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Commercial application of a cotton pest management programme in the Emerald Irrigation Area and observations on the beneficial fauna

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Summary

Trials were carried out over three seasons (1977-78 to 1979-80) in irrigated cotton in the Emerald Irrigation Area of central Queensland to test a pest management system similar to that shown to be viable in southern cotton areas. In each season, crops grown under the system outyielded the district average, at less cost. Non-disruptive insecticides were used to control the key pests *Heliothis punctigera* Wallengren and *H. armigera* Hübner, so that predaceous species were permitted to survive until at least mid-season. After this, parasitism of *Heliothis* spp. eggs by *Trichogramma* sp. increased to significant levels.

The pest management approach has since been adopted commercially on a large scale.

INTRODUCTION

Commercial cotton production began in the Emerald Irrigation Area of central Queensland in 1976. Previously only a small number of experimental crops had been grown (Hamilton 1980). Insect pests were controlled by regularly applying chemicals such as DDT, DDT/camphechlor, parathion and endrin. These were directed mainly at the major pests *Heliothis punctiger* Wallengren and *Heliothis armiger* Hübner and the occasional pests *Earias huegeli* Rogenhofer and *Aphis gossypii* Glover.

In 1976, severe infestations of *Heliothis* spp. were poorly controlled by these chemicals and a degree of resistance to DDT, DDT/camphechlor and parathion was subsequently shown by Kay, Greenup and Easton (1983). Growers used up to 22 applications of varying combinations of chemicals to obtain lint yields averaging only 540 kg/ha. Since agronomic problems were also encountered, these results could not be attributed entirely to insect damage. Nevertheless there was a clear need to rationslise the approach to pest control.

Therefore, a series of field trials was conducted to test and refine for the Emerald area a pest management system similar to those being developed in southern Queensland and New South Wales cotton areas. While it was anticipated that good control of pests would be obtained with the selective insecticides chosen, the seasonal occurrence and abundance of individual predators, and the contribution to control made by them as part of a total pest management system for the Emerald region, were not known.

The Emerald Irrigation Area

The area is situated on the Central Highlands of Queensland (200 m elevation), close to the Tropic of Capricorn and 270 km inland. It is currently the most northern commercial cotton producing area in Australia. The main irrigated crops are cotton, soybeans, wheat and sunflowers while the surrounding dryland areas grow sunflowers, sorghum, wheat, safflower and predominantly native pastures for beef production.

Most crops are watered by furrow irrigation, with water being supplied from the Fairbairn Dam situated upstream from Emerald on the Nogoa River.

Cotton is generally planted in October-November and squaring starts in late November-early December. The period of maximum flowering and boll production extends from late December to mid February. The last effective flowering date, that is the date after which bolls set from flowers will not mature due to cool temperatures, is about April 7.

Pest species

Pests of seedling cotton include thrips (*Thrips tabaci* Lindeman), jassids (*Amrasca terrareginae* (Paoli) and *Austroasca viridigrisea* (Pacti)), tipworm (*Crocidosema plebejana* Zeller) and rough bollworm (*Earias huegeli*). Generally, unless plant stand is affected, these pests are not controlled specifically and the first *Heliothis* treatment gives sufficient control.

The major pests of cotton in the Emerald Irrigation Area are *H. punctigera* and *H. armigera* which attack terminals, squares, flowers and bolls.

Light trap catches over a number of years showed that *H. punctigera* is the more numerous species from early to mid-season, after which it may be outnumbered by *H. armigera*. However, moth catches and field infestations of the latter were never as high as those for *H. punctigera* in the early part of each season. The seasonal occurrence and species sequence, therefore, are similar to those of other Australian cotton areas (Wardaugh, Room and Greenup 1980). The insecticide resistance pattern is also similar: *H. armigera* is resistant to a range of insecticides and no resistances have been demonstrated for *H. punctigera* (Goodyer, Wilson, Attia and Clift 1975; Goodyer and Greenup 1980; Kay 1977; Kay *et al.* 1983).

METHODS

Seven pest management trials were conducted at Emerald in 6 to 30 ha commercial fields of irrigated Deltapine 16 cotton during the period 1977 to 1980. Each season, 2 ha of unsprayed cotton were grown for comparison. Stand densities varied from 10 to 16 plants/m.

For each crop the number of *Heliothis* spp. eggs and larvae in five random 1 m lengths of row were counted *in situ*, weekly. Predators were sampled weekly from the commencement of squaring using a vacuum collecting unit, five random 4 m lengths of row being sampled. Parasitism of *Heliothis* spp. eggs was determined from frequent collections of from 60 to 200 eggs taken using the leaf-punch and card system of Hoffman, Ertle, Brown and Lawson (1970).

Decisions about when to spray were made according to a sequential sampling plan similar to that described by Sterling (1976) but with differing thresholds, and all sprays were applied by aircraft. Also, each week the number of squares, flowers and bolls in five random 1 m lengths of row per trial were counted and the data logged as crop development thresholds (Hearn and Room 1979). These were used to ensure that the sequential plans of Sterling (1976) developed for use in southern Queensland and modified for Emerald conditions would permit economically sound cotton yields. A yield approximating the expected district average was chosen as the minimum acceptable.

Whenever possible, only insecticides known to be relatively selective were used in the pest management programme. Endosulfan was the most frequently used but Elcar® and low dosages of methomyl were sometimes employed. Less selective chemicals such as fenvalerate were occasionally used towards the end of the season. This approach was adopted in order to minimise the possibility of problems arising similar to those which occurred during the 1976-77 season and which lead to the present study being carried out.

Comparative data from a commercial crop treated mostly with fenvalerate were collected during 1979-80.

RESULTS AND DISCUSSION

Data from two trials plus an unsprayed and a commercial crop, all grown during 1979-80, are discussed as being representative of the general trends which occurred in pest and predator populations and the control tactics used in all three seasons' trials.

Seasonal population levels of *Heliothis* spp. and beneficial species for these crops are shown in Figures 1a-d. A typical crop development threshold is shown in Figure 2. The insect data from that crop are presented in Figure 1c.

The seasonal occurrence of the more numerous beneficial species is shown in Figure 3a-c.

In unsprayed crops an initial *Heliothis* oviposition peak usually occurred during December. Predator populations increased and the system stabilised with predators apparently consuming many eggs and emerging larvae. Despite this predatory activity, a small larval population continued, which reduced yields below a commercially acceptable level. Alternative prey such as aphids, thrips and loopers helped sustain the predator population.

In contrast, large fluctuations in the number of *Heliothis* spp. eggs and larvae were recorded in all seasons in crops which were sprayed, regardless of the treatments (Figure 1b,c,d). High egg numbers or continuous low level oviposition eventually gave rise to economically damaging larval populations, which were controlled by spraying. In crops treated with selective insecticides significant predator populations were present for at least the early part of the season.

Generally their numbers decreased in late January (Figure 1b,c) due to the cumulative adverse effect of successive insecticide applications. *Nabis kinbergii* Reuter and *Chrysopa* spp. apparently were tolerant of endosulfan and bred in the crops treated with this chemical. The reduction in available prey brought about by the successive applications of endosulfan probably caused their numbers to decline.

Predators were eliminated from crops by the application of broad spectrum insecticides (Figure 1d). Susceptibility of the predators to the insecticides, as well as the elimination of suitable prey, caused the decline: the predators did not recolonise the crop when late-season aphid and mite populations developed.

Insecticides used, and costs and yields obtained in some trials in each season, are compared with those for the average district commercial crop in each season in Table 1.

The series of trials confirmed that a management approach to pest control in Emerald cotton was viable and the net returns were as great as or greater than those expected under a schedule-type broad-spectrum spray programme. The introduction of the synthetic pyrethroid insecticides in 1977-78 resulted in excellent *Heliothis* spp. control but often caused outbreaks of secondary pests, chiefly aphids, which then required specific sprays.

The regular pest monitoring which was part of the management system allowed a determination of when the most susceptible egg and larval stages occurred and when such infestations, if left unchecked, were likely to cause economic damage. Insecticide sprays could then be applied with greatest effect. Decisions in commercial crops were generally made on a temporal basis, which often resulted in mistimed sprays, which in turn led to more sprays being applied than was necessary.

The management system was less costly than the commercial system. This occurred because in most cases fewer sprays were applied, specific aphid control was rarely necessary and the preferred insecticides and reduced dosages employed were cheaper than the alternatives. Also, the management system remained cost effective after allowing for the extra labour costs of pest monitoring which ranged from $10 to $15/ha over the 3 year period.

Beneficial species

Bishop and Blood (1977) have listed the predatory and parasitic species found in south-east Queensland cotton and Room (1979) has listed those in New South Wales cotton. The beneficial fauna at Emerald was found to be similar.

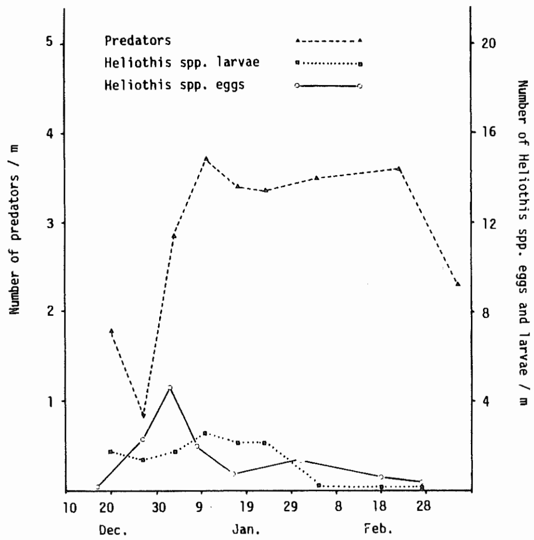

Figure 1a. Numbers of *Heliothis* spp. eggs and larvae and predators per metre of row during the key growth period in 1979-80 in an unsprayed crop.

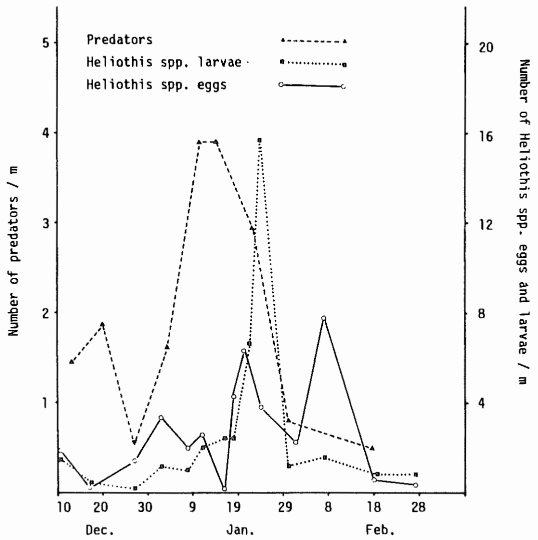

Figure 1b. Numbers of *Heliothis* spp. eggs and larvae and predators per metre of row during the key growth period in 1979-80 in pest management trial I.

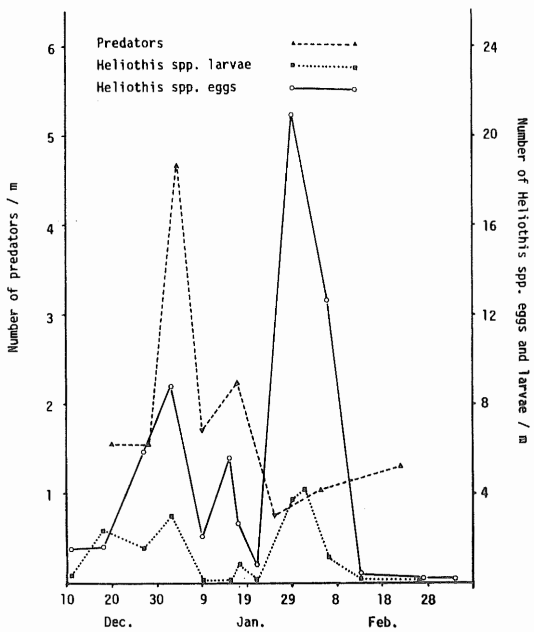

Figure 1c. Numbers of *Heliothis* spp. eggs and larvae and predators per metre of row during the key growth period in 1979-80 in pest management trial II.

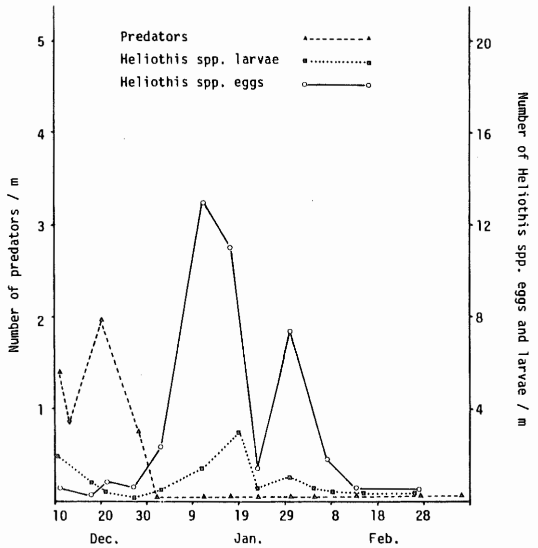

Figure 1d. Numbers of *Heliothis* spp. eggs and larvae and predators per metre of row during the key growth period in 1979-80 in a crop sprayed with broad spectrum insecticides.

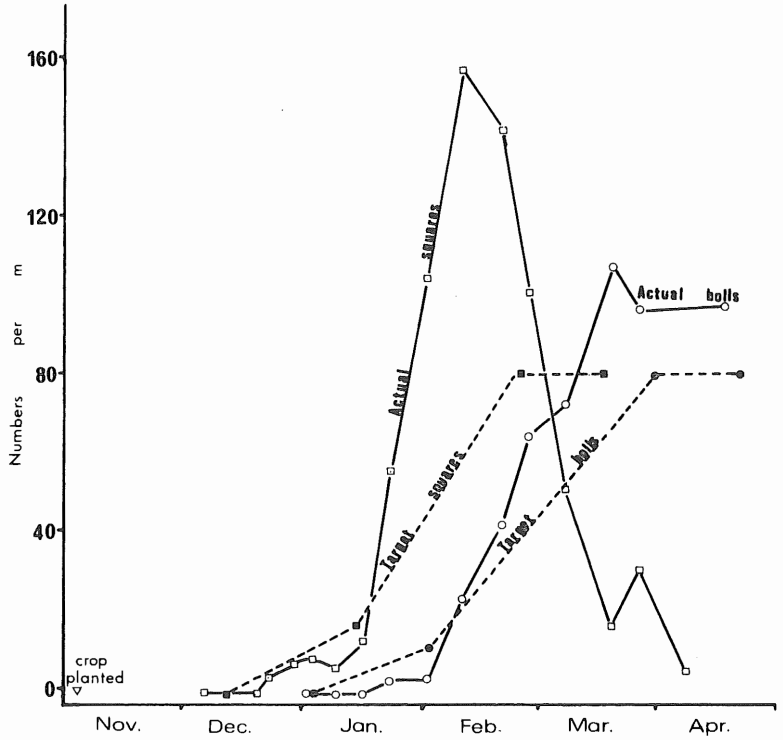

Figure 2. Typical crop development threshold. Target and actual squares and bolls per metre of row.

The most common and abundant predator was *N. kinbergii*. This predator generally entered the crop at squaring and commenced to breed. It was most abundant (up to 2 to 7/m) in both sprayed and unsprayed crops during January (Figures 3a,b).

Chrysopa sp. adults were often collected in large numbers in the suction samples but larvae were less common. Maximum numbers of 1/m were present during late December-early January. In sprayed crops, *Deraeocoris signatus* (Distant) was common in December but was eliminated by sprays applied for *Heliothis* control as squaring progressed (Figure 3b), as was *Campylomma livida* Reuter. Both these species preyed on *Heliothis* spp. eggs and larvae (Room 1979) but *Campylomma* has also been shown to feed on squares, causing them to drop (Bishop 1980).

Other predatory species which were numerous at times but occurred on a less reliable basis were *Coccinella repanda* (Thunberg) and *Micraspis frenata* (Erichson) (Coccinellidae), *Dicranolaius bellulus* (Guerin-Meneville), *Geocoris* sp. and a variety of spiders, chief of which were *Chiracanthium diversum* L. Koch (Clubionidae), *Diaea* spp. (Thomisidae), and *Oxyopes spp.* (Oxyopidae). Spider numbers fluctuated throughout the season and numbers rarely attained the peak levels of the more prevalent insectan predators.

The egg parasite *Trichogramma* sp. (Trichogrammatidae) was not prevalent until mid-season when 60% parasitism was common occasionally more than 80% of eggs were parasitised.

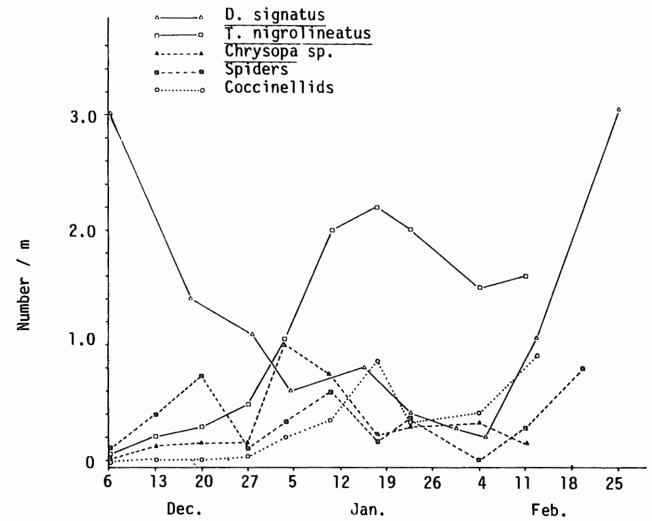

Figure 3a. Numbers of individual predators per metre of row during key growth period in 1979-80 in unsprayed crop.

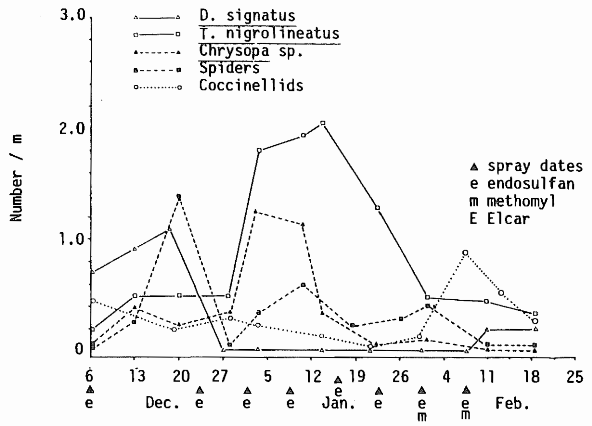

Figure 3b. Numbers of individual predators per metre of row during key growth period in 1979-80 in pest management trial II.

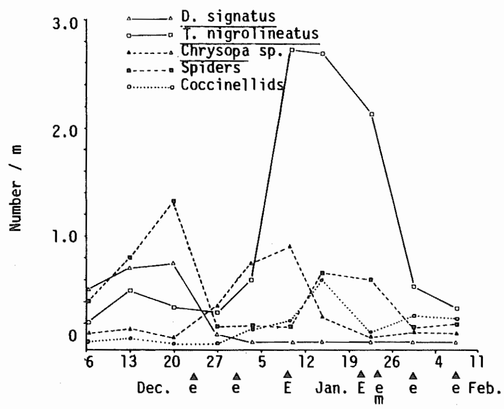

Figure 3c. Numbers of individual predators per metre of row during key growth period in 1979-80 in pest management trial I.

Table 1. Insecticide treatments, costs and yields: cotton grown under various insect control strategies at Emerald

Crop	Insecticide used	Total sprays	Approximate cost (insecticide only) ($/ha)	Lint yield (kg/ha)
1977-78				
Pest management trial (12 ha)	5 endosulfan	5	40	888
Average district commercial	1 DDT/camphechlor 8 fenvalerate (3 with parathion added)	9	157	832
Unsprayed (2 ha)	..	..	..	562
1978-79				
Pest management trial (6 ha)	4 endosulfan 2 Elcar®* plus amitraz 2 Elcar® plus methomyl (112 g/ha) 1 fenvalerate 1 prefenofos	11	135	1406
Average district commercial	1 endosulfan 5-6 fenvalerate 4-5 fenvalerate plus parathion	10-12	225	1012
Unsprayed	..	..	..	675
1979-80				
Pest management trial (1) (8 ha)	1 endosulfan (750 g/ha) 2 endosulfan (560 g/ha) 3 endosulfan (375 g/ha) 2 endosulfan (375 g/ha) plus methomyl (112 g/ha)	8	24	1507
(2) (6 ha)	6 endosulfan 2 Elcar® plus molasses 1 endosulfan plus methomyl (112 g/ha) 1 endosulfan plus chlordimeform	10	62	1237
Average district commercial	2 endosulfan 7 fenvalerate 1 profenofos	10	173	1125
Unsprayed (2 ha)	..	..	..	720

* Elcar is a commercial formulation of a nuclear polyhedrosis virus specific to *Heliothis* spp. Where dosages are not given, standard rates apply.

CONCLUSION

Yields obtained in the pest management trials exceeded the district average and pesticide costs were greatly reduced. The system was shown to be effective and applicable in the Emerald district. During the 1979-80 season 45% of Emerald growers were applying a pest management programme.

Beneficial species, when allowed to survive in a pest control system based on selective *Heliothis* controls, assisted by destroying most of the eggs and larvae of *Heliothis* spp., as well as limiting damaging aphid and mite populations.

The management programme allowed survival of significant numbers of predaceous species. However, predator numbers decreased from mid-season not only because of the toxicity of the chemicals used but also the reduction in prey numbers.

Wherever possible, broad spectrum insecticides should be reserved for use late in the season when numbers of beneficial species are low. Furthermore, secondary pests which may multiply as a result of their use will have little time to do so before defoliation.

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