RESISTANCE MONITORING IN TWO-SPOTTED MITE: COTTON SEASONS 2001/2002 and 2002/2003

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Key Points

1. Resistance of mites to miticides was monitored over two seasons and is critical for assessing the effectiveness of the IRMS.
2. No resistance was detected to abamectin or difenthiuron.
3. Bifenthrin (Talstar) resistance was common during the study.
4. Incipient propargite resistance was detected in 2001-2002 but not in the following season.
5. Chlorfenapyr resistance was first detected in the 2001-2002 season and has increased quickly in both level and the proportion of resistant strains detected. In response, the resistance management strategy for chlorfenapyr use in cotton now recommends a restriction of use from two to one spray per season.

Introduction

The Insecticide Resistance Management Strategy (IRMS) for cotton is designed to manage insecticide use, maintain the susceptibility of pest species to insecticides and to manage resistance where it already exists so that it does not become worse (Johnson and Farrell 2003). One pest, the two-spotted spider mite is renowned for rapidly developing resistance to insecticides worldwide. In order to prevent this happening in cotton a mite-specific component has been developed in the IRMS. This strategy is based around two core principles (1) use limitations, ie a maximum of two applications of any pesticide group, and (2) rotation, ie. non-consecutive use of the same chemical.

Monitoring is an integral part of the effective management of resistance in *T. urticae* in Australian cotton. Results of annual monitoring have chronicled the demise of the

organophosphates and anticipated the need for newer chemistry (Herron *et al.* 1998; Herron *et al.* 2001). Here we present monitoring data for seasons 2001-2002 and 2002-2003 and discuss implications for future resistance management of mites.

Method

Strains Tested

Strains were randomly collected late in each respective cotton season from growing regions in NSW and Queensland. The 2001/2002 collections included PE (Namoi Valley), WN (Namoi Valley), MI (Namoi Valley), KU (Namoi Valley), BE (Namoi Valley), SO (Namoi Valley), ST (St George) and AC (Namoi Valley). The 2002/2003 collections included G (Namoi Valley), W (Namoi Valley), Y (Namoi Valley), RA (Hay), TO (Namoi Valley), HA (Hillston).

Chemicals Tested

Proprietary commercial formulations of profenofos (Curacron®), bifenthrin (Talstar®), abamectin (Agrimec®), propargite (Comite®), and chlorfenapyr (Intrepid®) were used, except difenthiuron (Pegasus®). The UV activated carbodiimide derivative of diafenthiuron, CGA-140408 was tested instead.

Bioassay

Edge and James (1982) have described the bioassay procedure used in detail. Briefly, the method requires young adult female mites to be transferred from culture to French bean leaf discs. Mites and leaf disc are then sprayed with insecticide with the aid of a Potter spray tower. Each test is replicated three or four times and includes a water only sprayed control.

Analysis

Data were analysed using a Probit program written in GENSTAT 5 statistical software (Barchia, 2001). LC_{50} values plus their 95% fiducial limits were calculated using the probit method outlined in Finney (1971) and included control mortality correction (Abbott 1925). Resistance factors (RF) (RF_{50}) plus their associated 95% confidence intervals (CI) were calculated as outlined in Robertson and Preisler (1992). Discriminating-dose tests were corrected for control mortality (Abbott 1925).

Results

Abamectin, and diafenthiuron resistance was not detected (Table 1). Bifenthrin resistance was detected in all but three strains with resistance frequencies being variable. A small percentage of propargite resistant mites were detected in strains ST and KU during season 2001-2002 only. During season 2001-2002 a small proportion of chlorfenapyr resistant mites were detected in strain BE but not enough to significantly alter the LC_{50} level resistance factor (Table 2). However, in the following 2002-2003 season chlorfenapyr resistance was detected in 4 of the 6 strains tested with a maximum level of 8.7-fold.

Table 1. Testing results for the 2001/2002 and 2002/2003 cotton seasons- strains of two-spotted mite (TSM) against a 0.02% discriminating dose (DD) of propargite, 0.0001% DD of abamectin, 0.02 % bifenthrin and 0.002% DD of diafenthiuron (CGA-140408).

Strain	season	Mortality at DD diafenthiuron	Mortality at DD for bifenthrin	Mortality at DD for propargite	Mortality at DD for abamectin
ST	2001/2002	100	100	99	100
BE		100	54	100	100
WN		100	83	100	100
AC		100	54	100	100
MI		100	98	100	100
PE		100	3	100	100
SO		100	75	100	100
KU		100	86	97	100
G	2002/2003	100	48	100	100
W		100	55	100	100
Y		100	72	100	100
RA		100	100	100	100
TO		100	86	100	100
HA		100	100	100	100

Discussion

Monitoring during seasons 2001-2002 and 2002-2003 detected the first instance of chlorfenapyr resistance in *T. urticae* from Australian cotton. Unlike the situation in nectarine crops where resistance was detected after a single application (Herron and Rophail 2003), chlorfenapyr resistance in *T. urticae* from cotton was not detected until

Table 2. Full log dose probit analysis results for chlorfenapyr against two-spotted mite during the 2001/2002 and 2002/2003 cotton seasons

Strain	season	Slope (s.e.)	LC50 (95% F.L.) % ai	RF(95% CI)
Susceptible	-	3.0 (0.46)	0.0017 (0.0014-0.0021)	-
ST	01/02	2.3 (0.17)	0.0017 (0.0014-0.0019)	0.99 (0.75-1.29)
*BE		1.3 (0.55)	0.0014 (0.00054-0.0025)	0.83 (0.21-3.2)
WN		2.6 (0.64)	0.00084 (0.00049-0.0011)	0.48 (0.30-0.76)
AC		2.6 (0.48)	0.00034 (0.0026-0.0041)	1.94 (1.30-2.88)
MI		2.8 (0.85)	0.0024 (0.0018-0.0030)	1.37 (0.79-2.39)
PE		3.0 (1.13)	0.0011 (0.00066-0.0015)	0.65 (0.37-1.15)
SO		2.0 (0.62)	0.0011 (0.00071-0.0016)	0.66 (0.36-1.21)
KU		3.1 (0.57)	0.00091 (0.00061-0.0011)	0.52 (0.37-0.73)
G*	02/03	1.4 (0.35)	0.015 (0.0082-0.023)	8.7 (4.0-18.6)
W*		1.7 (0.35)	0.039 (0.0022-0.0057)	2.2 (1.3-4.0)
Y		1.7 (0.35)	0.0039 (0.0022-0.0057)	0.5 (0.4-0.6)
RA*		1.0 (0.42)	0.00022 (0.000016-0.00075)	0.1 (0.002-0.9)
TO*		1.7 (0.08)	0.00087 (0.00067-0.0012)	0.5 (0.4-0.6)
HA		2.8 (0.23)	0.00066 (0.00055-0.00075)	0.4 (0.3-0.5)

**survivors at a DD of 0.04% ai chlorfenapyr*

the fifth season of use for *Helicoverpa* spp. and *T urticae* control. This difference in time to detection may be related to differences in chemical use between cotton and nectarines, as *T. urticae* on the two crops are largely controlled with different products.

While bifenthrin resistance was detected in *T. urticae* from Australian cotton in 1997 it was not possible to modify product use, as it was essential for control of *Helicoverpa* spp. (Herron *et al.* 2001). Consequently, resistance has not declined and in season 2001-2002 bifenthrin resistance was detected in 7 of 8 strains and in 2002-2003 in 4 of 6 strains. This was not the case for chlorfenapyr and beginning in the 2003-2004 season cotton growers were restricted to using chlorfenapyr only once per season for either *Helicoverpa* spp. or *T. urticae* control. Chlorfenapyr resistance in Australian *T. urticae* may be incompletely dominant and monogenic (Uesugi *et al.* 2002). A single locus resistance would be expected to evolve faster with increased insecticide-use (Tabashnik 1990) so the halving of the chlorfenapyr selection pressure could extend the useful life of the product. This will become clearer when data for season 2003-2004 are available.

Despite chlorfenapyr resistance development, the IRMS for *T. urticae* in cotton is working well. For example, *T. urticae* is known to develop resistance to abamectin after as few as twelve applications (Clark *et al.* 1994) yet resistance has never been detected in Australian cotton. Similarly, propargite resistance leading to control failure is an ever present possibility (Dennehy *et al.* 1987) yet propargite resistance did not increase in either level or abundance after it was detected in 2001-2002. Despite problems with bifenthrin and chlorfenapyr the IRMS is undoubtedly prolonging the useful life of products used to control *T. urticae* in cotton.

Acknowledgments

The Cotton Research and Development Corporation provided funding (DAN139c, DAN163c, CSP74C and CSP103C). Dr Idris Barchia, Special Biometrician, for the probit analysis.

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