

REPORTS

Part 1 - Summary Details

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

CRDC Project Number: **DAQ121C**

Final Report: x Due 30-September 2004

Project Title: Aphid bio-control in cotton

Project Commencement Date: 1 Jul 2002 **Project Completion Date:** 30 Jun 2004

Research Program: 3 Crop Protection

Part 2 – Contact Details

Administrator: Mr Stuart Makings, Senior Planning Officer
Organisation: Department of Primary Industries and Fisheries
Postal Address: PO Box 2282, Toowoomba QLD 4350
Ph: 07 46398885 **Fax:** 07 46398881 **E-mail:** Stuart.Makings@dpi.qld.gov.au

Principal Researcher: Mr BA Franzmann, Principal Entomologist
Organisation: Department of Primary Industries and Fisheries
Postal Address: PO Box 102 Toowoomba QLD 4350
Ph: 07 46881313 **Fax:** 07 46881199 **E-mail:** Bernie.Franzmann@dpi.qld.gov.au

Supervisor: Mr BA Franzmann
Organisation: Department of Primary Industries and Fisheries
Postal Address: PO Box 102 Toowoomba QLD 4350
Ph: 07 46881313 **Fax:** 07 46881199 **E-mail:** Bernie.Franzmann@dpi.qld.gov.au

Researcher 2 Dr L Wilson
Organisation: CSIRO, Plant Industry
Postal Address: Locked Bag 59 Narrabri NSW 2390
Ph: 02 67991550 **Fax:** 02 67931186 **E-mail:** Lewis.Wilson@csiro.au

Signature of Research Provider Representative: _____

1. Outline the background to the project.

The cotton aphid, *Aphis gossypii* is a pest of escalating concern in Australia. With increasing utilisation of Bt cotton and consequent reduction in insecticide applications, coupled with emerging insecticide resistance, cotton aphids appear to be more of a problem than previously. The cotton aphid also has been shown to carry, or cause, a new major problem for the Australian cotton industry, cotton bunchy top. Fundamental to the development of IPM systems for cotton aphid is the knowledge of what parasitoids are active and their relative importance.

The cotton aphid parasitoid, *Lysiphlebus testaceipes* released in Australia in 1984 has recently been found attacking corn aphids on sorghum in cotton areas in Australia. The parasitoid has not been recorded from the cotton aphid in Australia though no systematic survey has been carried out. This parasitoid was recently rated by USA cotton IPM specialists as the most important parasitoid of all those attacking pest insects in cotton in the USA.

Two other aphids also occur in cotton. Nothing is known about how the natural enemies of the different aphids interact and influence the biological control of each aphid species. Trap crops are an important part of cotton production. Other aphids in trap crops including the cowpea aphid, soybean aphid and corn aphid may also play an important role in providing a refuge for biocontrol agents of aphids in cotton.

Aphid parasitoids in other agroecosystems have provided effective biological control of aphids (eg. lucerne in Australia and wheat in South America). The new parasitoid, *L. testaceipes* may be able to provide effective biocontrol of cotton aphid in Australian cotton.

2. List the project objectives and the extent to which these have been achieved.

Objectives

- 1) Document aphid bio-control agents in cotton in Queensland.

Three years of observation, sampling and trial data has produced extensive information on the occurrence of bio-control agents and their relative importance.

- 2) Evaluate the role of bio-control agents in influencing aphid populations.

Eleven parasitoid/predator exclusion trials and four sentinel trials have shown that bio-control agents can prevent or greatly hinder aphid establishment and subsequent build up in cotton crops.

- 3) Evaluate alternative hosts in the population dynamics of cotton aphid in Queensland.

More than 90 weeds were extensively and intensively sampled for cotton aphids and information was gained on their role in the aphid's population dynamics.

- 4) Evaluate the influence of management practices on aphid biocontrol.

In the final year of the project, in order to examine the effect of different management practices, a number of commercial cotton production sites were set up but all were sprayed to control aphids before good data were obtained.

- 5) Evaluate inoculative/inundative release of parasitoids for aphid control.

Techniques were developed to successfully mass rear aphid parasitoids for inoculative release and two field trials were carried out to evaluate the technique.

3. Detail the methodology and justify the methodology used.

- 1) Document aphid biocontrol agents in cotton in Queensland.

- a) Intensively sample Darling Downs cotton crops for aphids and bio-control agents.

In the three seasons of the project, 19 commercial cotton crops on the Darling Downs were monitored for aphids and their bio-control agents. Additional information was obtained by observations in the parasitoid/predator exclusion trials.

On a few occasions monitoring was carried out during the night to obtain information on nocturnal bio-control agents.

On a few occasions fields were inoculated with aphids and these colonies were checked regularly to document bio-control agents, which act quickly on invading aphids.

- b) Extensively sample Central Qld cotton crops for aphids and bio-control agents.

Seven trips were made to CQ and usually 4-5 cotton crops were sampled at Emerald, Biloela and Theodore during each trip.

- 2) Evaluate the role of bio-control agents in influencing aphid populations.

- a) Carry out parasitoid/predator exclusion trials on aphids in cotton.

Eleven parasitoid/predator exclusion cage trials were carried out. Studies were done at Narrabri and on the Darling Downs. The trials examined the effect on aphid populations of excluding all natural enemies or excluding only large natural enemies.

Other studies to evaluate bio-control agents included feeding studies on the white-collared ladybird, *Hippodamia variegata* and the silverfly, *Leucopis formosana*. In a glasshouse trial, red and blue beetles, *Dicranolaius bellulus* were evaluated as aphid bio-control agents.

- 3) Evaluate alternative hosts in the population dynamics of cotton aphid in Queensland.

- a) Carry out systematic sampling for cotton aphids on alternative hosts on the Darling Downs.

For the first two years of the project, weeds at four sites on the Darling Downs were sampled monthly for cotton aphids and their natural enemies.

During the project other crops such as sorghum and barley were also sampled for incidence of natural enemies that are important bio-control agents of cotton aphid.

- b) Carry out systematic sampling for cotton aphids on alternative hosts in central Queensland during the off-season (May-October).

Trips were made to central Queensland during the off-season and weeds and ornamentals sampled.

- 4) Evaluate the influence of management practices on aphid bio-control.

- a) Evaluate the influence of trap crops in aphid bio-control in adjacent cotton.

In the 2003/04 season, in order to examine the effect of different management practices, three commercial cotton production sites were set up to examine the effect of adjacent fallow, or sorghum or maize but all were sprayed to control aphids before good data were obtained.

- 5) Evaluate inoculative /inundative release of parasitoids for aphid control.

- a) Carry out glasshouse trials on plant/aphid/parasitoid combinations for optimum mass-production.

Four initial combinations were tested before the optimum was found.

- b) Carry out field trials on the effect of inoculative/inundative release.

Two field trials were conducted where large numbers of the parasitoid *Lysephlebus testaceipes* were released at a number of foci in the field and parasitoid establishment was checked at various distances from the focus of inoculation.

4. Detail and discuss the results including the statistical analysis of results.

- 1) Document aphid biocontrol agents in cotton in Queensland.

Very few aphids and natural enemies were found in cotton crops that were regularly sprayed.

The most common and apparently important natural enemies were the white-collared ladybird, transverse ladybird, variable ladybird, red and blue beetle and brown smudge bug. Other, apparently less important predators include green and brown lacewings, two species of hoverfly and a silverfly. Spiders seemed to be of very little importance as aphid bio-control agents.

The parasitoids *L. testaceipes* and *Aphidius colemani* are also important particularly late in the season on established aphid infestations.

Results of 24h-studies indicated that none of these predators were active at night. The results suggest that sampling through the day alone gives a good indication of the abundance of natural enemies.

Results for CQ were similar to those from the Darling Downs and Northern NSW.

- 2) Evaluate the role of bio-control agents in influencing aphid populations.

Eleven parasitoid/predator exclusion trials were conducted. The results of all these trials demonstrated that predators reduced aphid populations. Figure 1 shows the result of one trial where 100 aphids were applied per leaf on 28/2/03. Aphid numbers were considerably reduced where they were exposed to predators over a two-week period. However the results from these trials gave no firm indication as to which of the extant predators were responsible for the reduction.

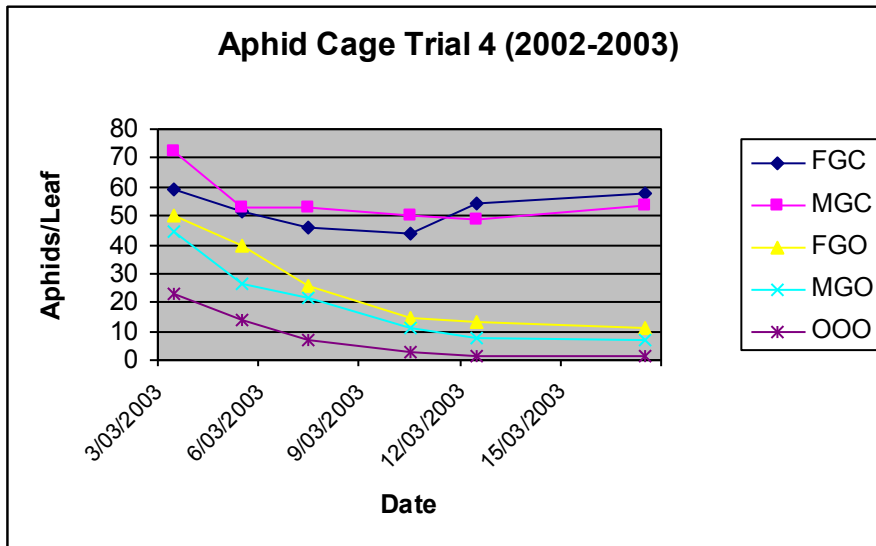


Fig1. Results of protecting aphid populations from all predators (FGC) or large predators (MGC)

The parasitoids *L. testaceipes* and *A. colemani* were found on a number of occasions completely cleaning up large aphid infestations late in the season.

The feeding studies on the white-collared ladybird showed that larvae consume about 600-800 aphids during their 9-10 day larval development period. Adults consume about 200 aphids per day for the 8-9 weeks of their life. The results indicate that the ladybird is a very important predator of cotton aphid.

A glasshouse trial with red and blue beetles showed that the beetles can hinder aphid build-up, restricting populations to 25% of an uncontrolled population over a four-week period. The results indicate that the beetle is of 'moderate' importance as a cotton aphid bio-control agent.

The silverfly was found to be a common predator of cotton aphid. Feeding studies showed that each larva consumes about 20-30 aphids during their development. The results indicate that silverfly larvae consume too few aphids to play a significant role in cotton aphid bio-control unless the flies are in very large numbers.

3) Evaluate alternative hosts in the population dynamics of cotton aphid in Queensland.

During sampling of weeds and non-cotton crops, cotton aphids were not found on other crops but were found on weeds. The most important weed hosts for producing the largest over-wintering populations were bladder ketmia, cobbler's pegs, marshmallow and Paddy's lucerne. These were also generally the most significant summer hosts. Many natural enemies also reproduced and survived on cotton aphids on these hosts during the cool season but a range of other aphid/weed systems were found to be very important in maintaining over-wintering natural enemy abundance. For example large infestations of *Dysaphis* sp. on scotch thistle and curled dock were extensively parasitised by *L. testaceipes* and white-collared and variable ladybirds bred extensively on *Aphis nerii* on balloon cotton.

Barley was found to be an extremely important winter refuge for natural enemies of cotton aphid. For example in one crop on the Darling Downs in September 2003, 10 big cotton aphid predators (ladybirds, lacewings and hoverflies) were found per metre of row. There were also some cotton aphid parasitoids present. The oat aphid commonly infested barley crops and these were often heavily parasitised by *L. testaceipes*.

- 4) Evaluate the influence of management practices on aphid bio-control.

In the final year of the project, in order to examine the effect of different management practices, a number of commercial cotton production sites were set up but all were sprayed to control aphids before good data were obtained.

- 5) Evaluate inoculative /inundative release of parasitoids for aphid control.

A protocol for mass rearing *L. testaceipes* on the oat aphid on barley was developed.

Two field trials were carried out to investigate inoculative release. In the first trial parasitoids were successfully established. In the second trial there was no evidence of establishment.

5. Provide a conclusion as to research outcomes compared with objectives. What are the “take home messages”?

A complex of predators, particularly adult ladybirds, can prevent or significantly hinder the establishment of aphid infestations in cotton. Some ladybirds find and commence to destroy aphids within 2-4 hours of aphid establishment in the cotton crop.

Aphid predators can prevent or hinder aphid population build up in cotton crops.

Aphid parasitoids can completely destroy established aphid infestations.

Barley crops provide an enormous over-wintering nursery for many of the important natural enemies of cotton aphid.

Cotton aphids survive over winter on a few weed species.

Other aphid/weed systems are important in maintaining natural enemy abundance during the winter.

6. Detail how your research has addressed the Corporation’s three Outputs - Economic, Environmental and Social?

The research was directed toward a reduction in insecticide spraying for aphid control leading to the direct economic benefit of saving on insecticide and application costs, an environmental benefit of less insecticide in the environment, and the social benefit of increased “quality of life” for cotton families with a reduction in insecticide usage on cotton farms

7. Provide a summary of the project ensuring the following areas are addressed:

a) technical advances achieved

A mass-rearing technique for cotton aphid parasitoids was developed.

b) other information developed from research

The role and relative importance of various bio-control agents of cotton aphid was elucidated.

c) are changes to the Intellectual Property register required?

No

8. Detail a plan for the activities or other steps that may be taken:

(a) to further develop or to exploit the project technology.

Further developments have been devolved to CSIRO cotton-aphid research group at Narrabri.

(b) for the future presentation and dissemination of the project outcomes.

Future presentations and dissemination will be done by Lewis Wilson, CSIRO, Narrabri.

(c) for future research.

Future research should aim to incorporate sampling for natural enemies into decision-making for control of cotton aphids.

As barley was often found harbouring enormous numbers of natural enemies, the concept of planting strips of barley close to cotton in spring might prove a fruitful avenue of research.

9. List the publications arising from the research project and/or a publication plan.

Franzmann B, Wilson L and Smith T (2002) Two new bio-control agents for cotton aphid. Proceedings of 11th Australian Cotton Conference. Pp 329-333

Franzmann B, Smith L, Trackson K, Wilson L (2004) The silverfly: A predator of cotton aphid. The Australian Cottongrower Vol25 No 1 : 24&26.

Wilson L. Heimoana S Smith T Herron G Franzmann B (2004) Research on aphid ecology and management. CD – 12th Australian Cotton Conference 9pp

Results of interest and significance will be further published through The Australian Cottongrower” and incorporated into the “Pest and Beneficial Guide” and the “Cotton IPM Guidelines”.

Some publications in scientific journals are planned.

10. 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 or the Australian community.

A good start was made into ultimately incorporating sampling for bio-control agents into cotton decision-making, particularly in relation to the use of Bollgard.

Part 4 – Final Report Executive Summary

Provide a one page Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web. Explain the main outcomes of the research and provide contact details for more information. It is important that the Executive Summary highlights concisely the key outputs from the project and, when they are adopted, what this will mean to the cotton industry.

The research into aphid bio-control in cotton has documented the agents attacking cotton aphid in southern and central Queensland, and provided an indication of their relative importance.

When aphids are invading cotton crops in the summer, a complex of predators (particularly adult ladybirds) can prevent or severely restrict aphid establishment in the crops. Predators can also restrict aphid population increase within the crop.

When aphid populations reach high numbers in cotton crops, parasitic wasps can completely wipe out these populations within a few weeks.

Many weed species are hosts of the cotton aphid, but only a few are used by the aphid to maintain its survival over the winter months, when cotton plants are unavailable. These weeds should be controlled to reduce over-winter survival. However some weeds, which harbour other aphids, which do not attack cotton, play an important role in maintaining bio-control agents of cotton aphid over the winter months.

Barley crops also often harbour enormous numbers of bio-control agents and is a reservoir of bio-control agents in the late-winter and spring period.

Adoption of these findings by cotton growers will allow them to make a more objective and rational evaluation of the usefulness of the natural enemies they find in their crops. This information can be used to guide decisions about spraying for aphid control, particularly under the low spray regimes in Bollgard cotton.