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COTTON RESEARCH AND DEVELOPMENT CORPORATION

Project title: Assessing the effectiveness of *Helicoverpa* predators

Project Number: UNE 13C

Research Organisation: University of New England

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A final report prepared for the Cotton Research and Development Corporation

1. Introduction:

The production of cotton in Australia relies heavily on the use of broad spectrum insecticides to control two key pests, *Helicoverpa punctigera* and *Helicoverpa armigera*. The possible loss of two of these insecticides, synthetic pyrethroids and endosulfan, because of resistance in *H. armigera* and environmental concerns respectively, has rekindled the search for ways of utilising alternative sources of pest mortality, including native predators of *Helicoverpa* spp.

Room (1979) showed that many of the predatory arthropods normally found in Australian cotton fields and other crops and surrounding uncultivated land will feed on *Helicoverpa* eggs and larvae under laboratory conditions. It is therefore an appealing possibility that endemic predators could contribute substantially to the maintenance of *Helicoverpa* to below economic thresholds if pest management practices were modified to conserve them. With the current use of insecticides for producing cotton this potential is not normally realised because sprays aimed at *Helicoverpa* and other pests also kill the predators.

2. Objectives:

This study was initiated to quantify the impact of those predators commonly found in Australian cotton fields and thereby reveal the importance of the various predatory species in *Helicoverpa* pest management. Trials to investigate the commercial feasibility of growing cotton under 'soft-option' strategies (that is, without pyrethroids or endosulfan) at 'Midkin' (Auscott Pty. Ltd., Moree) provided populations of *Helicoverpa* and predators for our comparisons. Field work was also conducted on organically-grown cotton at 'Alcheringa', near Boggabilla, and 'Wilby', near North Star. Unsprayed cotton from these sites and from research sites of the Australian Cotton Research Institute was also used, and these field studies were complemented with laboratory studies of predation carried out at the University of New England.

3. Results and Discussion:

Field surveys of the insect populations using suction samplers were conducted throughout two growing seasons. These did not reveal any close relationships between any particular predator species and the presence or abundance of *Helicoverpa*. This indicated that the predators were generalists and that their populations were probably determined by the total levels of prey available. The most abundant predators included the red and blue beetle (*Dicranolaius bellulus*), transverse ladybirds (*Coccinella transversalis*), damsel bugs (*Nabis kinbergii*), minute pirate bugs (*Orius* spp.), big eyed bugs (*Geocoris* spp.) and predatory shield bugs (*Oechalia schellenbergii*), as well as many species of spiders. Detailed information on the seasonality and spatial distribution of all these predators, and of many potential alternative prey species, was obtained.

Where predator populations were relatively high (as in unsprayed plots) large *Helicoverpa* populations were substantially reduced but not nearly to the levels presently regarded as economic thresholds. Yields in the 'soft-option' crops were comparable to those in conventional cotton, but there was no reduction in the number of sprays required. Predator numbers declined during the season, though not as severely as in the conventional (pyrethroid sprayed) plots. There was little evidence that predators contributed substantially to *Helicoverpa* control under these conditions. In organic cotton, relatively high numbers of predators did not prevent a severe *Helicoverpa* outbreak, which was not satisfactorily controlled by the organic pesticides available to the growers, and yields were much lower than in conventional cotton. The results from the organic trials have already been reported separately to the Cotton Research and Development Corporation (Stanley and Gregg 1994a).

Field cages were used to isolate particular predator species over plants seeded with known levels of *Helicoverpa* eggs or larvae. The predators tested were the red and blue beetle (*Dicranolaius bellulus*), transverse ladybirds (*Coccinella transversalis*) and damsel bugs (*Nabis kinbergii*), because they were the most abundant species being collected in the survey. Lacewing larvae (*Mallada signata*) were also tested because at the time they were becoming available from commercial suppliers. The numbers of predators used in the cages were up to ten times the levels usually found in the crops treated with 'soft-option' insecticides.

Predator densities comparable with those usually encountered in cotton fields in commercial cropping areas (2 to 5 per meter) did not significantly reduce *Helicoverpa* survival in the field cage trials. Increasing the number of predators (red & blue beetles or lacewing larvae) to 30 per meter reduced the survival of *Helicoverpa* larvae from 60% to 40% over a range of *Helicoverpa* densities of 20 to 100 per meter. These are, however, much higher densities than would be tolerated in a commercial crop. Red and blue beetles appeared to have little effect on *Helicoverpa* eggs until presented with greater than 60 eggs per meter. The mortality of *Helicoverpa* due to environmental factors varied considerably from 40% to 70% throughout the cage trials. When this background mortality was high, no additional mortality due to predation was detectable even at predator densities of 30 per meter (damsel bugs, transverse ladybirds or red & blue beetles). These trials also indicated that the presence of alternative prey, such as aphids, reduced the impact of the predators on *Helicoverpa*.

Preliminary studies on the possibility of using immunological methods, based on antibodies developed as part of the LepTon^R *Helicoverpa* identification kit (Trowell *et al.* 1994) were also undertaken. These studies indicated that this method can be developed as a reliable indicator of predation in the field.

5. Conclusions, recommendations and application to industry:

The predators tested from Australian cotton appeared to be in insufficient numbers to be relied upon, alone, to give control of *Helicoverpa*. This applied to conventional, soft-option and organic management systems. The results of similar predator studies in the international literature are highly variable. Factors such as environmental conditions, predator behaviour and life cycles and alternative food sources have all been suggested to greatly alter the impact of predators on a given target pest. The general conclusions are that predators are sometimes effective but generally their impact is unpredictable and frequently inadequate. The low impact recorded consistently throughout this study strongly indicates that endemic predators at the densities produced by current practices cannot be relied upon to control *Helicoverpa* spp.

However, pest management in Australian cotton is changing in ways which offer scope for better utilisation of predators as an additional source of mortality, within an integrated pest management program. The widespread adoption of transgenic cotton expressing Bt toxin (Fitt *et al* 1994) will reduce the use of insecticides, particularly the pyrethroids which are especially destructive to natural enemies. In turn, predator impact will be one of a number of factors which must be exploited to reduce the selection pressure for the development of resistance to Bt cotton. Greater numbers of predators might be encouraged to inhabit our cotton crops through manipulation of their habitats or searching behaviour (Thomas *et al.* 1992, Mensah and Harris 1995), and this may increase the reliability or the overall effect of predators. For these reasons, further work on the impact of predators, and the relative value of different predatory species, is required.

6. Communication of results.

Results have been communicated through papers and posters in the 1994 Australian Cotton Conference (Stanley and Gregg 1994b), the First World Cotton Research Conference (Stanley and Gregg 1994c), and the Australian Entomological Society (Stanley and Gregg 1994d). In addition, contributions to two Co-operative Research Centre for Tropical Pest Management Workshops on Integrated Pest Management in Raingrown Cotton were made, two being published in the Proceedings of the second of these workshops (Stanley and Gregg 1994e, Gregg 1994). Also, both the principal researcher and the supervisor have participated in and communicated results to a number of Cotton Research and Development Corporation workshops (*Early season pest management*, August 1992 and May 1993; *Cotton 2001*, March 1993; *Organic cotton*, December 1993; *Pest management*, May 1994; *Sucking pests*, November 1994; *Integrated pest management*, December 1994; *Heliothis management in Australia*, November 1995). Results were also presented to the Auscott agronomists meeting (August 1993 & 1994) and to several seminars and field days run by NSW Agriculture (Moree golf club, October 1992; 'Trawalla', Moree, February 1993; 'Norwood', Moree, February 1994; 'Alcheringa, Goondiwindi, February 1994) At a more informal level there was regular contact and discussion with growers, agronomists and consultants.

7. Appendix

i. Budget

	Year		
	1992/3	1993/4	1994/5
Total funds contributed by the Corporation	9,650	22,749 ¹	11,537
Funds contributed by the University of New England.			
1. Scholarship for J. Stanley	16,500	17,000	17,000
2. Participation of P. Gregg ²	8,500	9,200	9,600

Notes:

1. The original budget for 1993/4 was \$11,749. This was supplemented by a further \$11,000 awarded in January 1994 to conduct research on organic cotton.

2. Participation of the project supervisor is costed using a multiple of 3x the proportion of the supervisor's time (5%), to accommodate infrastructure and technical support.

ii. Royalty and intellectual property arrangements

The University of New England has entered into an agreement with CSIRO and Abbott Australasia Pty. Ltd. regarding the use of antibodies developed during research on the LepTon^R identification kit, for the purposes of detecting predation on *Helicoverpa* spp. Commercialisation of the process is not anticipated within the foreseeable future, however.

8. Special considerations

A secondary aim of this project was to train a young researcher in fields of interest to the cotton industry and Australian agriculture in general. Mr. Stanley is currently in the final stages of completing his PhD thesis, which is now in advanced draft form. He is now employed by CSIRO Division of Entomology in Brisbane, working in the field of biological control.

As a consequence of the Corporation workshop on Integrated Pest Management held at Narrabri in December 1994, it was decided that further research to follow up the

areas of study initiated in this project was warranted. Ms. Marie-Louise Johnson has since been appointed to a CRDC postgraduate fellowship, and is continuing the research related to laboratory predation studies and the use of immunological methods for detecting predation.

9. References

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Trowell, S., Garsia,K., Skerit,J., Hill,A., Forrester,N. and Bird,L. (1994) The LepTon test kit (Pat. Pending) - the Heliothis ID project comes to fruition. *Seventh Australian Cotton Conference, Broadbeach, August*. Australian Cotton Growers Research Association, Brisbane. pp. 17-20.

Summarised report

The production of cotton in Australia relies heavily on the use of broad spectrum insecticides to control two key pests, *Helicoverpa punctigera* and *Helicoverpa armigera*. Since many of the predatory arthropods normally found in Australian cotton fields and other crops and surrounding uncultivated land will feed on *Helicoverpa* eggs and larvae under laboratory conditions, it is possible that they might contribute substantially to the maintenance of *Helicoverpa* to below economic thresholds if pest management practices were modified to conserve arthropod predators. This study was initiated to quantify the impact of predators commonly found in Australian cotton fields and thereby reveal the importance of the various predatory species in *Helicoverpa* pest management. Study sites included cotton grown under conventional and 'soft-option' strategies (that is, without pyrethroids or endosulfan), and organically-grown cotton as well as unsprayed cotton. These field studies were complemented with laboratory studies of predation carried out at the University of New England.

Field surveys of the insect populations using suction samplers were conducted throughout two growing seasons. These did not reveal any close relationships between any particular predator species and the presence or abundance of *Helicoverpa*, suggesting that the predators were generalists. The most abundant predators included the red and blue beetle (*Dicranolaius bellulus*), transverse ladybirds (*Coccinella transversalis*), damsel bugs (*Nabis kinbergii*), minute pirate bugs (*Orius spp.*), big eyed bugs (*Geocoris spp.*) and predatory shield bugs (*Oechalia schellenbergii*), as well as many species of spiders. Detailed information on the seasonality and spatial distribution of all these predators, and of many potential alternative prey species, was obtained.

Where predator populations were relatively high (as in unsprayed plots), large *Helicoverpa* populations were substantially reduced but not nearly to the levels presently regarded as economic thresholds. Yields in the 'soft-option' crops were comparable to those in conventional cotton, but there was no reduction in the number of sprays required. Predator numbers declined during the season, though not as severely as in the conventional (pyrethroid sprayed) plots. There was little evidence that predators contributed substantially to *Helicoverpa* control under these conditions. In organic cotton, relatively high numbers of predators did not prevent a severe *Helicoverpa* outbreak, which was not satisfactorily controlled by the organic pesticides available to the growers, and yields were much lower than in conventional cotton.

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of predators (red & blue beetles or lacewing larvae) to 30 per meter reduced the survival of *Helicoverpa* larvae from 60% to 40% over a range of *Helicoverpa* densities of 20 to 100 per meter. These are, however, much higher densities than would be tolerated in a commercial crop. Red and blue beetles appeared to have little effect on *Helicoverpa* eggs until presented with greater than 60 eggs per meter. The mortality of *Helicoverpa* due to environmental factors varied considerably throughout the cage trials. When this background mortality was high, no additional mortality due to predation was evident even at predator densities of 30 per meter (damselflies, transverse ladybirds or red & blue beetles). These trials also indicated that the presence of alternative prey, such as aphids, reduced the impact of the predators on *Helicoverpa*. Preliminary studies on the possibility of using immunological methods, based on antibodies developed as part of the LepTon^R *Helicoverpa* identification kit (Trowell *et. al.* 1994) were also undertaken. These studies indicated that this method can be developed as a reliable indicator of predation in the field.

In conventional, 'soft-option' and organic management systems alike, the low impact recorded consistently throughout this study strongly indicates that endemic predators at the densities produced by current practices cannot be relied upon to control *Helicoverpa* spp. However, pest management in Australian cotton is changing in ways which offer scope for better utilisation of predators as an additional source of mortality, within an integrated pest management program. The widespread adoption of transgenic cotton expressing Bt toxin will reduce the use of insecticides, and in turn, predator impact will be one of a number of factors which must be exploited to reduce the selection pressure for the development of resistance to Bt cotton. Greater numbers of predators might be encouraged to inhabit our cotton crops through manipulation of their habitats or searching behaviour, and this may increase the reliability or the overall effect of predators. For these reasons, further work on the impact of predators, and the relative value of different predatory species, is required.

Results of the study have been communicated through papers and posters in scientific and industry conferences, and presentations to grower seminars and field days. A secondary aim of this project was to train a young researcher, who is currently in the final stages of completing his PhD thesis.

Abstract

Studies of the impact of endemic predators on the key pests of cotton, *Helicoverpa armigera* and *H. punctigera*, were undertaken using field cage and laboratory techniques. The seasonal abundance of these predators in conventionally managed cotton, 'soft-option' cotton, organic cotton and unsprayed cotton was evaluated using suction sampling. The most abundant predators included the red and blue beetle (*Dicranolaius bellulus*), transverse ladybirds (*Coccinella transversalis*), damselflies (*Nabis kinbergii*), minute pirate bugs (*Orius spp.*), big eyed bugs (*Geocoris spp.*) and predatory shield bugs (*Oechalia schellenbergii*), as well as many species of spiders.

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