

Insecticide resistance in cotton aphid and two-spotted spider mite: seasons 2004-2005 and 2005-2006

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Abstract

For season 2004-2005, sixty-one percent of cotton aphid populations were Pirimor® resistant but Intruder®, Actara®, Thiodan® and Pegasus® susceptible. Two-spotted mite was Agrimec®, Comite® and Pegasus® susceptible. Intrepid® resistance was detected in 43 and Talstar® 57 percent of mite stains. Curacron® resistance in two-spotted mite was ubiquitous and often at high frequencies. At the time of writing testing for season 2005-2006 was incomplete but Pirimor® resistance seemed less than in season 2004-2005. Intrepid® resistance was still detected in 67% of the two-spotted mite strains although the product was not available for use in cotton. We conclude that the resistance management strategy for cotton aphid and two-spotted mite should remain 'as is' for season 2006-2007.

Introduction

With the introduction of transgenic cotton, control for *Helicoverpa* spp. has declined, however, this has allowed mirid population to survive, which now often require control. The insecticides applied to control mirids are often disruptive of beneficials, thereby increasing the risk of outbreaks of secondary pests such as aphids or mites. Two-spotted mite has a proven ability to develop resistance and recently developed resistance to chlorfenapyr (Intrepid®)(Herron *et al.* 2004). A few years earlier, high-level organophosphate and carbamate resistance has developed in cotton aphid (Herron *et al.* 2001).

The pest status of aphids is often related to the contamination of the cotton lint with sugary 'honey-dew'. However, earlier outbreaks can significantly reduce yield and recently cotton aphid was confirmed as a vector for 'Cotton Bunchy Top' syndrome. These changes in the system mean that the need for effective tools to control aphids and resistance management for those tools is critical to the cotton industry.

Cotton aphid reproduces asexually causing very rapid changes in resistance levels. Management of aphids is further complicated because there is no dilution of resistance by outcrossing to susceptibles, as is used to manage *Bt* resistance in *Helicoverpa* spp. Therefore, aphids can very quickly become a major problem when chemical control fails due to resistance (Herron *et al.* 2001).

Two-spotted mite is notorious world-wide for developing resistance. As new compounds have become available we have pro-actively established baseline resistance levels and cross-resistance profiles and initiated routine resistance monitoring. Unfortunately, resistance continues to evolve as seen most recently to Talstar® (Herron *et al.* 2001a) and then Intrepid® (Herron *et al.* 2004). This is occurring largely due to use of these compounds against other pests, rather than mites themselves, and is disturbing, as it reduces the number of chemicals available for two-spotted mite control. Management of mites is complicated because most chemicals are also targeted against other pests such as aphids or *Helicoverpa* spp. and this has contributed to resistance development to organophosphates, Talstar® and Intrepid®.

Effective management of two-spotted mite and cotton aphid will be best achieved by pursuing an integrated approach that includes resistance management, based on a sound understanding of their resistance and cross-resistance spectra (reported separately in M^cLoon and Herron). Continued resistance monitoring, and the timely inclusion of new chemistry, is essential for effective ongoing management of this pest species. Here we report our resistance monitoring data for cotton aphid and two-spotted mite for seasons 2004-2005 and 2005-2006.

Materials and methods

Chemicals

Proprietary commercial formulations of pirimicarb (Pirimor®), thiamethoxam (Actara®), acetamiprid (Intruder®), profenofos (Curacron®), bifenthrin (Talstar®), abamectin (Agrimec®), propargite (Comite®), chlorfenapyr (Intrepid®) were used, except difenthiuron (Pegasus®) where the UV activated carbodiimide derivative, CGA-140408 was tested instead.

Cotton aphid

Aphids were collected by researchers, CRC Industry Development Officers, consultants and growers from cotton fields. They were then sent by overnight courier to the bioassay laboratory at Camden (EMAI) and each field strain cultured separately on pesticide-free cotton (Deltapine 90) at $25 \pm 4^\circ\text{C}$ under natural light. Strain integrity was assured by maintaining populations in purpose built insect proof cages. Aphids were tested by placing them in a 35 mm Petri dish on an excised cotton plant leaf disc fixed in agar (Herron *et al.* 2001). Batches of ten adult female aphids per leaf disc were then sprayed with the aid of a Potter spray tower that produced an aqueous deposit of $1.6 \pm 0.07 \text{ mg cm}^{-2}$ with a 2 mL spray aliquot (Herron *et al.* 2001). Each test was replicated and included a water only sprayed control. After spraying, Petri dishes were covered with ventilated clear plastic film and maintained at $25 \pm 0.1^\circ\text{C}$ in 16:8 L:D for 24 h after which mortality was assessed.

Two-spotted mite

Strains of two-spotted mite were randomly collected late in each cotton season and put into culture as above. The bioassay procedure required young adult female mites to be transferred from culture to French bean leaf

discs (Herron *et al.* 2001a). Mites and leaf discs were then sprayed with insecticide with the aid of a Potter spray tower as above. Each test was replicated and included a water only sprayed control. After spraying, mites on leaf discs were maintained at 28 ± 0.1 °C in constant light for 48 h after which mortality was assessed.

Results

During season 2004-2005, strains of mites were collected from the Namoi, Gwydir and Griffith areas (Table 1). Agrimec®, Comite® and Pegasus® resistance was not detected. Intrepid® resistance was detected in 3 of the 7 strains and Talstar® resistance in 4 of the 7 stains. Curacron® resistance was ubiquitous and often at high frequencies. In the following 2005-2006 season, Agrimec® and Comite® resistance was again not detected but Pegasus® testing was not yet complete. Intrepid® and Talstar® resistance was detected in 4 and 2 of the 6 strains tested respectively. Curacron resistance frequencies were very high in the two strains tested (AN and KI)

Table 1. Percent mortality at the discriminating dose (ie percent susceptible) for various strains of TSM collected during season 2004-2005 and 2005-2006 and evaluated for resistance against Talstar®, Intrepid®, Agrimec®, Comite®, Pegasus® (CGA-140408) and Curacron®

Year	Strain	Area	Chemical					
			Talstar®	Intrepid®	Agrimec®	Comite®	Pegasus®	Curacron
04-05	AN	Namoi	29	96	100	100	100	12
	G	Namoi	31	84	100	100	100	19
	TG	Griffith	100	100	100	100	100	43
	GL	Gwydir	100	100	100	100	100	10
	NH	Namoi	44	90	100	100	100	17
	RAV	Griffith	100	100	100	100	100	79
	PU	Namoi	50	100	100	100	100	10
05-06	AN	StGeorge	100	100	100	100	TBC	2
	KI	StGeorge	100	99	100	100	TBC	1
	BE	U Namoi	58	93	100	100	TBC	TBC
	CU	U Namoi	93	97	100	100	TBC	TBC
	M	U Namoi	100	98	100	100	TBC	TBC
	CA	not noted	100	100	100	100	TBC	TBC

TBC=to be completed

Aphids were collected more widely than mites in season 2004-2005 with samples from the Gwydir, the Namoi, Goondiwindi, Dalby, Bourke, St George and Hillston (Table 2) No resistance was detected against Intruder®, Actara®, Thiodan® or Pegasus®. Pirimor® resistance was detected in 61% of the populations surveyed. Testing during season 2005-2006 was still very much at initial stages at the time of writing with only Pirimor® data available. Although testing is yet not complete, Pirimor® resistance appears to be less abundant than in the previous season.

Table 2. Percent mortality at the discriminating dose (ie percent susceptible) for various strains of cotton aphid collected during season 2004-2005 and 2005-2006 and evaluated for resistance against Pirimor®, Pegasus® (CGA-140408), Thiodan®, Actara® and Intruder®

Year	Strain	Area	Chemical				
			Pirimor®	Pegasus®	Thiodan®	Actara®	Intruder®
04-05	Norw	Gwydir	92	100	100	100	100
	Lamer	Gwydir	87	100	100	100	100
	F2#1 AC	Namoi	Did	not	establish	into	culture
	Mapl F1	Goondi	100	100	100	100	100
	Carring	Goondi	100	100	100	100	100
	Pall F4	Goondi	100	100	100	100	100
	McD K3	S George	95	100	100	100	100
	Alc F007	Goondi	Did	not	establish	into	culture
	Mor Win	Goondi	Did	not	establish	into	culture
	Car F2-7	Goondi	Did	not	establish	into	culture
	Mor E4	Goondi	Did	not	establish	into	culture
	War18-22	Goondi	Did	not	establish	into	culture
	Tuck	Goondi	Did	not	establish	into	culture
	Car20-25	Goondi	99	100	100	100	100
	Caffery	Dalby	100	100	100	100	100
	Lat F15	Bourke	100	100	100	*	*
	Lat F17	Bourke	96	100	100	100	*
	Lat F18	Bourke	100	100	100	100	100
	Lat LM3	Bourke	90	100	100	100	100
	Bee F16	Gwydir	Did	not	establish	into	culture
	Tara	Namoi	95	100	100	100	100
	Hava F4	Namoi	91	100	100	100	100
	Beech	Namoi	Did	not	establish	into	culture
	Purl F42	Gwydir	91	100	100	100	100
	Milo	Gwydir	Did	not	establish	into	culture
	Glen F6B	Namoi	100	100	100	100	100

Year	Strain	Area	Chemical				
			Pirimor®	Pegasus®	Thiodan®	Actara®	Intruder®
	Mira F2	Namoi	100	100	100	100	100
	Veth F5	Gwydir	93	100	100	100	100
	LFL F1 B	Hillston	97	100	100	100	100
	LFL30/2015	Hillston	90	100	100	100	100
	LFLG16-26	Hillston	100	100	100	100	100
	LFLY12-15	Hillston	Did	not	establish	Into	culture
	LFL B lat	Hillston	92	100	100	100	100
	LFL dr lat	Hillston	93	100	100	100	100
05-06	ACRI R6 1	Namoi	8.1	TBC	TBC	TBC	TBC
	CH	Gwydir	100	TBC	TBC	TBC	TBC
	Tell F 33	Gwydir	TBC	TBC	TBC	TBC	TBC
	Wood	Gwydir	100	TBC	TBC	TBC	TBC
	Yar	Downs	Did	not	establish	into	culture
	Oak F 1	Downs	100	TBC	TBC	TBC	TBC
	Aru F 3	Downs	TBC	TBC	TBC	TBC	TBC
	War M7	Downs	100	TBC	TBC	TBC	TBC
	Over F 4	Downs	TBC	TBC	TBC	TBC	TBC
	Sin F 23	Downs	Did	not	establish	into	culture
	Eden	Downs	100	TBC	TBC	TBC	TBC
	ACR1 R6 2	Namoi	TBC	TBC	TBC	TBC	TBC
	War F 2	U Namoi	TBC	TBC	TBC	TBC	TBC
	Bell F 15	U Namoi	TBC	TBC	TBC	TBC	TBC
	Mer	U Namoi	TBC	TBC	TBC	TBC	TBC
	Cur F 25	U Namoi	TBC	TBC	TBC	TBC	TBC
	Cur F 22	U Namoi	100	TBC	TBC	TBC	TBC
	Car F 2-7	MacIntyre	TBC	TBC	TBC	TBC	TBC
	My D Cr	MacIntyre	100	TBC	TBC	TBC	TBC
	Alch C4-5	MacIntyre	TBC	TBC	TBC	TBC	TBC
	Rio G	Mungindi	TBC	TBC	TBC	TBC	TBC
	Har	St George	TBC	TBC	TBC	TBC	TBC
	Cal	Namoi	TBC	TBC	TBC	TBC	TBC
	Uya	Namoi	TBC	TBC	TBC	TBC	TBC
	Mill 1	Namoi	Did	not	establish	into	culture

*=Not tested

TBC=to be completed

Discussion

During season 2001-2002 Intrepid® survivors were detected for the first time. Season 2002-2003 produced an alarming trend of increasing level and abundance of Intrepid® resistance. In response the mite management strategy for Intrepid was modified from season 2003-2004 with a reduction in total Intrepid sprays to one per season for either *Helicoverpa* spp or *T. urticae*. Unfortunately during season 2004-2005 resistance was detected in 3 out of 7 strains tested but encouragingly resistance frequencies in each strain were generally less than in seasons 2003-2004. For season 2005-2006 Intrepid® was not available for use in Australian cotton yet resistance continued to be detected though at frequencies less than season 2003-2004.

Pirimor® resistance was detected in 61% of cotton aphid populations. As Pirimor® resistance is extremely high level in cotton aphid control, failures would likely result. Unfortunately Pirimor® is known to cause cross resistance to Folimat® / Rogor® and so those products would also be compromised by resistance. Pirimor resistance remains despite a change to the management strategy in 2003-2004 when Pirimor® and Folimat® use was restricted by the implementation of chemical use windows. During season 2004-2005 it is possible that control of mirids with Folimat® or Rogor® was also selecting for resistance in concurrent aphids populations, by eliminating susceptible clones from fields. During season 2005-2006 aphids were difficult to find and those populations collected were nearly all Pirimor® susceptible (for more complete Pirimor® data see Herron and M^cLoon). It is unknown if the lack of Pirimor resistance was due to low aphid pressure or grower avoidance of Pirimor with the substitution of newer chemistry such as Intruder® or in some cases Pegasus® for whitefly control.

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