Australasia Pty. Ltd.
thiamethoxam	Actara	250 g kg^{-1} WG	0.3 g L^{-1}	Syngenta Crop Protection
spinosad	Success Naturalyte	120 g L^{-1} EC	0.01 g L^{-1}	Dow AgroSciences Aust. Ltd.

EC = Emulsifiable concentrate
SC = suspension concentrate
SG = water soluble granule
SL = soluble concentrate
WG = water dispersible granule
WP = wettable powder

[1] Herron and James (2005)

RESULTS

Thrips for resistance testing were collected from capsicum, chilli, lettuce, lucerne, ornamentals, strawberry and tomato (Table 2). Over three years of resistance monitoring (2003-2004 to 2005-2006) resistance was not detected against acetamiprid, dimethoate, methamidophos or thiamethoxam (Table 3). Low-level resistance was detected against abamectin, acephate, chlorpyrifos, dichlorvos, endosulfan, fipronil, malathion, methidathion, methiocarb and methomyl. High-level

Table 2. Number of Western Flower Thrips strains collected each season from a range of different host crops that were subsequently evaluated for resistance.

Crop	Season		
	2003-2004	2004-2005	2005-2006
Capsicum		2	2
Chilli		2	3
Lettuce		1	1
Lucerne	1		
Ornamental	3	1	
Strawberry		2	1
Tomato	1		

resistance was detected to α-cypermethrin (25x) and spinosad (87x) (Table 2).

DISCUSSION

In Australia, chemicals are largely used to control WFT and resistance remains a threat to the whole Australian WFT chemical control strategy. In this study resistance was detected against many chemicals used for WFT control but there was complete susceptibility remaining (ie 100% mortality at the SDC recorded for all populations tested) to acetamiprid, dimethoate, methamidophos and thiamethoxam. In many instances where survivors at the SDC were detected, resistance frequencies and resistance factors were low, but for the first time, high-level spinosad resistance causing control failure is reported.

Low-level (1.8x) spinosad and fipronil (0.8x) resistance was first detected in 2002-2003 but subsequent laboratory selection with fipronil and spinosad showed that resistance to both insecticides could quickly increase under selection pressure (Herron and James 2005). Our recent field monitoring has verified this is now at serious risk yet spinosad remains the only registered chemical compatible with IPM of WFT and biological control. For WFT IPM to achieve greater adoption improved resistance management of strategic chemicals, particularly spinosad, is paramount (Jones *et al*. 2005). With spinosad now the most widely used insecticide for WFT control, its loss to resistance will jeopardise the entire WFT control strategy.

It is worthy of note that methamidophos resistance failed to be detected when it has been found in previous studies (Herron and James 2005, Herron and Gullick 2001). By the late 1990s methamidophos was the mainstay insecticide for WFT control with use recommended on cucumber, lettuce, capsicum, tomato and ornamentals (Infopest 2001). However, by 2002 methamidophos was under review by the National Registration Authority (NRA) (now the Australian Pesticides and Veterinary Medicines Authority (APVMA)(NRA 2002). Since then its use has been progressively restricted and is now available for use on ornamentals only (Infopest 2006). We consider it likely that the progressive restriction in methamidophos use has contributed to the reduction in the resistance frequency.

Due to high-level ubiquitous resistance pyrethroids are no longer recommended for use against WFT in Australia (Herron and Gullick 2001). Additionally, field trials showed pyrethroid resistance was not reduced by alternation to unrelated insecticides (Herron and Cook 2002). Some two seasons after pyrethroids were no longer recommended 25x α-cypermethrin resistance was still detected in WFT from lucerne after a pyrethroid spray and subsequent control failure.

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Table 3. Dose-response summary for 16 insecticides tested over three consecutives seasons of Western Flower Thrips resistance monitoring.

Chemical	Season								
	2003-2004			2004-2005			2005-2006		
	N	% mortality at SDC	RFs	N	% mortality at SDC	RFs	N	% mortality at SDC	RFs
abamectin	4	87 - 100	*	3	100	*	2	99 - 100	*
acetamiprid	*	*	*	*	*	*	1	100	*
acephate	4	97 - 100	*	*	*	*	*	*	*
α-cypermethrin	1	9	25	*	*	*	*	*	*
chlorpyrifos	4	52 - 86	* - 4.5	*	*	*	*	*	*
dichlorvos	4	80 - 94	1.5 - *	7	84 - 99	*	4	87 - 97	*
dimethoate	1	100	*	1	100	*	3	100	*
endosulfan	5	99 - 100	*	*	*	*	3	100	*
fipronil	5	64 - 100	0.7 – 4.0	8	62 - 100	0.4 – 4.7	7	87 - 100	1.8 - *
malathion	4	93 - 98	3.0 - *	4	93 – 100	*	*	*	*
methamidophos	5	100	*	*	*	*	3	100	*
methidathion	3	100	*	4	99 - 100	*	2	100	*
methiocarb	3	92 - 96	*	*	*	*	1	99	*
methomyl	4	94 - 98	* - 1.4	8	91 - 100	*	4	96 - 100	*
thiamethoxam	*	*	*	*	*	*	3	100	*
spinosad	5	84 - 100	0.9 – 2.6	8	24 - 100	0.1 - 40	7	12 - 100	* - 87

SDC - Susceptible discriminating concentration
N - Number of strains tested
RF - Resistance Factor (LC50 field population/LC50 reference susceptible strain)
* Not tested (some RFs include a single probit regression result only so a complete range is not available eg *-1.5 or 3.0 - *)

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