Cotton Research and Development Corporation

Project Title: Development and field testing of micro-computer cotton management packages

Project No:	CSP53C
Research Organisation:	CSIRO Plant Industry
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A final report prepared for the Cotton Research and Development Corporation

1. Introduction

Since 1991 CRDC has supported the development of micro-computer based decision support systems, entomoLOGIC and hydroLOGIC. EntomoLOGIC has replaced SIRATAC for insect pest management and has also broadened the user base to include many private consultants. It is being continually updated to incorporate the latest pest management research and practices.

EntomoLOGIC was field tested by over 100 growers and consultants in the 1992/93 season[1]. At the same time a series of commercial-scale field trials of entomoLOGIC was conducted by CSIRO in the Namoi Valley. These trials, covering 4 sites in 1992/93, aimed to evaluate a soft approach using only selective chemicals (eg Bt and Chlorfluazuron) and also to demonstrate the value of entomoLOGIC as an aid to decision making. The trials were visited by large groups on field days and aroused considerable interest. Warwick Madden conducted an expanded series of large scale trials in the 1993/94 season, covering 5 sites in the Lower Namoi, Upper Namoi and dryland (Edgeroi).

The hydroLOGIC program[2] was also released commercially for the 1992/93 season. This program has always aroused considerable interest in the industry, particularly among consultants, with its what-if simulaton capabilities. Sales of hydroLOGIC were initially slow, but there are now around 100 registered users after CSIRO assumed full responsibility for its distribution.

The development of entomoLOGIC has been supported by annual workshops in 10 growing regions and extensive large scale collaborative field trials. These field trials were initially conducted by Mr Warwick Madden, and later by Sandra Deutscher. The purpose of the trials is to demonstrate effective crop management using entomoLOGIC and to collect data to support the incorporation of IPM strategies into future program recommendations.

In 1993 the entomoLOGIC Development Group (EDG), comprising consultants, users and representatives of grower associations, was formed to help set priorities for further development and promote adoption of entomoLOGIC. Mr Bruce Pyke of CRDC is chairman of this group. The group aims to meet up to 6 times annually, including 3 times during the cotton season to provide immediate feedback. While most meetings are held at Myall Vale, meetings are also held periodically in other valleys to allow local representatives to attend during the season. The last meeting in Warren attracted 25 participants, and included a detailed discussion of features required in entomoLOGIC Version 2.

Expected Outcomes and benefit to the cotton industry

- Effective management packages incorporating the latest research results and management strategies with input from practical experience and field testing.
- Effective systems for farm data collection and record keeping and management of trials.
- Improved adoption of programs with training and support available in all growing regions.
- Development and validation of integrated pest management strategies to reduce the dependence of the industry on broad spectrum pesticides.
- Development of a tool to facilitate the implementation of management strategies for Bt cotton.

2. Objectives

1. Continue to develop entomoLOGIC and related management packages incorporating the latest research results and management practices.

2. Validate entomoLOGIC and demonstrate IPM systems on a commercial scale.

3. Promote the continued adoption of entomoLOGIC and provide training and support for growers and consultants in all regions.

3. Results and Discussion

Staffing

Mr Lance McKewen B.E. (Hons), Grad. Dip. Bus. Sys.	Senior Research Scientist CSIRO funded	60%
Ms Sandra Deutscher B.App.Sc.(Sys.Ag), Ass.Dip. App. Sc. (Sys. Ag)	Experimental scientist	100%
Mr Chris Plummer B.App.Sc.	Programmer CSIRO Funded	100%

Progress:

This project commenced on the 1st July, 1994, following on from the earlier project CSP29C.

Since that time the following has occurred:

(1) Following meetings of the entomoLOGIC Development Group, the specification for an all-new entomoLOGIC (currently known as Version 2) was prepared. This included all of the pest management technology of Version 1.6, plus the capacity to link the OZCOT crop model to provide the functionality of hydroLOGIC. A complete production recording database was designed to provide inputs to the entomoLOGIC models and also allow users to keep full agronomic records.

(2) Programming commenced on the Windows version of entomoLOGIC 2, and some of the code was also tested on Apple Macintosh. The new program was on target for release in the first week of October and an incomplete version was displayed at the Australian Cotton Conference in August 1994.

(3) At the end of August Stephen Klinge, the main programmer working on entomoLOGIC, became ill and commenced a period of extended sick leave. Prior to this Stephen had been working up to 14 hours per day 7 days a week to meet deadlines for completion of entomoLOGIC Version 2. Other members of the entomoLOGIC team had also been working extended hours.

(4) It was not practicable for another programmer to complete entomoLOGIC 2 in the short time remaining so an update of the current entomoLOGIC was prepared by Greg Nash (CRC for Sustainable Cotton Production. This included all of the insect management technology with mite analysis and LepTon support updated for the 1994/95 season. The Windows Report Writer program, commenced by Stephen Klinge, was completed by Lance McKewen and released following entomoLOGIC Version 1.7.

(5) Faxes were sent to all grower associations expressing interest in speaking about the entomoLOGIC project at local grower meetings. All associations approached with the exception of Macquarie and St George responded by inviting us to speak in late 1994. As a result of these meetings and displays at the Cotton Conference, the number of entomoLOGIC users increased dramatically.

(6) There are now 430 registered users of entomoLOGIC in the Australian Cotton Industry. This has increased from 300 in December 1995 and 165 in October 1994. The continuing increase in usage has been partly due to the adoption of computers by most farms and agronomists. A more important factor has been the increasing complexity of insect management, particularly with Ingard varieties, and the need to keep accurate records of crop operations. Most growers and consultants see the need to adopt IPM in some form and are seeking the tools to allow them to proceed with confidence.

There is strong support for entomoLOGIC in all valleys from Emerald and Theodore to the South Burnett and the Darling Downs, and west to St George. In NSW entomoLOGIC is used from the Breeza plains to Warren and Bourke and also at Menindee by Tandou, as well as the major growing valleys in the north of the state. In the 1996/97 season the adoption of entomoLOGIC by private consultants has been most pleasing and it has become the industry standard for recording and exchanging information as well as agronomic management.

Many large industry organisations have adopted entomoLOGIC as the standard crop management and recording tool for their agronomists. Large corporate farms including Auscott, National Mutual, Twynam, Tandau, Clyde and Coulton's have been long time supporters of entomoLOGIC. In the 1996/97 season they have been joined by Colly Farms and IAMA in adopting entomoLOGIC as the corporate standard.

Several of the larger private growers have employed agronomists or consultants specifically to run entomoLOGIC this year. In the Namoi Valley this includes Doreen (David Blows), Wire Lagoon (Mackeys), Clinton Freer, Grellmans, Jack Warnock and Carberrys. The support of these growers and consultants Jack Murray, Phil Lawrence and Chris Lehmann is acknowledged and appreciated.

(7) As in previous seasons, training workshops were held in many districts for new and existing entomoLOGIC users. In 1994, drought conditions and the fact that existing users were already familiar with entomoLOGIC caused workshops to be programmed on a needs basis. In that year workshops were held at Emerald, Theodore, Warren and Bourke. In other areas new users received one-on-one assistance as required.

(8) Considerable assistance and technical support has been delivered from the new Technology Resource Centre at ACRI (funded by the Cotton CRC). The Centre has also handled the logistics of duplicating disks and manuals and mailing updates of entomoLOGIC and the Report Writer to all registered users.

(9) Results were analysed from the 5 large scale pest management trials conducted in the Namoi region during the 1993/94 season. Among other results, the trial confirmed that the entomoLOGIC system performs as well under dryland conditions as in irrigated cotton.

(10) Despite the drought conditions a further 5 trials were conducted in the 1994/95 season by Warwick Madden. These trials were held at sites in the Boggabri, Edgeroi, Merah North, Wee Waa and Myall Vale (Leitch) areas.

(11) The results of the large scale trials over the past 3 seasons were presented by Lance McKewen at each of the regional Resistance Management meetings in 1995. These results and similar

work on thresholds commenced by Dallas Gibb were instrumental in the adoption of a 2 larvae/m threshold pre-flowering as a key component of the Resistance Strategy. Recommendations on early season management have also been widely adopted by growers and consultants.

(12) This strategy was accepted by growers and consultants on the basis that it had been demonstrated over several seasons in the field under both full and short season conditions. A dramatic reduction in early season spraying has resulted in the 2 subsequent seasons. Consultants have also been using many "softer" options to reduce flaring of mites and Heliothis. An additional benefit is that the shortage of chemicals such as Larvin, Curacron, and Comite seen in previous seasons has not so far occurred.

(13) Training workshops on entomoLOGIC were again held in each growing valley in 1995 and 1996. These have been an excellent forum for communication with growers and consultants, and for obtaining feedback from individual users. These workshops, held annually since 1992, have greatly assisted in the adoption of entomoLOGIC in all growing regions and the establishment of entomoLOGIC as a standard for the Industry. As well as training new entomoLOGIC users, the workshops provide information and training on each major update of the program.

(14) The large scale field testing program was continued by Sandra Deutscher in the 1995/96 and 1996/97 seasons. The current series is concentrating on the performance and management of Ingard in both irrigation and dryland. Starting with the 1996/97 season the entomoLOGIC trial program is investigating all these factors for Ingard cotton under both irrigation and dryland conditions. All of the Ingard varieties are currently represented in these trials.

(15) An all-new entomoLOGIC program, based on the entomoLOGIC 2 specification, was released as entomoLOGIC 95 in February, 1996. As well as pest management technology from previous versions of entomoLOGIC, it contained a full field history system enabling all field and crop operations on a farm to be recorded. A much improved version was released as entomoLOGIC 96 at the Australian Cotton Conference in August 1996. The entomoLOGIC 96 release included support for Ingard cotton and high quality pictures and descriptions for each insect found in cotton. This program has been very widely adopted in the 1996/97 season and is now the industry standard for pest management and farm recording. Further updated versions were released in January 1997 and May 1997.

4. Discussion

There are now 430 registered users of entomoLOGIC in the Australian Cotton Industry. Obviously not all 430 registered copies of entomoLOGIC are used for daily insect management. However we have some evidence that around 70% are used for management purposes. A survey was sent to all registered users with the mail-out of the May 1997 update. The partial response to this survey has made the results inconclusive to date. However we do have regular contact with many of the entomoLOGIC users.

Many large industry organisations have adopted entomoLOGIC as the standard crop management and recording tool for their agronomists. Large corporate farms including Auscott, National Mutual, Twynam, Tandau, Clyde and Coulton's have been long time supporters of entomoLOGIC. In the 1996/97 season they have been joined by Colly Farms and IAMA in adopting entomoLOGIC as the corporate standard.

Several of the larger private growers have employed agronomists or consultants specifically to run

entomoLOGIC this year. In the Namoi Valley this includes Doreen (David Blows), Wire Lagoon (Mackeys), Clinton Freer, Grellmans, Jack Warnock and Carberrys. The support of these growers and consultants Jack Murray, Phil Lawrence and Chris Lehmann is acknowledged and appreciated.

A very important part of the entomoLOGIC project is the large scale field testing carried out on private farms. These trials, which commenced on 4 sites in 1992/93, aimed to evaluate a soft approach using only specific chemistry and also to demonstrate the value of entomoLOGIC as an aid to decision making. The trials were visited by large groups on field days and aroused considerable interest. Lance McKewen and Warwick Madden conducted an expanded series of large scale trials in the 1993/94 and 1994/95 seasons, covering 5 sites each year in the Lower Namoi, Upper Namoi and dryland (Edgeroi) districts. Further trials were conducted by Sandra Deutscher in the 1995/96 and 1996/97 seasons. The current series is concentrating on the performance and management of Ingard in both irrigation and dryland.

More detailed results of the field program are presented in Appendix B.

This work was instrumental in establishing a threshold of 2 larvae/m for Heliothis in the 1995/96 Resistance Management Strategy. This strategy was accepted by growers and consultants on the basis that it had been demonstrated over several seasons in the field under both full and short season conditions. A dramatic reduction in early season spraying has resulted in the 2 subsequent seasons. Consultants have also been using many "softer" options to reduce flaring of mites and Heliothis. An additional benefit is that the shortage of chemicals such as Larvin, Curacron, and Comite seen in previous seasons has not so far occurred. There was actually a shortage of Bt products in the 1995/96 season!

In our opinion, cotton agronomists in the next decade will be relying on three main technologies for pest management. These are:
(i) conventional insecticide chemistry
(ii) Ingard (Bt transgenic) cotton
(iii) new IPM technology including food spray and virus.

Each of these technologies has its own problems and limitations, and none is a silver bullet which is universally applicable. It appears that agronomists will need to rely on a combination of at least 2, if not all 3 techniques to manage a given farming system or even a single crop.

EntomoLOGIC is a management tool which is designed to enable the implementation of all 3 of these technologies. The implementation of sampling systems and thresholds for conventional cotton has been well developed and tested over many versions. In the entomoLOGIC 96 releases, thresholds and label directions for Ingard cotton have been included and these are being extensively tested during the 1996/97 season. The mid-season update of entomoLOGIC 96 includes revised thresholds and directions for Ingard released by the TIMS committee.

The mid-season entomoLOGIC 96 release also includes the first steps toward future support for food sprays. An enhanced entry for predator numbers allows different types of predators to be counted using either visual or vacuum sampling. Using the Heliothis counts, the program calculates the pest to predator ratio, an important parameter in food spray decisions.

It is hoped in future versions to include the full decision process for food spray and virus applications. We would also like to conduct independent field testing of the food spray technology and its implementation in entomoLOGIC. This to some extent depends on interaction with Rhone-Poulenc and researchers working in this area.

5. Conclusions, Recommendations and Application to Industry

Conclusions

The field trials have demonstrated that entomoLOGIC can be used effectively to manage insect pests on cotton with either conventional or 'soft' insecticides. Yield, maturity or quality differences between conventional and 'soft' insect management over four seasons of field trials have been insignificant. This work has shown that using 'soft' chemicals when possible to control Heliothis is not only economically viable but a more sustainable approach to insect management.

Over the four years of field work, differences in yield and maturity between the conventional and "soft" treatments have been insignificant. An IPM approach, using standard thresholds and preserving beneficial insects early in the season, has been demonstrated to produce early, high yielding crops under long season, short season, irrigated and dryland conditions. This approach has often led to a reduction in the overall number of sprays and the cost to the grower. It has also helped reduce dependence on particular chemical groups. This will assist growers to avoid chemical shortages and reduce selection for resistance.

The easy recording and available reporting facilities in entomoLOGIC 95 made monitoring pest and predator numbers an uncomplicated task. This valuable tool can model the development of Heliothis pests and the growth of mite populations with associated yield losses. Many improvements and additions to the program have created a decision support system capable of assisting in many facets of cotton agronomy.

Recommendations

1. Continue to develop and field test entomoLOGIC and related management packages with particular emphasis on Ingard cotton and later food spray technology.

2. Validate the entomoLOGIC thresholds, sampling systems and decision rules for Ingard and compare the economic performance of Ingard with conventional cotton.

3. Promote the continued adoption of *cottonLOGIC* programs and provide training and support for growers and consultants in all regions.

6. Communication of Results

Results of this work have been disseminated through the distribution and usage of the computer programs and associated user documentation. Annual workshops and training courses have been held in all growing regions to support users of the programs.

Progress has been publicised with articles in the Australian Cotton Grower. Presentations and detailed computer displays were held at the World Cotton Conference and at the ACGRA Cotton Conferences 1992-1996. Field day groups have visited the sites of the commercial scale field trials in each of the seasons since 1992/93.

References:

1. McKewen L.D. McFarlane S.D. and Madden W.R., "entomoLOGIC and hydroLOGIC - What's Happening?", Proc. 6th Australian Cotton Conference, Broadbeach, 1992, pp 323-327.

2. Wells A.T. and Marsden S., "Hydrologic - a new approach to irrigation management", The Australian Cottongrower, Vol. 10, No. 3, 7-9, 1989.

3. Wells A.T. and Hearn, A.B., "OZCOT: A Cotton Crop Simulation Model for Management", Mathematics and Computers in Simulation 33 (1992) pp 433-438.

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5. McKewen LD, Madden WR, Klinge S and Nash G, "Management Tools for Integrated Pest Management - entomoLOGIC's Role", Proc. 7th Australian Cotton Conference, Broadbeach, August 10-12, 1994, pp 155-169.

6. Deutscher S and McKewen L, "Early Season Pest Management - Can it Make a Difference?", Proc. 8th Australian Cotton Conference, Broadbeach, August 14-16, 1996, pp 173-183.

7. McKewen L, Plummer C, Nash G and Deutscher S, "EntomoLOGIC 96. Further Improvement of a Successful Product", Proc. 8th Australian Cotton Conference, Broadbeach, August 14-16, 1996, pp 185-188.

7. Appendix

A. BUDGET

B. FURTHER SUPPORTING DATA

History of entomoLOGIC

The first release of entomoLOGIC, for the 1990/91 season, was a prototype developed on the Apple Macintosh. A revised prototype was developed for the 1991/92 season and included many additional features, including the *Heliocoverpa* development model from Siratac.

The IBM compatible version of entomoLOGIC was developed in 1992. A widespread release prior to the 1992/93 season included a display at the ACGRA Cotton Conference and presentations to consultants at various chemical conferences. This was followed by a series of 10 1-day workshops in all of the major growing regions, which were well attended by both growers and consultants.

EntomoLOGIC was field tested by over 100 growers and consultants in the 1992/93 season[1]. At the same time a series of commercial-scale field trials of entomoLOGIC was conducted by CSIRO in the Namoi Valley. These trials, covering 4 sites in 1992/93, aimed to evaluate a soft approach using only selective chemicals (eg Bt and Chlorfluazuron) and also to demonstrate the value of entomoLOGIC as an aid to decision making. The trials were visited by large groups on field days and aroused considerable interest.

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EntomoLOGIC versions 1.5 and 1.6 were released for the 1993/94 season and contained a much greater range of features including the *Heliocoverpa* development model, previously only in the Macintosh version. It also incorporated a new sampling system and management thresholds for mites developed by Dr Lewis Wilson at Narrabri. Aspects of the new insecticide resistance management strategy for summer were also incorporated, including support for the *Heliocoverpa* identification kit, developed by CSIRO Division of Entomology.

Lance McKewen and Warwick Madden conducted an expanded series of large scale trials in the 1993/94 and 1994/95 seasons, covering 5 sites each year in the Lower Namoi, Upper Namoi and dryland (Edgeroi) districts. Further trials were conducted by Sandra Deutscher in the 1995/96 and 1996/97 seasons. The current series is concentrating on the performance and management of Ingard in both irrigation and dryland.

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Results of Field Investigations 1992 - 1997

INTRODUCTION

Since 1992, CSIRO Cotton Research Unit has conducted large scale insect management trials in the upper and lower Namoi Valley. The trials have utilised large field areas on privately owned farms, generally in collaboration with a commercial consultant. Over the past 4 seasons, an average of 3 trials per season have been conducted, covering both long and short season irrigation areas and dryland production.

The primary aim of the trials has been to field test and validate the insect management decision support system entomoLOGIC. This included testing the functionality of the program and also establishing its value as a tool for monitoring field trials. The second aim of the work was to compare different pest management approaches, including a range of "hard" and "soft" options. The aim of the "soft option" was to preserve beneficial insects for as long as possible to determine whether their impact on pest numbers was sufficient to reduce the total number of sprays.

In all cases, the aim was to produce the maximum possible yield and earliness, regardless of the treatments imposed. This was important considering that the trials were conducted on a commercial scale on private farms.

METHOD

Treatments and management

The pest management strategies included (i) commercial management using the full range of chemical options, (ii) using entomoLOGIC to set thresholds and assist with spray decisions, using the full range of available chemistry and (iii) using entomoLOGIC for spray decisions with a restricted set of selective insecticides ("Soft Sprays").

There was some variation over the 4 years of the trials in the details of the hard treatment, depending on the circumstances and the degree of interaction with the consultant. In all cases the hard comprised either option (i) or (ii) above, which meant that it was managed with standard or lower thresholds and the full range of chemical options.

The soft treatment was always managed as outlined in (iii), using the entomoLOGIC models for Heliothis and mites and the presence-absence sampling system to assist with spray decisions. Wherever possible, selective insecticides were used to minimise the effects on beneficial insects, particularly pre-flowering when beneficials were more abundant. These soft insecticides included *Bacillus thuringiensis* (Bt), endosulfan, chlorfluazuron (before it was withdrawn) and low rates of thiodicarb. Excluded were chemicals belonging to the organophosphate and systhetic pyrethroid groups.

Trial Design

The trial sites in general covered an entire field on the farm, enabling each plot to be wide enough to minimise the effects of spray drift. Each trial field was divided into four plots with two replicates of each treatment. Where practicable to minimise the impact of spray drift on beneficial insects, the two 'soft' plots were located together in the middle of the field with the two 'hard' treatments on either end.

Crop Checking

The trials were checked for insects (Heliothis, Mites, other pests and beneficials) twice weekly and spray decisions made using standard thresholds in entomoLOGIC. The Heliothis Development Model in entomoLOGIC was applied to determine present and future insect populations in the three days following the check. The Mite model showed the percentage of infestation and yield loss, and an indication of whether a spray was required.

Fruit counting commenced about 2 months after planting and gave a good indication of the crops progression, an early fruit comparison between the two treatments and predicted dates for defoliation and harvest.

Maturity Assessment

After boll opening commenced, the maturity of each treatment was measured to the nearest day using specially hand-picked maturity plots. Four 2 metre sections of row were marked out from each replicate and each week all fully open bolls were hand picked. These were later ginned to calculate average turn out % and boll weights for each sample. The relative earliness or maturity of each treatment was also assessed, determining the number of days from planting to 60% open. The ginned

samples were then tested for quality using an HVI. The fibre characteristics recorded included length (inches), uniformity, strength (g/tex), elongation and micronair (an indication of fibre fineness and maturity).

Harvesting and Yield Assessment

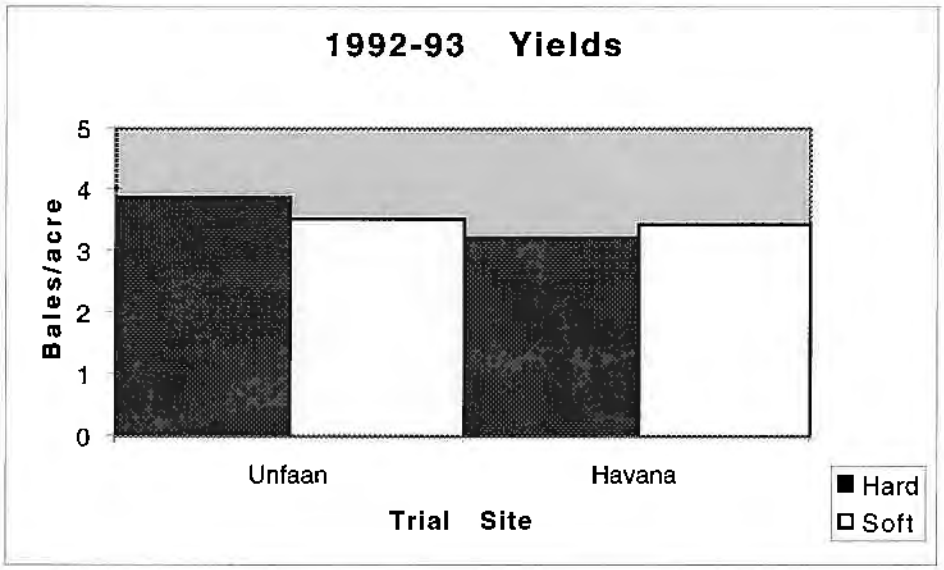
Harvesting of the trials was completed using machine spindle pickers (irrigation) or machine strippers (dryland). Enough cotton was picked to build one module from each plot. Each basket picked was weighed using portable scales and the weights recorded. The areas picked were measured using a trundle wheel enabling yields to be calculated. The module numbers were recorded and each module was weighed and ginned separately to give another assessment of turn out % and quality.

RESULTS

1992/93 SEASON

Two replicated trials were completed in the **1992/93** season (the first season of trials). Both were high yielding crops, but showed significant differences in yield between the 'soft' and the 'hard' treatments. On one site the 'hard' (9 sprays) treatment out-yielded the 'soft' (8 sprays) treatment by 8%, while on the other site the 'soft' (7 sprays) out-yielded the 'hard' (11 sprays) by 7% (See Figure 1).

Figure 1. Yield summary from 1992-93 trials.



No significant differences in maturity were measured between the treatments (see Table 1 below).

Table 1. 1992/93 trial summary

Trial Site and treatment	HAVANA -HARD	HAVANA -SOFT	UNFAAN -HARD	UNFAAN -SOFT
Sprays	11	7	9	8
MATURITY(DAYS FROM PLANT)	192	190	175	180
AVE BOLL WEIGHT (Grams)	4.5	4.8	5.2	4.9
AVERAGE BOLL NO. (/2M)	168	181	207	224
TURN-OUT PERCENTAGE	36	35	37	37
YIELD (BALES/acre)	3.44	3.20*	3.81	3.52*

* significant difference

During the season it was difficult to assess beneficial activity as spray drift from the conventionally sprayed cotton reduced predator numbers over the whole field. The sites had been carefully chosen to minimise drift from the other fields, but not within the trial field. In the following year, measures where taken to further reduce the effects of spray drift which included, having the treatments sufficiently wide, positioning both of the 'soft' plots in the centre of the field and using a ground rig where possible.

1993/94 Season

During the **1993/94** season, four trials were conducted including a dryland trial. Two out of the four sites showed significant differences in yield between treatments. The yield difference on the *Havana* trial was the result of a soil condition affecting of the two adjoining 'soft' plots in the centre of the field. The *Waiwera* trial experienced high mite pressure, with the mites on the 'hard' treatment clearly requiring control before those on the 'soft'. Unfortunately when the 'soft' eventually required spraying for mites, supplies of Comite ®, the only suitable miticide, had run out. Therefore the effects of mites on the 'soft' treatment resulted in a 20% difference in yield.

The maximum difference in maturity between treatments in any of the trials was 4 days. This also tends to discount insect management as a major factor in the yield differences observed.

An irrigated trial was conducted at *Kilmarnock*, near Boggabri, providing an opportunity to test the soft approach in a shorter-season area. There was only 4 days difference in maturity and no significant difference in yield.

While unforseen factors complicated the interpretation of treatment effects on the long season irrigated sites, results on the dryland site at *Calatoota* were very encouraging. Good yields (around 1.6 bales/acre) were obtained with chemical costs of only $75/ha. There was a clear difference of 2 sprays between the hard and soft treatments which can be directly attributed to the loss of beneficial insects after an early organophosphate spray on the hard.

Figure 2. Yield summary for 1993/94 trials.

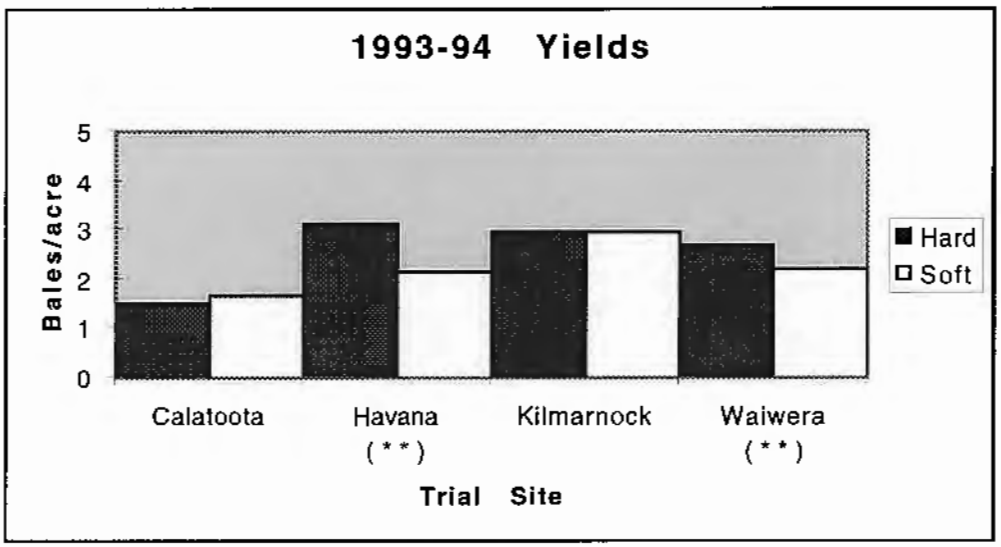


Table 2. 1993/94 trial summary

Trial Site	Havana		Waiwera		Kilmarnock (Upper Namoi)		Calatoota (dryland)	
Treatment	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft
Sprays	8	8	8	7	6	6	6	4
MATURITY(DAYS)	176	178	170	168*	179	183*	150	151
AVE BOLL WEIGHT (g)	4.55	4.10*	4.44	4.13*	4.11	3.88	5.09	4.79*
AVE BOLL NO. (/2M)	196	176	223	192*	244	193	149	123*
TURNOUT (%)	39.6	39.9*	41.4	41.6	41.9	41.0*	41.3	41.2
YIELD (BALES/acre)	3.11	2.16*	2.71	2.19*	2.94	2.95	1.51	1.64

* significant difference

1994/95 Season

Despite the drought conditions, a further 4 trials were conducted in the 1994/95 season, with 2 in the long season irrigation area, 1 short season at Boggabri and 1 dryland near Edgeroi. The **1994/95** season presented no significant difference in yield between the 'hard' and 'soft' treatments at any of the sites (see Figure 3).

Maturity data from *Willapunga* and *Glencoe* both showed significant differences of 7 and 3 days respectively. The 'hard' treatments in both cases were slightly earlier. The loss of Helix (Chlorfluazuron) after the 1993/94 season, reduced the number of 'soft' options available at the end of the season.

Figure 3. Yield summary for the 1994/95 trials.

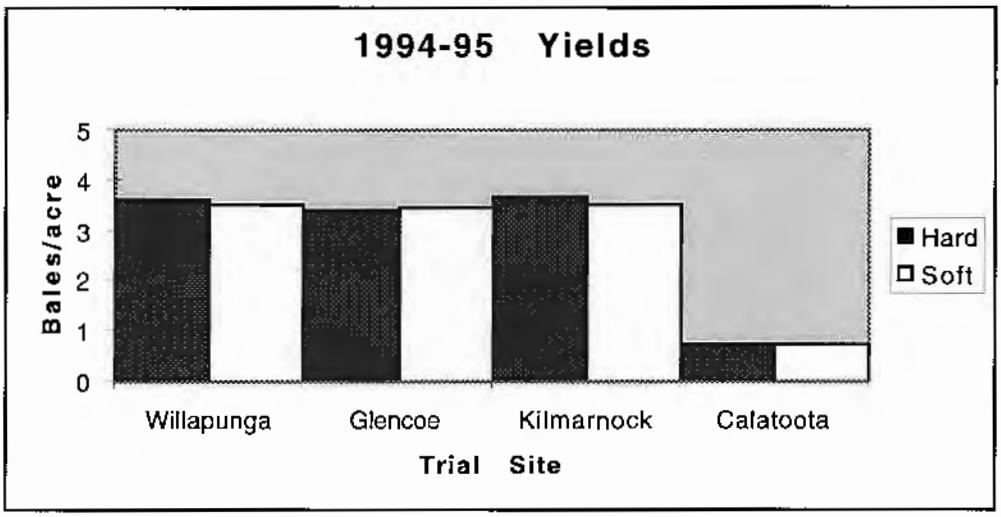


Table 3. 1994/95 trial summary

Trial Site	Willapunga		Glencoe		Kilmarnock (Upper Namoi)		Calatoota (dryland)	
Treatment	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft
Sprays	11	6	5	4	5	4	6	4
MATURITY(DAYS)	177	184*	161	164	181	182	n/a	n/a
AVE BOLL WEIGHT (Grams)	4.68	4.62	4.47	4.40	5.88	5.81	n/a	n/a
AVERAGE BOLL NO. (/M)	127	117*	118	120	104	84*	n/a	n/a
TURNOUT PERCENTAGE	41.0	39.9	42.4	42.3	39.8	38.3	n/a	n/a
YIELD (BALES/acre)	3.63	3.52	3.40	3.48	3.67	3.51	0.72	0.76

* significant difference

1995/96 Season

Results from the **1995/96** trials showed no significant difference in yield between the 'hard' and the 'soft' treatments at any of the sites (as shown in Figure 4 below).

Figure 4. Yield summary for 1995/96 trials.

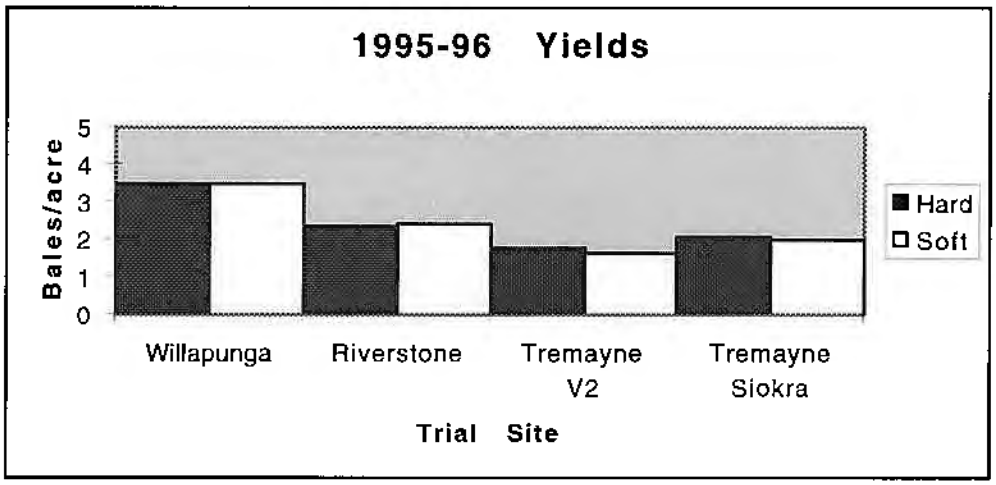


Table 4. 1995/96 trial summary

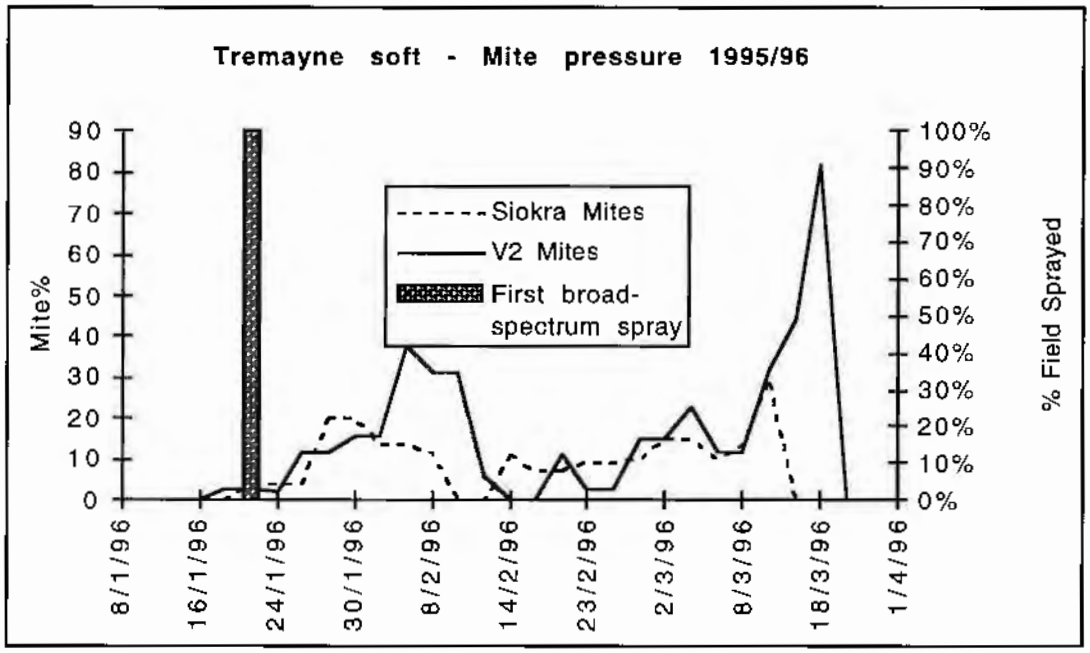
Trial Site	Willapunga		Riverstone (Upper Namoi)		Tremayne (dryland V2)		Tremayne (dryland 1-4)	
Treatment	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft
Sprays	9	9	7	6	10	10	10	10
MATURITY(DAYS)	182	184	194	193	174	179	161	174*
AVE BOLL WEIGHT (g)	5.68	5.88	5.76	5.80	5.12	5.17	4.97	4.85
AVE BOLL NO. (/m)	95	89	66	48	53	58	75	86
TURNOUT (%)	37.9	38.2	38.3	38.4	n/a	n/a	n/a	n/a
YIELD (BALES/acre)+	3.49	3.48	2.39	2.41	1.77	1.62	2.06	1.97

* significant difference + Turnout assumed 39% picked, 32% stripped

There was however a yield difference between the Siokra 1-4 and the Sicala V2 on *Tremayne* dryland trial. After the January/February rainfall, the dryland crop on Tremayne grew vigorously and Heliothis pressure increased. Poor spray penetration was experienced on the V2 section, which resulted in the use of more 'harder' broad-spectrum insecticides and an increase in mite populations. Other recent work has found that overuse of broad-spectrum insecticides early in the season can lead to dramatic and highly damaging outbreaks of mites (Wilson 1993).

The following graph shows a dramatic increase in mite numbers after the third spray on 20/01/96 (which was the first broad-spectrum insecticide used). It also shows the distinct difference in mite populations between the Siokra (okra leaf) and Sicala (normal leaf) cotton grown. Apart from plant resistance to mites, the more open canopy of okra leaf cultivars also allows better penetration of pesticides into the crop (Jones et al. 1986).

Figure 5. Tremayne mites 1995/96.



DISCUSSION

Over the four years of work, differences in yield and maturity between the "hard" and "soft" treatments have been insignificant. An IPM approach, using standard thresholds and preserving beneficial insects early in the season, has been demonstrated to produce early, high yielding crops under long season, short season, irrigated and dryland conditions. This approach has often led to a reduction in the overall number of sprays and the cost to the grower. It has also helped reduce dependence on particular chemical groups. This will assist growers to avoid chemical shortages and reduce selection for resistance.

Some other observations from the trials deserve mention.

1. Over the four years of the trials no loss of yield or earliness has been experienced due to thrips or mirids, whether controlled or not. This of course may not be the case in all valleys for all seasons.

2. In all of the trials, sprays were rarely required before Christmas, due to low early pressure, the use of the standard threshold (2 small/m) and the action of beneficial insects. Where an early spray was required to control Heliothis, application of Bt preserved predators for a further period.

3. Any differences in maturity between the hard and soft treatments have been insignificant. Where the hard treatments have been earlier it has been by margins of only 2 - 7 days. This contradicts the theory that standard thresholds cause loss of earliness. Similarly, differences in yield have been insignificant. In some trials the soft treatment out-yielded the hard treatment.

4. Plots managed with a minimum of hard sprays finished healthier and were less susceptible to premature senescence.

5. A number of the trials could not be completed or were inconclusive for reasons not related to the trial. Yield losses and problems were experienced for the following reasons: drought conditions or delayed irrigation, soil conditions, errors in spray application or ordering, poor plant establishment, verticillium wilt, inappropriate choice of variety, herbicide damage, weed problems and chemical shortages. This shows how important it is for growers and consultants to ensure that all of these factors are under control before worrying about crop protection.

CONCLUSIONS

The field trials have demonstrated that entomoLOGIC can be used effectively to manage insect pests on cotton with either conventional or 'soft' insecticides. Yield, maturity or quality differences between conventional and 'soft' insect management over four seasons of field trials have been insignificant. This work has shown that using 'soft' chemicals when possible to control Heliothis is not only economically viable but a more sustainable approach to insect management.

The easy recording and available reporting facilities in entomoLOGIC 95 made monitoring pest and predator numbers an uncomplicated task. This valuable tool can model the development of Heliothis pests and the growth of mite populations with associated yield losses. Many improvements and additions to the program have created a decision support system capable of assisting in many facets of cotton agronomy.

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References

Jones, J.E., James, F.C. Sistler & S. J. Stringer. 1986. Spray penetration of cotton canopies as effected by leaf and bract isolines. La. Agric. 30: 14-17.

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8. Special Considerations