



**COTTON RESEARCH AND DEVELOPMENT CORPORATION**

# **FINAL REPORT**

**"Pesticide resistance in cotton aphid and two-spotted mite."**

**DAN 139C**

**1<sup>st</sup> July 1999 to 31<sup>st</sup> October 2002  
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## Part 1 - Summary Details **REPORTS**

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Please use your TAB key to complete part 1 & 2.

**CRDC Project Number:** **DAN139C**  
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### ***Part 3.3 – Final Reports***

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The points below are to be used as a guideline when completing your final report.

- 1. Outline the background to the project.**
- 2. List the project objectives and the extent to which these have been achieved.**
- 3. How has your research addressed the Corporations three outputs: Sustainability, profitability and international competitiveness, and/or people and community?**
- 4. Detail the methodology and justify the methodology used.**
- 5. Detail results including the statistical analysis of results.**
- 6. Discuss the results, and include an analysis of research outcomes compared with objectives. What are the “take home messages”?**
- 7. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. Where possible include a statement of the costs and potential benefits to the Australian cotton industry and future research needs.**
- 8. Detail how your research has addressed the Corporations three Outputs: Sustainability, and/or Profitability & International Competitiveness, and/or People & Communities?**
- 9. Describe the project technology (eg. commercially significant developments, patents applied for or granted licenses etc).**
- 10. Provide a technical summary of any other information developed as part of the research project. Include discoveries in methodology, equipment design, etc.**
- 11. Detail a plan for the activities or other steps that may be taken;**
  - (a) to further develop or to exploit the project technology.**
  - (b) for the future presentation and dissemination of the project outcomes.**
- 12. List the publications arising from the research project.**
- 13. Are changes to the Intellectual Property register required?**

### ***Part 4 – Final Report Executive Summary***

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Provide a half to one page Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web. List the main outcomes and contact details for more information.

## *Cotton Aphid*

Due to its ability to rapidly develop resistance cotton aphid (*Aphis gossypii* Glover) is world-wide the major aphid pest of cotton. It causes significant problems in Thailand, The Sudan, Russia and the USA. In Australian cotton it is a persistent secondary pest with potential to become a major pest due to resistance.

Resistance allows the uncontrolled increase in aphid numbers causing their sugary honeydew secretions to contaminate the cotton lint. This causes significant discounts due to the need to clean the cotton before it can be spun in today's high speed spinning equipment. Such a scenario happened recently in the USA causing an immediate and substantial downgrading of the contaminated lint value. Recent Australian research has also confirmed that uncontrolled aphid outbreaks earlier in the cotton season can significantly impede plant development, through aphids competing for plant assimilate causing dramatic yield reductions (up to 75 %). As cotton production in Australia is a 1.5 billion-dollar industry uncontrolled resistance would be a national disaster, due to loss of yield but more significantly damage to our international reputation as a producer of 'clean' cotton.

Resistance management in Australia is further complicated because cotton aphid reproduces asexually with female aphids giving birth to live female 'clones'. Unmanaged insecticide use can rapidly kill susceptible clones, leaving only resistant clones. Further use of the same insecticide group then may select for genotypes within the resistant clones that have small transcription errors or mutations that favour fitness or confer other mechanisms of resistance. Selection of resistant clones allows the rapid proliferation of resistance because there is no outcrossing with susceptible wild types. A second pest aphid, the green peach aphid is also a sporadic but at times damaging pest in cotton. This species is already widely resistant to a range of insecticides and can present major control problems for cotton growers.

Until recently aphids were a recurrent late-season pest in cotton. However, over the past 4 years this situation has changed with a trend toward earlier and more widespread development of aphids in cotton crops. The elevated pest status of aphids is due to a number of related factors:

1. Reduced early season applications of the cyclodiene endosulfan that is a moderately effective aphicide due to environmental concerns.
2. Thirty-percent of cotton production is currently based on the transgenic Ingard® variety that has less early season insecticide use and hence reduced insecticidal suppression of aphids.
3. Resistance - resistant aphids survive in situations where formerly they would have been easily and economically controlled.
4. There has recently been a virus like disease, cotton bunchy top (CBT) in cotton associated with aphids, as a result many growers now support lower aphid control thresholds thereby accelerating resistance selection.
5. Seasonal conditions – wetter and milder winters in 1998 and to a less extent in 1999 favoured the abundant and widespread growth through winter of a range of alternative hosts for aphids favouring overwinter survival of aphids. Further, wet conditions also impede effective on-farm hygiene practices leading to survival of 'stub' cotton that serves as an overwinter host for resistant clones. Recent dry winters in 2001 and 2002 have resulted in lower aphid survival through winter and hence very low populations on cotton. A wet winter could however rapidly reverse this trend.

In 1999 the first control failures for cotton aphid were experienced in NSW and confirmed due to resistance. The following season, specific cases were revisited giving sequential data through two seasons. Resistance was patchy within regions and inconsistent between years (except for some serious hotspots). It confirmed that the resistance problem was due to cross-resistance between the older organophosphate insecticides and the newer carbamate insecticide pirimicarb, rendering these two key aphicide controls ineffective. There has been continued evidence of resistance in subsequent years. Resistance in pirimicarb is critical because pirimicarb is a very selective insecticide, with little impact on beneficial species, and is therefore highly compatible with IPM systems in cotton. When resistance developed in the USA pirimicarb was abandoned. This is not the case in Australia and the strategies developed through this study have preserved the efficacy of this valuable compound. This is extremely difficult because resistance when found is typically at high levels (>1,000X).

To help understand the underlying basis of the resistance to pirimicarb, and hence improve the chance of effective management, Dr Robin Gunning and Dr Graham Moores (Rothamstead, UK) did a preliminary screen on resistant clones. They found that the underlying resistance biochemistry (resistance mechanism(s)) is probably a target-site insensitivity and furthermore suggested that pirimicarb resistance can be maintained without selection. Once selected resistance should therefore persist through the season and overwinter causing ongoing and progressively worsening control problems.

However in the 2000-2001 season the tracking of resistance over time at specific sites showed instances where resistant aphids did not overwinter. The failure of resistant aphids to overwinter is likely linked to their requirement for overwinter hosts – they do not have a diapause stage in Australia. This was reinforced with a combination of a dry winter, with few alternative hosts and good on-farm hygiene. The integrated resistance management strategy for aphids (described below) was amended to further exploit this unexpected phenomenon.

Research also considered resistance in the green peach aphid. We found this species widely resistant to organophosphates and carbamates but that resistance levels between these groups varied significantly, with consequent important implications for management. Green peach aphid resists pirimicarb by increased detoxification caused by overproduction of an esterase. However, cotton aphid resists pirimicarb by a target site insensitivity that produces much higher levels of resistance.

There are currently no silver bullets for managing aphids so in consultation with other researchers a strategy that integrates a number of tactics to reduce the fitness of the resistant clones was developed. The integrated strategy is quite complex and now includes:

1. *Reduction of on-farm overwintering hosts for aphids (ie a host free period).* Aphids will only survive through winter on suitable hosts and growers are advised to target those overwintering on-farm hosts for aphid control.
2. *At-planting insecticide treatment.* Some seed treatments or ‘at-planting’ soil applied insecticides will control aphids and reduce or delay the need for foliar aphicides allowing beneficial aphid predators to survive.
3. *Sample effectively for aphids.* Aphids are often restricted to the younger growth so it is essential to sample crops and host plants correctly. It is also easier to manage aphids if they are detected early as this allows better decisions regarding preservation of beneficials and management of other pests.
4. *Rotate aphicides.* The five key insecticide rotation groups are (i) carbamates and organophosphates, (ii) imidacloprid and thiamethoxam, (iii) diafenthiuron, (iv) pymetrozine and (v) endosulfan.
5. *Don't follow a failure with another product from the same group.* In the past many growers follow an observed control failure with an application of a compound susceptible to a common resistance mechanism (ie cross-resistance). (see point 4 above). Later in the season options such as organophosphates will only be efficacious if aphid populations are effectively managed early.
6. *Maintain beneficial insects by using the most selective option.* Sprays applied for aphids or other pests can be detrimental to beneficials that would otherwise help to reduce aphid survival.
7. *Plant CBT tolerant Varieties.* There are a range of CBT resistant cotton varieties available that allow growers concerned about this disease to tolerate higher aphid numbers and reduce resistance selection.
8. *Adhere to thresholds* The recent advent of a virus type syndrome means that some growers are unwilling to tolerate conventional aphid thresholds, thereby increasing resistance selection.

This strategy has been widely disseminated to the cotton industry (see section -Extension) and is well accepted.

### ***Two-spotted mite***

Worldwide over 33 species of mites attack cotton, but in Australia damage is due mainly to three species of Tetranychid mite, the banana spider mite (*Tetranychus lambi*), the bean spider mite (*T. ludeni*) and the two-spotted mite (*T. urticae*), though the latter is by far the most common. Two-spotted mite is extraordinarily

adaptable and renowned for developing resistance to chemicals used for its control. Two-spotted mite is acknowledged as the most serious world mite pest of agriculture due to its ability to develop resistance and in Australia uncontrolled resistance has rendered some horticultural crops uneconomic. Two-spotted mite has been the dominant mite pest in cotton since the early 1980s. Uncontrolled populations can cause significant losses of yield and fibre quality.

Organophosphates (OP) were used during the early 1960s, particularly for the control of *Helicoverpa armigera* (Hübner) and *H. punctigera* (Wallengren). Most of the compounds used to control *Helicoverpa* spp. were broad-spectrum, and probably reduced beneficial populations, which in turn contributed to the development of mite outbreaks. These were controlled in Australia with applications of organophosphate pesticides. Demeton-S-methyl was the preferred miticide because its systemic nature did not require good coverage. Dicofol was also used, but proved less effective than demeton-S-methyl and so was not recommended for tetranychid mite control after 1970. Control failures with demeton-S-methyl due to apparent resistance were evident after the 1968/69 season and resulted in the widespread use of monocrotophos for mite control. During the 1971/72 season, mites proved very difficult to control with monocrotophos and resistance was again suspected but not confirmed with laboratory assays. Resistance rendered all older organophosphates ineffective by 1980 but the newer organophosphates, profenofos and monocrotophos, remained with reduced efficacy until 1995. Since 1976 we have monitored resistance in mites from cotton.

Organophosphates in Australian cotton were replaced by the specific acaricides propargite (Comite®, Bullet®) and dicofol (Kelthane®, Mitifol®) in the early 1990's. Those two acaricides have subsequently been augmented with abamectin (Agrimec®, Wizard®), chlorfenapyr (Intrepid®), diafenthiuron (Pegasus®) and bifenthrin (Talstar®). The current strategy was developed in the early 1990's as the first selective miticides became available (propargite / dicofol) based on max of 2 applications and non-consecutive use. 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. The strategy requires the development of baselines, the use of discriminating doses and finally the checking of populations that had survivors at the discriminating dose by full log-dose probit analysis. Of the more recent chemistry, problems have been detected in bifenthrin and more recently chlorfenapyr.

#### *Bifenthrin*

Bifenthrin was registered at the beginning of the 1993/94 season for control of *Helicoverpa* spp. and two-spotted in Australian cotton and was incorporated into the resistance management strategy. Incipient bifenthrin resistance was first detected in a population of two-spotted mite during the 1996/97-cotton season. Resistance increased progressively in both level and abundance over the following three seasons. Bifenthrin resistance in two-spotted mite has now reduced the reliability of bifenthrin and control failures continue to be reported. However, I do not consider the evolution of bifenthrin resistance in two-spotted to indicate a failure of our resistance management strategy. The problem is related to its more intensive use against *Helicoverpa* sp, which coincidentally selects for resistance in any mites present. For comparison without resistance management (in horticulture) the pyrethroid (fluvalinate) failed the year after the chemical was released. Without resistance management bifenthrin resistance in two-spotted mite would most likely have evolved much faster than it did.

More importantly, the development of bifenthrin resistance highlights the problem for products that are targeted against more than one pest. Most miticides currently available in Australian cotton also have other targets, for example propargite as a pyrethroid synergist; abamectin is used against *Helicoverpa punctigera*, diafenthiuron against aphids and chlorfenapyr against *Helicoverpa* spp. Product use against other pests will also select for resistance in coincident mite populations, whether these are at economic levels or not. We now recommend growers and consultants consider coincidental product use as far as possible to avoid repeated pesticide selection when mites are present in the field (See section – refereed scientific).

Recent bifenthrin resistance monitoring during the 1999-2000 cotton season, detected resistance in 9 of the ten strains tested. For the 2000-2001 season bifenthrin resistance was detected in 5 out of 6 strains tested. For 2001-2002 resistance was detected in 7 of the 8 strains tested. This suggests that the abundance of bifenthrin resistance is not changing. The highest frequency of resistant mites in any one population has also remained static with a 2000-2001 season strain having 97% resistant mites, matched exactly in 2001-2002 by a strain from a different farm.

### *Chlorfenapyr*

Chlorfenapyr was first registered for the 1998-1999 season. It is a highly effective miticide, also registered against *Helicoverpa* at a higher rate. Monitoring has chronicled declining slope values for chlorfenapyr between seasons. Slopes started at 3.0 – 4.1, the following season they were 2.3 - 3.0, then 2.0 – 3.2, 1.6 – 2.7 and in season 2001-2002 1.3 - 3.1. In 2001-2002 there were also survivors at the discriminating dose, a result that constitutes prima facie resistance. Clearly there is a general trend toward chlorfenapyr resistance in two-spotted mite from cotton.

### *Profenofos*

Monitoring for profenofos resistance in two-spotted mite is now continued for its historical interest rather than for practical resistance management. In season 1998-1999 profenofos resistance in TSM peaked at 383x. In season 1999-2000 resistance exceeded 500x in two strains with another three strains having resistance at 200 – 300x. For 2000-2001 season profenofos resistance peaked at 221x with remaining strains having resistance levels <64x. However for season 2001-2002, resistance again rose peaking at an all time high of 1718x.

### *Propargite*

Propargite is the mainstay miticide for two-spotted mite control in Australian cotton. It is a highly effective miticide at higher temperatures and resistance monitoring has been routinely done for several seasons. However, resistance has not been regularly detected but in season 2001-2002 a small number of resistant mites were found in two strains.

### *Diafenthiuron*

This pro-insecticide is converted to its active form by UV light. For that reason the UV activated carbodiimide is used for bioassay. We have monitored for resistance since the 1997-1998 season with no indications of any problems. However, for season 2001-2002 three strains had mites that survived a dose that previously gave 100% kill.

### *Abamectin*

Abamectin is a highly effective miticide and resistance monitoring has been routinely done for several seasons. To date no abamectin resistance has been detected in two-spotted mite from Australian cotton.

### *Dicofol*

Dicofol use against two-spotted mite in cotton is restricted to NSW only with application limited to ground rig. Due to high cost and contact only action dicofol receives little use so resistance testing was not done during the current study.

## **Recommendations**

- Strain(s) of two-spotted mite with survivors at the chlorfenapyr discriminating dose should be subject to additional selection. Strains should be selected with chlorfenapyr at least three times and then subsequently retested for resistance using full log-dose probit assays. This is required to unequivocally confirm or refute resistance and give a likely worst-case resistance level.
- Strain(s) of two-spotted mite that showed survivors at 0.0001% of the UV activated carbodiimide (diafenthiuron) should also be subject to additional selection. This should be done with new product sourced from Switzerland. Strains should be pressured three times and subsequently retested using full log-dose probit assays. This should confirm or refute resistance. If vigour tolerance is confirmed the discriminating dose should be raised to at least 0.0002% of the UV activated carbodiimide.
- The resistant cotton aphid strain James Quin should be subject to additional selection with aldicarb. This should be done at least three times and the strain subsequently retested for resistance using full log-dose probit assays. Aphids from a susceptible, James Quin and aldicarb-pressured strain should be put onto cotton plants and challenged at the aldicarb recommended rate. If the level of response does not significantly alter and aphids are killed at the recommended rate then the strain likely shows vigour tolerance rather than cross-resistance. Aldicarb can then be removed from the current organophosphate/carbamate alternation group
- Monitoring continues to underpin the effective management of resistance of two-spotted mite and cotton-aphid in Australian cotton. Routine monitoring of both these pests must continue and adapt to the introduction of new and novel chemistries. Pymetrozine is one such chemical introduced for aphid

control from the 2002-2003 season. Previous attempts to bioassay pymetrozine have failed and methods must be developed for this and similar chemicals as a matter of urgency. A range of other foliar aphicides may become available in the near future including the neonicotinoid acetamiprid, bring the total to three compounds from this group (including thiomethoxam and imidacloprid). Resistance management strategies will need to allow for this and resistance monitoring implemented as appropriate.

- Western Flower Thrips (WFT) emerged as pest in cotton during the 2001-2002 season and limited pre-emptive resistance monitoring was done. If WFT emerge as a serious pest and routine resistance monitoring is required additional resources would be necessary.

## **Results by pest by year**

## RESISTANCE TESTING OF TWO-SPOTTED MITE: 1999/2000

### *Strains Tested*

*Tetranychus urticae* (TSM)- Y = Yuronah Field 32 Macquarie Valley, Co = Condraminer Toowoomba Darling Downs, NF2 = Colly Farms Field 136 Gwydir, W = Willawood Namoi Valley, Ku = Kurrabooma Field 1 Gwydir, Ka = Kamilaroi Field 7 Gwydir, Wa = Wambandry Field 40 Macquarie Valley, NF1 = Colly Farms Field 125 Gwydir, MV = Macquarie View Field 1 Macquarie Valley, Ty = Tyunga Toowoomba. *Tetranychus ludeni* (BSM)- Condraminer

### *Chemicals Tested*

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

### *Results*

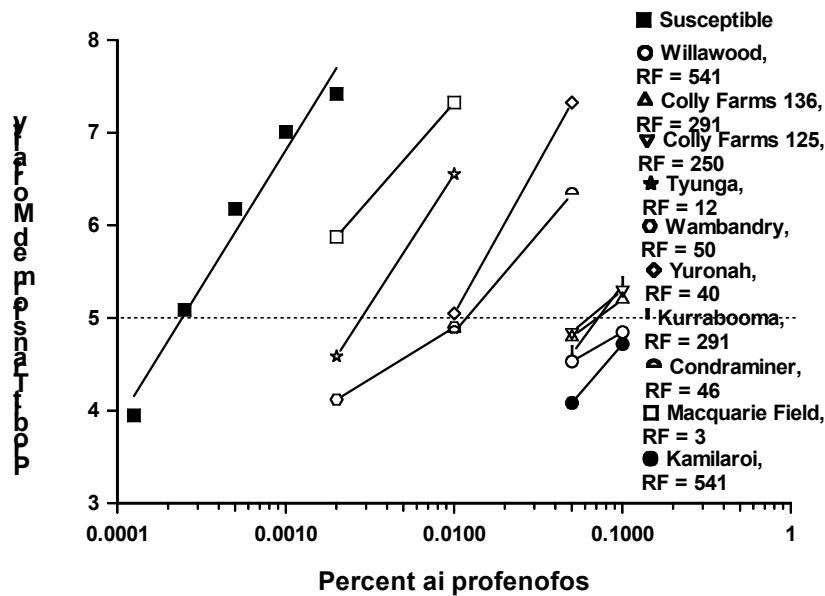
Abamectin and bifenthrin resistance was not detected in BSM (Table 1). Profenofos resistance in two strains of TSM was extreme (>500x)(Figure 1). Abamectin and propargite resistance was not detected in TSM but bifenthrin resistance was common comprising up to 80% of the individuals in one strain (Colly Farms 136)(Table 1) with associated resistance of 109 and 485x at LC50 and LC99 respectively (Table 2). Chlorfenapyr resistance was not detected in TSM and all but one strain seemed to exhibit a degree of negative cross-resistance (Table 3). Diafenthiuron resistance was not detected in TSM (Table 4).

### *Discussion*

During season 1999/2000 resistance exceeded 500x in the strains Willawood and Kamilaroi with another three strains having resistance at 200 – 300x. Clearly, profenofos resistance is now abundant and at extreme levels, field control of TSM would be negligible.

In season 1998/2000 I noted probit slope values for chlorfenapyr had generally lessened from 3.0 – 4.1 to 2.3 - 3.0 with one strain having a distinct plateau in the probit regression at about LC<sub>97</sub>. At that time I speculated something may-be-a-foot in the form of incipient resistance. Slope values for chlorfenapyr continue to be lower and for season 1999/2000 range from 2.0 – 3.2 with 6 slopes <2.5. A distinct plateau is evident in the dose-response for strain Colly Farms 125 at about LC<sub>50</sub>. That strain was also the most chlorfenapyr tolerant and showed none of the negative cross-resistance evident in the other nine strains. Again, definitive chlorfenapyr was not been detected in season 1999/2000 but?

During the 1999/2000 cotton season, bifenthrin resistance was detected in 9 of the ten strains tested. Resistance levels peaked at 109x in a population containing 80% resistant mites. Two strains Colly Farms, field 125, Gwydir Valley and Colly Farms, field 136, Gwydir Valley, contained mites which survived 1.28 % bifenthrin, the highest rate that could be applied without severe phytotoxicity. Strain NF1 was not sprayed with bifenthrin during the season while the strain Colly Farms 136 had 3 bifenthrin applications. As both populations had highly resistant mites, we assume Colly Farms generally had a low frequency of highly bifenthrin resistant *T. urticae* at the start of the 1999/00 season. The high (109x) resistance detected in strain Colly Farms 136, compared with Colly Farms 125 (3.0 x), probably resulted from bifenthrin selection of an already heterogeneous resistant population. It is likely that the initial bifenthrin spray applied to strain Colly Farms 136 failed because of resistance. The grower then applied a second spray. Despite a limit of two applications per season, a third bifenthrin spray was applied without achieving adequate control. Resistance in TSM has now reduced the reliability of bifenthrin for mite control in Australian cotton. Control failures and very high-level resistance should be expected.



**Figure 1** Diagnostic dose testing for profenofos against two-spotted mite for the 1999/2000 cotton season

**Table 1.** Testing results for the 1999/00 cotton season- 10 strain of two-spotted mite (TSM) and one strain of bean spider mite (BSM) against a 0.01% discriminating dose (DD\*) of propargite, 0.0001% DD of abamectin and 0.02 % bifenthrin

Strain	Mortality at DD for bifenthrin	Mortality at DD for propargite	Mortality at DD for abamectin
TSM Y	92	100	100
TSM Co	100	100	100
TSM NF2	20	100	100
TSM W	65	100	100
TSM Ku	91	100	100
TSM Ka	86	100	100
TSM Wa	97	100	100
TSM NF1	84	100	100
TSM MV	94	100	100
TSM Ty	96	100	100
BSM Co	100	100	Not tested

\* BSM was tested against a TSM DD

**Table 2.** Testing results for the 1999/2000 cotton season- two-spotted mite against bifenthrin

Strain	Slope	LC50% ai	RF	LC99% ai	RF	field applications
Susc.	4.1	0.00089	-	0.0026	-	-
TSM Y	1.6	0.0035	3.9	0.058	22.3	?
TSM Co	1.8	0.0020	2.2	0.024	9.23	?
TSM NF2*	1.7	0.097	108.9	1.26	484.6	3
TSM W	1.1	0.0091	10.2	0.53	203.8	?
TSM Ku	1.4	0.0037	4.1	0.096	36.9	?
TSM Ka	1.3	0.0042	4.7	0.13	50.0	?
TSM Wa	1.7	0.0013	1.5	0.017	6.5	?
TSM NF1*	0.92	0.0026	2.9	0.32	123.1	0
TSM MV	0.86	0.0014	1.6	0.24	92.3	?
TSM Ty	0.91	0.00030	0.3	0.042	16.1	?

\*Survivors at 1.28% ai !

**Table 3.** Testing results for the 1999/2000 cotton season- two-spotted mite against chlorfenapyr

Strain	Slope	LC50 % ai	RF	LC99 % ai	RF
Susc.	3.1	0.0017	-	0.0072	-
TSM Y	2.0	0.00064	0.38	0.0095	1.32
TSM Co	2.8	0.00081	0.48	0.0055	0.76
TSM NF2	3.2	0.00068	0.40	0.0036	0.50
TSM W	2.9	0.00079	0.46	0.0050	0.69
TSM Ku	2.4	0.00070	0.41	0.0065	0.90
TSM Ka	2.0	0.00058	0.34	0.0084	1.17
TSM Wa	2.4	0.00074	0.43	0.0068	0.94
TSM NF1	2.1	0.0017	1.0	0.022	3.05
TSM MV	2.8	0.00029	0.17	0.0020	0.27
TSM Ty	2.4	0.00020	0.12	0.0019	0.26

**Table 4.** Testing results for the 1999/2000 cotton season- two-spotted mite against diafenthiuron

Strain	Slope	LC50 % ai	RF	LC99 % ai	RF
Susc.	6.0	0.00017	-	0.00036	-
TSM Y	8.1	0.00009	0.52	0.00017	0.47
TSM Co	4.1	0.00008	0.47	0.00030	0.83
TSM NF2	3.4	0.00007	0.41	0.00035	0.97
TSM W	5.4	0.00009	0.52	0.00025	0.69
TSM Ku	3.4	0.00007	0.41	0.00035	0.97
TSM Ka	3.8	0.00007	0.41	0.00026	0.72
TSM Wa	3.2	0.00011	0.64	0.00059	1.64
TSM NF1	3.7	0.00006	0.35	0.00027	0.75
TSM MV	4.0	0.00010	0.58	0.00038	1.05
TSM Ty	3.3	0.00009	0.52	0.00045	1.25

## **RESISTANCE TESTING OF TWO-SPOTTED MITE: 2000/2001**

### *Strains Tested*

AE = Auscott Ewenmar, Macquarie Valley (1/3/01), EL = Ellengerah, Macquarie Valley (1/3/01), WH = White Acres Field 35, Macquarie Valley (1/3/01), NA = Carabeen, Namoi Valley (28/2/01), CU = Cubbaroo, Namoi Valley (28/2/01), MI = Milawa Field 1, Macquarie Valley (1/3/01).

### *Chemicals Tested*

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

### *Results*

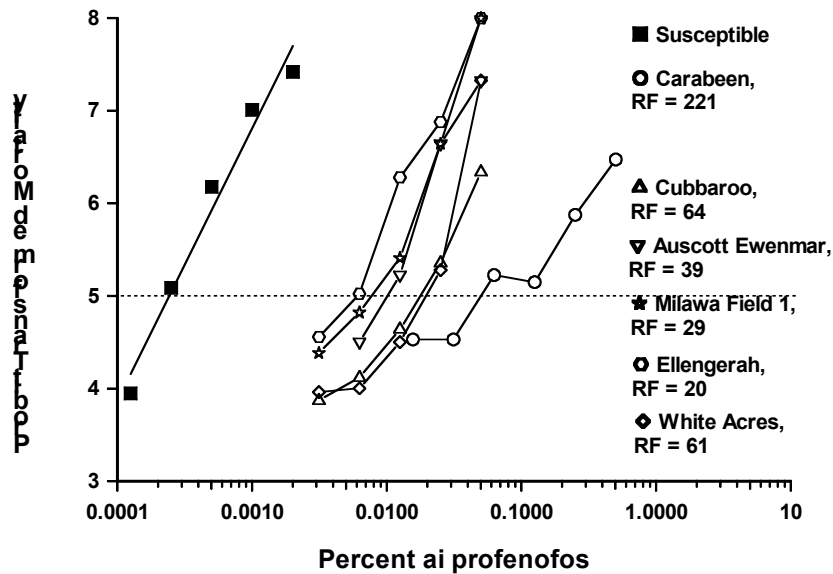
Propargite, abamectin, chlorfenapyr or diafenthiuron resistance were not detected (Tables 1, 2 and 3). Profenofos resistance was evident in every strain tested with a maximum level of 221x (Figure 1). Bifenthrin resistance was detected in all but one strain with resistance frequencies being highly variable between strains (Table 1). Although chlorfenapyr resistance was not detected all field-collected strains showed significant negative cross-resistance (Table 2).

### *Discussion*

In season's 1999-2000 I noted probit slope values for chlorfenapyr were trending down. They started at 3.0 – 4.1, the following season they were 2.3 - 3.0, then 2.0 – 3.2. This season slopes are again lower and now range from 1.6 – 2.7. Chlorfenapyr resistance has not yet been detected in twospotted mite from cotton. However, control breakdowns have recently been reported in horticulture with failures linked to resistance (GAH unpublished data). Loss of control was likely due to cross-resistance from organotin use and luckily organotins have had little or no use in cotton. However, the continuous reduction in slope is worrying and chlorfenapyr requires close monitoring.

During the 1999-2000 cotton season, bifenthrin resistance was detected in 9 of the ten strains tested. For the 2000-2001 season bifenthrin resistance was detected in 5 out of 6 strains tested. This suggests that the abundance of bifenthrin resistance to be much the same as it was. However, the most resistant strain in 1999-2000 season (NF2) had 80% bifenthrin resistant mites. In contrast, last season, strain Carabeen had 97% resistant mites. Clearly, bifenthrin resistance levels continue to increase so making the product more unreliable for mite control.

Profenofos resistance seemed a little lower than found previously. In season 1998-1999 profenofos resistance in TSM peaked at 383x in strain ACRI Block 17. In season 1999-2000 resistance exceeded 500x in the strains Willawood and Kamilaroi with another three strains having resistance at 200 – 300x. For the past 2000-2001 season resistance peaked at 221x in strain Carabeen with remaining strains having resistance levels <64x. Clearly, profenofos resistance is lower than it has been over the previous few seasons.



**Figure 2** Dose-response testing for profenofos against two-spotted mite for the 2000/2001-cotton season

**Table 1.** Testing results for the 2000/2001 cotton season- 6 strain of two-spotted mite (TSM) against a 0.01% discriminating dose (DD) of propargite, 0.0001% DD of abamectin and 0.02 % bifenthrin

Strain	Mortality at DD for bifenthrin	Mortality at DD for propargite	Mortality at DD for abamectin
Carabeen	3	100	100
Cubbaroo	40	100	100
Auscott Ewenmar	90	100	100
Milawa Field 1	56	100	100
Ellengerah	96	100	100
White Acres	100	100	100

**Table 2.** Testing results for the 2001/2001 cotton season- two-spotted mite against chlorfenapyr

Strain	Slope (s.e.)	LC50 (95% F.L.) % ai	RF(95% CI)	LC99 (95% F.L.) % ai	RF(95% CI)
Susc.	3.0 (0.46)	0.0017 (0.0014-0.0021)	-	0.010 (0.0082-0.014)	-
Carabeen	2.7 (0.81)	0.00048 (0.00034-0.00061)	0.3 (0.2-0.5)	0.0035 (0.0023-0.0078)	0.4 (0.09-1.3)
Cubbaroo	2.7 (0.42)	0.00038 (0.00030-0.00046)	0.2 (0.1-0.3)	0.0028 (0.0021-0.0044)	0.3 (0.1-0.6)
Auscott Ewenmar	1.8 (1.32)	0.00060 (0.00030-0.00096)	0.3 (0.07-1.7)	0.012 (0.0048-0.12)	1.2 (0.01-98.4)
Milawa Field 1	1.7 (0.36)	0.00015 (0.000092-0.00021)	0.09 (0.05-0.15)	0.0034 (0.0022-0.0066)	0.3 (0.1-1.1)
Ellengerah	2.2 (0.59)	0.00027 (0.00017-0.00037)	0.1 (0.09-0.3)	0.0031 (0.0021-0.0062)	0.3 (0.08-1.1)
White Acres	1.6 (1.56)	0.00053 (0.00010-0.00095)	0.3 (0.03-2.7)	0.015 (0.0054-0.79)	1.5 (0.006-387.6)

**Table 3.** Testing results for the 2000/2001 cotton season- two-spotted mite against diafenthiuron

Strain	Slope (s.e.)	LC50 (95% F.L.) % ai	RF (95% CI)	LC99 (95% F.L.) % ai	RF(95% CI)
Susc.	5.9 (1.86)	0.00018 (0.00015-0.00021)	-	0.00034 (0.00027-0.00049)	-
Carabeen	4.3 (0.75)	0.00022 (0.00017-0.00026)	1.2 (0.9-1.7)	0.00075 (0.00061-0.0010)	1.7 (0.8-3.6)
Cubbaroo	5.1 (0.85)	0.00024 (0.00020-0.00028)	1.4 (1.0-1.9)	0.00069 (0.00058-0.00090)	1.6 (0.8-3.3)
Auscott Ewenmar	3.6 (0.85)	0.00017 (0.00014-0.00020)	0.9 (0.6-1.4)	0.00075 (0.00052-0.0014)	1.7 (0.6-4.6)
Milawa Field 1	4.3 (0.68)	0.00023 (0.00018-0.00026)	1.3 (0.9-1.8)	0.00078 (0.00064-0.0011)	1.8 (0.8-3.7)
Ellengerah	4.8 (0.78)	0.00022 (0.00017-0.00025)	1.2 (0.9-1.7)	0.00067 (0.00056-0.00086)	1.5 (0.7-3.2)
White Acres	4.0 (1.56)	0.00016 (0.00012-0.00020)	0.9 (0.5-1.5)	0.00061 (0.00041-0.0013)	1.4 (0.4-5.1)

## RESISTANCE TESTING OF TWO-SPOTTED MITE: 2001/2002

### Strains Tested

PE = Pindara East Field 14, WN = Warriana Field 4, MI = Mirrabooka Field 4, KU = Kumbderdeen, BE = Belpais Field 4, SO = I Son's Field 32, ST = St George, and AC = ACRI Block 18 plot 12.

### Chemicals Tested

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

### Results

Abamectin resistance was not detected (Table 1). Bifenthrin resistance was detected in all but one strain with resistance frequencies being variable between strains. A small percentage of propargite resistant mites were detected in strains St George and Kumbderdeen (Table 1) and both strains had LC<sub>50</sub> resistance factors significantly greater than 1 (Table 2). A small proportion of chlorfenapyr resistant mites were detected in strain Belpais Field 4 but not enough to significantly alter the LC<sub>50</sub> level resistance factor (Table 3). However, 2000-2001 and 2002-2002 data show chlorfenapyr dose-responses are trending towards levels that caused control failure in horticulture (Figure 1). Unusually St George, Mirrabooka Field 4 and Pindara East Field 14 had survivors equivalent to a dose of 0.001% CGA-140408. Profenofos resistance was evident in every strain tested with a maximum level of 1718x (Figure 2).

### Discussion

For a number of seasons I have noted with some concern that probit slope values for chlorfenapyr were trending down season to season. They started at 3.0 – 4.1, the following season they were 2.3 - 3.0, then 2.0 – 3.2, 1.6 – 2.7 and now 1.3 - 3.1. For the first time, there have been survivors at discriminating dose, a result that constitutes prima facie resistance. Survivors were in strain Belpais Field 4 that also had the slowest slope value. Clearly there has been a general trend to Chlorfenapyr resistance. Strain Belpais Field 4 will be pressured with chlorfenapyr to see if resistance levels may ultimately match those experienced in horticulture.

During the 1999-2000 cotton season, bifenthrin resistance was detected in 9 of the ten strains tested. For the 2000-2001 season bifenthrin resistance was detected in 5 out of 6 strains tested. For season 2001-2002 resistance was detected in 7 of the 8 strains tested. This suggests that the abundance of bifenthrin resistance is not changing. The highest frequency of resistant mites in any one population has also remained static with 2000-2001 season strain Carabeen having 97% resistant mites, matched exactly in 2001-2002 by strain Pindara East Field 14.

Unusually St George, Mirrabooka Field 4 and Pindara East Field 14 had survivors equivalent to a dose of 0.001% CGA-140408. This is the first time since monitoring began that mites have survived such a dose. It could be interpreted as resistance, however, I consider it is more likely this is high level tolerance. To prove lack of resistance one strain will be pressured to see if levels rise and a new product sample sought to confirm CGA-140408 efficacy. If proven a robust discriminating dose for regular CGA-140408 resistance monitoring would likely be 0.002%.

For the 2000-2001 season profenofos resistance peaked at 221x in strain Carabeen with remaining strains having resistance levels <64x. Clearly, profenofos resistance was lower than it has been over the previous few seasons. However for season 2001-2002, resistance has again risen peaking at an all time high of 1718x in strain Warriana Field 4.

**Table 1.** Testing results for the 2001/2002 cotton season- eight strains of two-spotted mite (TSM) against a 0.02% discriminating dose (DD) of propargite, 0.0001% DD of abamectin and 0.02 % bifenthrin.

Strain	Mortality at DD for bifenthrin	Mortality at DD for propargite	Mortality at DD for abamectin
St George*	100	99	100
Belapais	54	100	100
Warriana	83	100	100
ACRI	54	100	100
Mirrabooka	98	100	100

Pindara	3	100	100
I Son's	75	100	100
Kumbderdeen	86	97	100

\* bifenthrin and propargite were additionally tested against *Tetranychus lambi* at the *T. urticae* rate and gave 100 and 92 percent mortality respectively

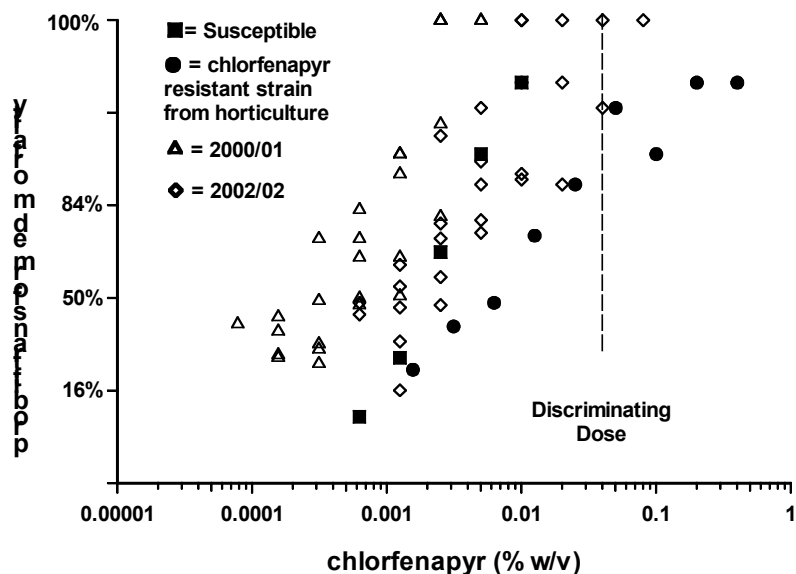
**Table 2.** Full log dose probit analysis for the 2001/2002 cotton season- two-spotted mite against propargite

Strain	Slope (s.e.)	LC50 (95% F.L.) % ai	RF(95% CI)	LC99 (95% F.L.) % ai	RF(95% CI)
Susc.	3.6 (0.71)	0.0014 (0.0012-0.0016)	-	0.0063 (0.0048-0.0098)	-
St George	4.8 (0.55)	0.0029 (0.0026-0.0032)	2.0 (1.6-2.6)	0.0089 (0.0075-0.011)	1.4 (0.7-2.7)
Kumbderdeen	2.4 (0.50)	0.0047 (0.0036-0.0059)	3.3 (2.1-5.1)	0.041 (0.028-0.073)	6.5 (2.1-19.9)

**Table 3.** Full log dose probit analysis results for the 2001/2002 cotton season- two-spotted mite against chlorfenapyr

Strain	Slope (s.e.)	LC50 (95% F.L.) % ai	RF(95% CI)	LC99 (95% F.L.) % ai	RF(95% CI)
Susc.	3.0 (0.46)	0.0017 (0.0014-0.0021)	-	0.010 (0.0082-0.014)	-
St George	2.3 (0.17)	0.0017 (0.0014-0.0019)	0.99 (0.75-1.29)	0.017 (0.014-0.022)	1.75 (0.91-3.34)
*Belapais	1.3 (0.55)	0.0014 (0.00054-0.0025)	0.83 (0.21-3.2)	0.081 (0.037-0.38)	7.98 (0.52-122)
Warriana	2.6 (0.64)	0.00084 (0.00049-0.0011)	0.48 (0.30-0.76)	0.0064 (0.0048-0.010)	0.62 (0.22-1.75)
ACRI	2.6 (0.48)	0.00034 (0.0026-0.0041)	1.94 (1.30-2.88)	0.027 (0.019-0.046)	2.66 (1.03-6.87)
Mirrabooka	2.8 (0.85)	0.0024 (0.0018-0.0030)	1.37 (0.79-2.39)	0.016 (0.010-0.033)	1.57 (0.41-5.91)
Pindara	3.0 (1.13)	0.0011 (0.00066-0.0015)	0.65 (0.37-1.15)	0.0067 (0.008-0.013)	0.72 (0.17-2.91)
I Son's	2.0 (0.62)	0.0011 (0.00071-0.0016)	0.66 (0.36-1.21)	0.016 (0.0094-0.040)	1.53 (0.33-7.05)
Kumbderdeen	3.1 (0.57)	0.00091 (0.00061-0.0011)	0.52 (0.37-0.73)	0.0050 (0.0040-0.0067)	0.48 (0.22-1.07)

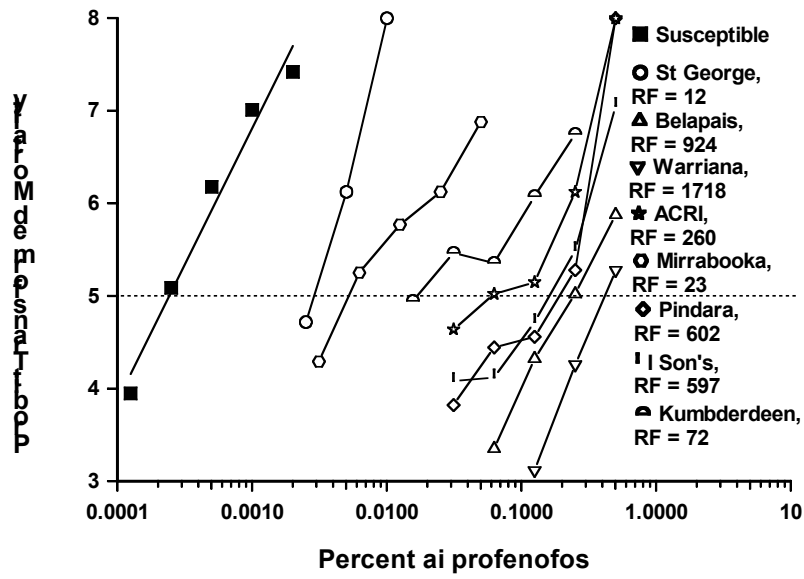
\*survivors at a DD of 0.04% ai chlorfenapyr



**Figure 1. Dose-response for chlorfenapyr showing how cotton is trending towards a response that caused control failure in horticulture.**

**Table 4.** Full log dose probit analysis results for the 2001/2002 cotton season- twospotted mite against CGA-140408 (diafenthiuron)

Strain	Slope (s.e.)	LC50 (95% F.L.) % ai	RF (95% CI)	LC99 (95% F.L.) % ai	RF(95% CI)
Susc.	5.9 (1.86)	0.00018 (0.00015-0.00021)	-	0.00034 (0.00027-0.00049)	-
St George	3.6 (0.41)	0.00030 (0.00025-0.00034)	1.7 (1.25-2.31)	0.0013 (0.0011-0.0017)	3.03 (1.47-6.24)
Belapais	4.3 (1.37)	0.00016 (0.00012-0.00019)	0.90 (0.57-1.41)	0.00054 (0.00043-0.00081)	1.25 (0.44-3.53)
Warriana	3.7 (2.1)	0.00012 (0.000082-0.00016)	0.71 (0.34-1.47)	0.00054 (0.00036-0.0014)	1.23 (0.19-7.88)
ACRI	3.6 (0.25)	0.00011 (0.000099-0.00013)	0.64 (0.48-0.85)	0.00051 (0.00044-0.00059)	1.15 (0.59-2.23)
Mirrabooka	3.2 (1.00)	0.00029 (0.00023-0.00037)	1.68 (1.00-2.80)	0.00015 (0.00011-0.00029)	3.5 (1.04-11.9)
Pindara	4.6 (8.18)	0.00015 (0.000033-0.00027)	0.87 (0.14-5.1)	0.00048 (0.00030-0.0013)	1.14 (0.016-82)
I Son's	3.7 (0.64)	0.00012 (0.00010-0.00014)	0.69 (0.49-0.97)	0.00052 (0.00040-0.00077)	1.18 (0.52-2.68)
Kumbderdeen	4.1 (1.58)	0.00015 (0.00012-0.00019)	0.86 (0.51-1.44)	0.00056 (0.00039-0.0011)	1.27 (0.37-4.38)



**Figure 2.** Dose-response testing including resistance factors (RF) for profenofos against eight strains of two-spotted mite for the 2001/2002-cotton season

### **Resistance testing of cotton aphid: 1999-2000**

For season, 1999/00 considerable effort went into cotton aphid resistance monitoring (Table 1). As field control failures were first detected at Emerald during 1998/99, the region was re-surveyed in some detail. Additional aphid populations were collected from southern Queensland and NSW. Resistance is now very easily found outside the Emerald region where it was first detected and is often linked to field control failure.

**Table 1** Frequency (%) of resistant aphids detected in populations of cotton aphid during the 1999-2000 cotton season

Strain	Pirimor	Curacron	Confidor	Folimat	Pegasus
Tessmans Farm Emerald	0	1	0	1	0
Neville Brownlie Emerald	17	5	0	12	0
DPI Emerald	16	5	0	7	0
Jabiwarra Emerald	97	36	0	93	0
Parker Farms Emerald	96	65	0	100	0
Tony Ronnfeldt Emerald	34	29	0	40	0
Kerry Downs Emerald	76	77	0	39	0
Fairfield Emerald	0	0	0	0	0
Currimundi Emerald	0	0	0	0	0
Pasedena Emerald	0	0	0	0	0
N. Robertson Dalby Downs 1	0	0	0	0	0
N. Robertson Dalby Downs 2	0	0	0	0	0
Jimbour Dalby	0	0	0	0	0
Taraba Goondiwindi	77	87	0	79	0
Mirrabooka Narrabri	70	58	0	89	0
Myalla Wee Waa	79	66	0	88	0
Lamer Moor Lower Namoi	53	31	0	76	0

During the 1999/2000 season, biochemical tests done by collaborators (Gunning and Moores) indicated cross-resistance between carbamate and organophosphate (OP) use. The practical outcome is carbamates and OPs should be considered a single group for the purposes of resistance management. Luckily for the coming 2000/2001 season Confidor will also be available for cotton aphid control. This will give growers access to 3 groups for the purposes of resistance management, 1. OP/ carbamate, 2. Pegasus and 3. Confidor. Unfortunately, both Pegasus and Confidor have long withholding periods of 5 and 13 weeks respectively. In addition, Pegasus can only be used on a closed canopy. The result is Confidor is only available for use earlier in the season and Pegasus later in the season. There is currently no new chemistry available for cotton aphid control within 5 weeks of crop harvest.

There are two likely control scenarios, the first where resistance has been detected or suspected and control failures reported and the second without control problems and resistance is not suspected. For the suspect resistance scenario a suitable treatment rotation may be Confidor, Pegasus, OP / carbamate. If resistance is not suspected, then any chemical can be used (dependant on price, withholding period, canopy closure etc). A suitable treatment rotation for the susceptible scenario may be OP / carbamate, Confidor, Pegasus.

The important point to remember is, if OP / carbamates are lost to resistance early in the season, they will not work in the 5 week period before harvest when new chemistry is unavailable. To manage resistance in cotton aphid it is crucial to rotate chemical groups including non-consecutive use of any group.

## Resistance testing of Cotton Aphid: 2000-2001

### Results and Discussion

Green peach aphid is a sporadic early pest of Australian cotton and this season we received two “early” strains associated with control failure. One strain died out before it could be tested but the second was tested for resistance. The green peach aphid strain showed both Curacron and Pirimor resistance but was susceptible to endosulfan and Decis (Table 1).

**Table 1.** Percent resistant green peach aphid

Strain (date)	Pirimor	Curacron	Rogor	Decis
Pindara 8/12	24	18	51	0

Testing of green peach aphid from cotton in 1994 showed that populations with a frequency of 24% pirimicarb resistance (as in Table 1) were >90 resistant to dimethoate (see Herron and Rophail 1994). Such resistance frequencies will undoubtedly result in control failure to either chemical.

For cotton aphid comparison back to last season’s data shows the Pirimor resistance frequency has risen from 59 percent to 78 percent (Table 2). There is a similar trend for Folimat with the resistance frequency rising from 65 to 78 percent. The exact percent resistant Pirimor and Folimat resistant populations is likely due to cross-resistance between these compounds. There was a smaller rise in the frequency of profenofos resistance from 64 to 74 percent. The good news was both Pegasus and Confidor resistance was not detected. Consequently, the many Confidor control failures reported during the current 2000 / 2001 season are due to factors other than resistance.

**Table 2** Percent resistant cotton aphid strains (Forty-one collected) from cotton during the 2000-2001 cotton season.

Chemical	Percent resistant 2001	Percent resistant 2000
Pirimicarb (Pirimor)	78	59
Omethoate (Folimat)	78	65
Profenofos (Curacron)	74	64
Diafenthuron (Pegasus)	0	0
Imidacloprid (Confidor)	0	0

By now we were well into are third season of field control failures associated with resistance. In the first 1998 / 1999 season control failures were restricted to the Emerald region of Central Queensland. By the second 1999 / 2000 season resistance was looking endemic with control failures reported in all Eastern Australian cotton growing areas. For the current 2000 / 2001 season a proportion of properties sampled last season have been re-sampled to ascertain what may be happening with resistance frequencies both within and between the cotton-growing season.

Organophosphate and carbamate resistance in cotton aphid can be maintained in laboratory culture without selection (O’Brien 1992). It seems reasonable then to speculate that resistant aphids would overwinter causing ongoing problematic control problems season to season. This scenario seems applicable to the Emerald property “Glendale” (Table 3). Resistant aphids were detected during 1999 / 2000 and again during the 2000 / 2001.

**Table 3.** Aphids collected by Dave Kelly from the Emerald region 2000/2001 (Percent resistant aphids)

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
Little Farm Road <sup>1</sup> (21/9)	0	0	0	0	0

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
McKays <sup>2</sup> (29/11)	0	0	0	0	0
Waterways <sup>3</sup> (29/11)	95	99	80	0	0
Parker Farms <sup>4</sup> (29/11)	0	0	0	0	0
Glendale <sup>5</sup> (13/12)	64	27	49	0	0
Kerry Downs <sup>5</sup> (13/12)	0	0	0	0	0
Currimundi <sup>5</sup> (13/12)	45	19	25	0	0
Fairfield <sup>5</sup> 13/12	31	24	25	0	0
Pasadena <sup>5</sup> 13/12	53	68	23	0	0
Jabiwarra (3/1)	31	30	26	0	0
Tessmans Farm Whittonvale <sup>6</sup> (4/1)	Died out before testing 93	Died out before testing 89	Died out before testing 63	Died out before testing 0	Died out before testing 0
DPI Research Stn (9/1)	0	1	0	0	0
Carmbly Brownlees (9/1)	88	81	37	0	0
Parker Farms 2 (16/1)	95	86	34	0	0

<sup>1</sup> notes: Off grapes

<sup>2</sup> notes: Not previously sampled

<sup>3</sup> notes: Previously sampled September 00

<sup>4</sup> notes: Sample from exactly the same spot as last year

<sup>5</sup> notes: Farms sampled last year

<sup>6</sup> notes: Survived Folimat 4 days prior to collection

There are also examples where resistance had not been detected during 1999 / 2000 but was abundant during 2000 / 2001. This is evident in the populations from “Pasadena” (Table 3), “Currimundi” (Table 3) and “Fairfield” (Table 3). In these three strains resistance went from undetectable to high frequency and likely control failure within a season. Looking at the result for “Waverley” (Table 4) once resistance is established on a property it is likely to remain at high frequencies for the remainder of the season. On this property resistance frequencies dropped slightly as the season progressed however they were always at levels likely to cause control failures. This is significant because it substantiates the control recommendations given below

**Table 4.** Aphids collected by Lewis Wilson from the Namoi and Macquarie regions 2000/2001 (Percent resistant aphids)

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
Waverley <sup>1</sup> (30/11)	91	98	72	0	0
Mirrabooka field 2 (8/12)	0	0	0	0	0
Mirrabooka field 5 (8/12)	95	93	54	0	0
Taratan (14/12)	Died out before testing	Died out before testing	Died out before testing	Died out before testing	Died out before testing
Greenwood	Died out before testing	Died out before testing	Died out before testing	Died out before testing	0
Grange <sup>2</sup> (3/1)	before testing	before testing	before testing	before testing	

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
Sicala <sup>3</sup> (17/1)	88	88	69	0	0
Opal <sup>4</sup> (17/1)	96	90	67	0	0
Siokra <sup>5</sup> (17/1)	96	90	33	0	0
Coomallie <sup>6</sup> (14/2)	95	85	43	0	0

<sup>1</sup> notes: Field 6; survived aerial application of Pirimor 22/11 which was obviously due to resistance

<sup>2</sup> notes: Survived 2x Pirimor, 1x Rogor and 2x Confidor, however, Confidor resistance not detected

<sup>3</sup> notes: Control problems Field 5 Willawood; grower used 1x Pirimor, 2x Confidor, 1x Predator

<sup>4</sup> notes: Control problems Field 4 Willawood; grower used 1x Pirimor, 1x Confidor, 1x Curacron

<sup>5</sup> notes: Control problems Field 8 Willawood; grower used 1x Pirimor, 1x Confidor, 1x Predator

<sup>6</sup> notes: Field 21; collected by R H, advised by email.

last season warning if organophosphates and carbamates are lost to resistance early in the season, they will not work in the 5 week period before harvest when new chemistry is unavailable.

Last season, a property at Emerald called “Parker Farms” had the highest frequency of resistant aphids. The abundance of resistance aphids on “Parker Farms” during 1999 / 2000 season would have easily caused control failures. The exact site was re-sampled for the current season, and surprisingly, no resistance could be detected early in the 2000 / 2001 season (Table 3). However in a second sampling later in 2000 / 2001 season again detected resistance. This apparent overwinter loss of resistance in aphids at “Parker Farms” is not an isolated instance. It was also seen on the properties “Kerry Downs” (Table 3) and “Mirrabooka” (Table 4). The result for “Mirrabooka” is particularly interesting as individual fields had aphids with completely different resistance profiles. “Mirrabooka” field 2 contained only susceptible aphids while field 5 contained highly resistant aphids. These data confirm anecdotal grower feed back that aphids separated only by metres can be completely different in their resistance profile.

These data have significant implications for the effective management of cotton aphid. If resistant aphids do not always persist season to season they must be killed, emigrate or be diluted (by and the immigration of susceptibles). So aphid control problems this season does not necessarily mean control problems next season. To facilitate this good outcome it would be advisable to try and destroy overwintering aphids and harbourages. In addition, farmers should use all chemistry at their disposal for aphid control during any one season and so consider the use of endosulfan. Such alternation will help reduce organophosphate and carbamate selection pressure and sustain their efficacy into the 5-week period before harvest when new chemistry is unavailable. As always, it is crucial to rotate chemical groups including non-consecutive use of any group.

In conclusion, testing suggests that resistant aphid populations may not persist season to season on all properties. To assist the natural off-season destruction of resistant populations we suggest cotton-growers target overwintering aphids and their harbourages for control. To additionally reduce the organophosphate and carbamate selection pressure during any single cotton season we ask growers to consider all aphid control options including endosulfan. Such alternation will help sustain organophosphate and carbamate efficacy into the 5-week period before harvest when new chemistry is unavailable.

**Table 5** Aphids collected by James Quin from the Gwydir regions 2000/2001 (Percent resistant aphids)

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
James Quin <sup>1</sup> (14/12)	15	3	1	0	0
Norwood <sup>2</sup> (no date)	0	8	8	0	0
Telleraga <sup>3</sup> (no date)	93	89	75	0	0
JQ- Gwydir <sup>4</sup>	96	95	100	0	0

<sup>1</sup> notes: Aphids survived field applications of Rogor and Pirimor, however, the frequency of resistant aphids was relatively low.

<sup>2</sup> notes: Aphids survived a field application of Confidor but resistance was not detected.

<sup>3</sup> notes: Aphids survived a field application of Pirimor. Pirimor resistance was at a high frequency and the failure was likely due to resistance.

<sup>4</sup> notes: Suspected of being resistant which has been confirmed.

**Table 6** Aphids collected by Rachael Dunn from the Namoi region 2000/2001 (Percent resistant aphids)

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
Taratan <sup>1</sup> (4/1)	95	94	56	0	0
Waverly <sup>1</sup> Field 6 (4/1)	66	64	34	0	0
Waverly <sup>1</sup> Field 10 (4/1)	70	78	52	0	0

<sup>1</sup> notes: Confidor resistance suspected but not detected.

**Table 7** Aphids collected by Susie McCutcheon from the Emerald region 2000/2001 (Percent resistant aphids)

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
David Duke <sup>1</sup> (2/1)	99	100	44	0	0

<sup>1</sup> notes: Confidor performed poorly in the field but resistance not detected.

**Table 8** Aphids collected by Janelle Macpherson from the Goondiwindi region 2000/2001 (Percent resistant aphids)

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
Goondiwindi K6 <sup>1</sup> (19/2)	98	74	72	0	0
Goondiwindi K7/8 <sup>2</sup> (19/2)	95	86	43	0	0

<sup>1</sup> notes: Aphids survived field application of Pirimor.

<sup>2</sup> notes: Aphids survived a field application of Predator (chlorpyrifos ethyl). This was investigated and only 2% of aphids were found resistant to Predator. An preliminary test conducted against chlorpyrifos methyl (Rescue) suggested control would be less effective than Predator.

**Table 9** Aphids collected by Simon Struss from the Biloela region 2000/2001 (Percent resistant aphids)

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
Wilcannia (1/3)	98	99	100	0	0

<sup>1</sup> notes: Survived a field application of Rogor. The control-failure was likely caused by the high frequency of OP resistant aphids.

**Table 10** Aphids collected by Paul Grundy from the Biloela region 2000/2001 (Percent resistant aphids)

Strain (date)	Pirimor	Folimat	Curacron	Pegasus	Confidor
Gibba brownlees (15/1)	86	79	76	0	0
P. French (15/1)	2	0	0	0	0
H. Anderson <sup>1</sup> (15/1)	5	0	0	0	0

<sup>1</sup> notes: Suspect Folimat spray at Anderson's but resistance not detected.

### ***Resistance testing of cotton aphid: 2001-2002***

For season 2001-2002 the chemicals bifenthrin, chlorpyrifos-methyl and endosulfan were included in the testing program when it was not scheduled (table 1). That also significantly delayed completion of the work.

Chlorpyrifos was included into the testing because cross-resistance data indicated it could control target site resistant strains (ie Pirimor resistant). Unfortunately, chlorpyrifos-methyl resistance itself was common so it is unlikely to be as useful as first hoped.

Collections were made from small plot trials at ACRI testing a range of chemical controls (Strains ACRI Block 18 plot 41 and Block 14 Plots 14, 19 and 22). The variation in response between plots was amazing and highlights the need for resistance bioassay support in any future field trials with conventional chemistry.

Strain Willawood 2001-2 had some degree of dimethoate resistance. I can tell this because the data show pirimicarb resistance and there is cross-resistance between these chemicals. Interestingly, the strain shows Profenofos resistance although this is likely a different mechanism. The strain is described as from a backyard surviving Lorsban drift from nearby cotton. Clearly suburbia in the vicinity of cotton with overwintering cotton aphid may provide a nucleus for early season control failures. It will be interesting if 2002-2003 strains support this conclusion. Early season backyard strains will now also be targeted for collection