THREE YEARS OF MONITORING INSECTICIDE RESISTANCE TO SILVERLEAF WHITEFLY IN COTTON

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KEY POINTS

- Bioassays developed and extensive screening undertaken between 2007-10
- No changes in resistance factors in cotton from 2007 to 2010
- Elevated resistance factors recorded in horticultural regions for pyriproxyfen (Admiral®) emphasise the importance of the cotton IRMS and a maximum one application Admiral® per season
- No changes recommended to current insecticide resistance management practices in cotton
- Registration of spirotetramat (Movento®) in the 2010-11 season with a unique mode of action will assist the insecticide resistance management strategy in cotton
- Future directions in resistance monitoring need to address correlating resistance factors with field performance

INTRODUCTION

Silverleaf whitefly (SLW), *Bemisia tabaci* (Gennadius), B biotype is an annual insect pest in cotton in the warmer production areas of Queensland and northern New South Wales. Silverleaf whitefly contaminate cotton lint with sugary exudates (honeydew) which reduces fibre quality and increases the cleaning frequency in spinning mills. Management of this pest is complicated by SLW's propensity to develop resistance to many insecticides. This has put considerable strain on the limited number of insecticides that remain efficacious against SLW. The registered SLW insecticides have been monitored over the past three cotton seasons (2007-10) for changes in resistance factors. The results of the resistance monitoring program are documented in this paper.

METHODOLOGY

A 'susceptible' strain of SLW (SU07-1) was obtained from CSIRO, Indooroopilly in 2007 where it had been in culture since 1995. The SU07-1 strain is not a true susceptible strain as it has had prior exposure to or risk of exposure to insecticides. It is believed that SLW entered Australia already possessing resistance to insecticides (Gunning, Conde et al. 1995). Further, the SU07-1 strain has been exposed to gene flow from the addition of wild type SLW of unknown origin prior to 2005 and was exposed to malathion once prior to 2007.

Field collections of whitefly were taken from cotton in QLD and northern NSW. *Bemisia tabaci* biotype identification was determined using a molecular based microsatellite technique using primers Bem23F and Bem23R to distinguish between Australian native, SLW and Q biotype.

For pyriproxyfen bioassays, adults were allowed to oviposit for 16 hours on excised cotton leaves. Leaves were dipped in a serial dilution of insecticide containing Agral® (600g/L) surfactant and maintained under controlled conditions at 27°C and 60% humidity for ten days to allow egg hatch. Treatments were scored for mortality (measured as failure of eggs to hatch).

For bifenthrin (Talstar®) and diafenthiuron (Pegasus®) assays, leaves were dipped in a serial dilution of insecticide containing Agral® (600g/L) surfactant. Adult SLW were aspirated into clip cages on treated leaves and maintained under controlled conditions for two and three days for the bifenthrin and diafenthiuron assays respectively. Bioassays were scored for mortality (measured as an absence of any movement of adults after tapping the cage lightly against the bench top).

Results were analysed using Probit 5 for Windows (Gillespie 1995) and correcting for control mortality using Abbott's formula. Resistance factors (RF) were calculated by dividing the lethal concentration (LC) for 50 percent and 90 percent mortality of field strains by the corresponding LC value for the susceptible strain (SU07-1). Strain responses were considered significantly different if the fiducial limits did not overlap.

RESULTS AND DISCUSSION

Pyriproxyfen (Admiral®)

Between 2007 and 2010, most field collections of SLW were susceptible to pyriproxyfen (table 1). In 2007-08 elevated RF were recorded in Ayr in the Burdekin (22 fold higher then the susceptible strain) and at St George (3 fold higher then the susceptible strain) from SLW collected off cotton. In 2008-09, resistance was detected at Ayr (108 fold higher then the susceptible strain) and Gumlu (178 fold higher then the susceptible strain) from SLW collected off melons. And in 2009-10, resistance was detected at Warburn (7 fold higher then the susceptible strain) for SLW collected off rockmelon and honeydew.

The results indicate that resistance to pyriproxyfen in SLW is not an immediate concern in cotton at this stage. The elevated resistance levels recorded in cotton from St George in 2007-08 were not recorded in subsequent years with resistance factors declining to a susceptible level between 2008-

10. Elevated RF detected in cotton in the Burdekin may have been a result of close proximity between cotton and horticulture production as pyriproxyfen was not used in cotton in the Burdekin.

The high RF recorded for SLW in horticulture regions indicate that there was a high proportion of resistant genes in the population, and with continual selection pressure, resistance to pyriproxyfen is likely to result in reduced field performance or field failure. In cotton-dominant areas, high RF in horticulture is likely to be diluted by the low RF in cotton and should help to conserve the efficacy of these products.

Diafenthiuron (Pegasus®)

Between 2007-10 most field collections of SLW were susceptible (table 2). In 2007-08, SLW from St George showed elevated resistance factors (2 fold higher then the susceptible strain). In 2008-09, SLW from Moree (ME09-1) had elevated resistance factors (2 fold higher then the susceptible strain). In 2009-10, a collection from St George (SG10-1) was 4 fold more resistant then the susceptible strain.

The elevated RF indicate that resistance genes are present in the population. That said, there has been no marked shift in RF since monitoring commenced in 2007. Furthermore, the elevated RF may be attributed to natural variability as no true baseline data was collected prior to registration of diafenthiuron in Australia. At this stage, there are no recommended changes to the insecticide resistance management strategy (IRMS).

Bifenthrin (Talstar®)

Between 2007-10, several field collections exhibited higher tolerance to bifenthrin then the susceptible strain (table 3). In 2007-08, field collections from Dalby (#13) and Ayr were 4 and 9 fold more resistant then the susceptible strain. In 2008-09, field collections from the lower Namoi (NM09-1 and NM09-3) and St George (SG09-2 and SG09-3) were 2, 3, 5 and 2 fold higher then the susceptible strain, respectively. In 2009-10, field collections from Biloela, Darling Downs (DD10-3), Emerald (EM10-1) and Warburn were more resistant then the susceptible strain (7, 2, 6, and 7 fold more resistant then the susceptible strain respectively).

While RF were elevated compared to the susceptible strain, they did not increase markedly over the three years of monitoring. Because of the limitations in correlating resistance factors to field performance, it is difficult to say if the observed RF are high enough to cause reduced field performance. Personal communication with growers and consultants indicates that multiple applications of bifenthrin within a season tend to be associated with reduced performance which

would indicate that resistance is at a level that is affecting field performance. It is not recommended that bifenthrin is used as a 'first line of defence', primarily due to its disruptiveness to beneficial insects and also because of concerns of resistance developing.

Future Directions

Resistance monitoring for SLW in cotton will continue through until at least 2013 with joint funding from DEEDI and CRDC. The suite of insecticides tested will be extended to include new insecticides as they are registered in cotton. Testing methodologies have been developed and baseline data has been generated for spirotetramat (Movento®) which is scheduled for registration in cotton in 2010-11. The registration of new insecticides with unique modes of action will greatly assist the IRMS by reducing the pressure placed on a limited number of insecticides for management of SLW.

Future directions in resistance monitoring require studies in correlating RF with field performance. Resistance monitoring, as it currently stands, can provide information on the changing status of RF however, it can not be used to predict when performance of an insecticide will decline in the field. Study of SLW populations in the field, pre- and post- insecticide spray combined with studies of SLW genotypes would complement existing resistance monitoring to develop a better IRMS for cotton.

SUMMARY

Three years of resistance monitoring from 2007-10 have been conducted for insecticides registered for SLW control in cotton. Elevated RF were recorded in some field collections for every insecticide tested, indicating that resistance genes are present in the population. While elevated RF were recorded in diafenthiuron and bifenthrin, there was no marked shift in RF over the three years of monitoring and there are no immediate concerns of resistance developing to these products. Elevated RF for pyriproxyfen were recorded in cotton and horticulture in the Burdekin between 2008-09 and there is concern that this product will lose efficacy against SLW under the current insecticide use regime in horticulture in the Burdekin. In other regions, RF for pyriproxyfen were at susceptible levels and there are no immediate concerns of resistance developing to this product in cotton dominant regions. No changes to the IRMS are recommended for any products registered in cotton for SLW control at this time.

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KEY WORDS

Bemisia tabaci. Silverleaf whitefly. Resistance monitoring.

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APPENDIX

Table 1. Resistance factors (RF) for pyriproxyfen for SLW from 2007-10

Year	Location	Host Plant	Resistant*
2007-08	Ayr	Cotton	✓(RF 22)
	Dalby	Cotton	×
	Emerald	Sunflower	×
	Moura	Cotton	×
	St George A	Cotton	×
	St George B	Cotton	✓ (RF 3)
2008-09	Ayr	Melon	✓ (RF 108)
	Biloela	Cotton	×
	Dalby	Cotton	×
	Emerald	weeds	×
	Gumlu	Melon	✓ (RF 178)
	Moree	Cotton	×
	Namoi/Gwydir	Cotton	×
	Namoi valley (NM09-1)	Soybean	×
	Namoi valley (NM09-2)	Cotton	×
	Namoi valley (NM09-4)	Cotton	×
	St George (SG09-1)	Cotton	×
	St George (SG09-2)	Cotton	×
	St George (SG09-3)	Cotton	×
	Theodore	Cotton	×
2009-10	Biloela	cotton	×
	Condamine	cotton	×
	Norwin	cotton	×
	Brigalow	cotton	×
	Emerald (EM10-1)	cotton	×
	Emerald (EM10-2)	cotton	×
	Comet	cotton	×
	Moree	cotton	×
	St George	cotton	×
	Warburn	rockmelon & honeydew	✓ (RF 7)

* ✓ indicates resistance factors are significantly different to the susceptible strain (fiducial limits do not overlap)

Table 2. Resistance factors (RF) for diafenthiuron for SLW from 2007-10

Year	Location	Host plant	Resistant
2007-08	Dalby	Cotton	✘
	Ayr	Cotton	✘
	Moura	Cotton	✘
	Emerald	Sunflower	✘
	St George (SG08-1)	Cotton	✘
	St George (#14)	Cotton	✓ (RF 2)
2008-09	Biloela	Cotton	✘
	Dalby	Cotton	✘
	Emerald	Weeds - various	✘
	Moree	Cotton	✓ (RF 2)
	Namoi/Gwydir	Cotton	✘
	Namoi valley (NM09-1)	Soybean	✘
	Namoi valley (NM09-2)	Cotton	✘
	Namoi valley (NM09-3)	Cotton	✘
	St George (SG09-1)	Cotton	✘
	St George (SG09-2)	Cotton	✘
	St George (SG09-3)	Cotton	✘
	Theodore	Cotton	✘
2009-10	Biloela	Cotton	✘
	Darling Downs (DD10-1)	Cotton	✘
	Darling Downs (DD10-2)	Cotton	✘
	Darling Downs (DD10-3)	Cotton	✘
	Emerald (EM10-1)	Cotton	✘
	Emerald (EM10-2)	Cotton	✘
	Emerald (EM10-4)	Cotton	✘
	Moree	Cotton	✘
	St George	Cotton	✓ (RF 4)
	Warburn	Melon	✘

* ✓ indicates resistance factors are significantly different to the susceptible strain (fiducial limits do not overlap)

Table 3. Resistance factors (RF) for bifenthrin for SLW from 2007-10

Year	Location	Host plant	Resistant
2007-08	Emerald	Sunflower	×
	Ayr	Cotton	✓ (RF 9)
	Dalby (DB08-1)	Cotton	×
	Dalby (#13)	Cotton	✓ (RF 4)
2008-09	Biloela	Cotton	×
	Dalby	Cotton	×
	Emerald	Weeds - various	×
	Moree	Cotton	×
	Namoi valley (NM09-1)	Soybean	✓ (RF 2)
	Namoi valley (NM09-3)	Cotton	✓ (RF 3)
	St George (SG09-1)	Cotton	×
	St George (SG09-2)	Cotton	✓ (RF 5)
	St George (SG09-3)	Cotton	✓ (RF 2)
	Theodore	Cotton	×
2009-10	Biloela	Cotton	✓ (RF 7)
	Darling Downs (DD10-1)	Cotton	×
	Darling Downs (DD10-2)	Cotton	×
	Darling Downs (DD10-3)	Cotton	✓ (RF 2)
	Emerald (EM10-1)	Cotton	✓ (RF 6)
	Emerald (EM10-4)	Cotton	×
	St George	Cotton	×
	Warburn	Rockmelon, honeydew	✓ (RF 7)

* ✓ indicates resistance factors are significantly different to the susceptible strain (fiducial limits do not overlap)