FINREP98.

CSIRO Plant Industry
Cotton Research Unit

FINAL REPORT

Project Title: **Development of management options for dry season cotton production in NW Australia.**

Project Code: **CSP66C**

Research Organisation: **CSIRO Plant Industry**
Kununurra and Narrabri

Principal Researcher: **Mr. Stephen Yeates - 100%**
CSIRO Plant Industry
c/- Frank Wise Research Institute
Kununurra, WA

Other Research Staff: **Mr. Geoff Strickland** (Agriculture WA, Perth)
Mr. Stewart Addison (Agriculture WA, Kununurra)
Ms. Amanda Annells (Agriculture WA, Kununurra)
Dr. Colin Martin (NTDPIF) - Darwin
Mr. Mike Kahl (NTDPIF) - Katherine

Support Staff: **Mr. Tony McCumstie - 100%**

Supervisors: **Dr. Gary P. Fitt**
Dr. Greg Constable
CSIRO Cotton Research Unit
P.O. Box 59
Narrabri, NSW, 2390

A Final Report Prepared for the Cotton Research and Development Corporation

Project: CSP66C Development of management options for dry season cotton production in NW Australia.

Summary

Limitations on the availability of irrigation water in eastern Australia has sparked considerable interest in the possibility of re-establishing cotton in the Ord River area of NW Australia, where extensive supplies of water and land are available. With a history of major insect problems any proposal to re-establish cotton production required a new perspective. To this end a joint CSIRO/ Agriculture WA research project was developed to make preliminary judgements concerning agronomic potential and pest management scenarios.

The major outcome planned was the development of a technical package for growing dry season cotton which could provide the basis for future work and the commitment of capital necessary for the development of irrigation and ginning infrastructure.

Agronomic Research. Over three seasons experimental yields were found to be very comparable with summer grown crops in temperate Australia. Sowing from mid March to mid April was optimal for yield and permitted harvest from mid September to early October prior to wet season rains in November. Synchronous boll opening due to rising end-of-season temperatures ensured a prompt harvest.

Good progress has been made in identifying suitably adapted varieties, sowing dates, nitrogen nutrition, in quantifying the effect of night temperatures on fiber quality, sowing densities and the management of growth regulators.

INGARD® efficacy Transgenic Bt cotton will be the foundation for pest management systems in the Ord region. Two years of field evaluations at Kununurra have demonstrated excellent efficacy of INGARD® varieties against a range of lepidopteran pests. *Helicoverpa spp* were effectively controlled for most of the season, although efficacy declined when the plants approached full boll load, thus requiring some late season *Helicoverpa* control.

IPM evaluations The development of an IPM system to complement transgenic varieties is essential to sustainable production. A series of IPM systems were evaluated. These include combinations of conventional and transgenic cotton with trap crops, beneficial nurseries and "soft" insecticides. All systems based on transgenic varieties required an average of 1.75 to 3 insecticide applications to control *Helicoverpa* compared to 7.5 sprays on conventional cotton. No conventional cotton was produced in 1997 but, in trials conducted during the preceding 3 years, 10 and 15 insecticide applications had been necessary.

Conclusions. The project successfully achieved its stated objective of 'developing a technical package for growing dry season cotton which could provide the basis for future work and the commitment of capital necessary for the development of irrigation and ginning infrastructure'.

There is a need for continued agronomic research on varietal performance, growth regulators, simulation modelling and irrigation management. New areas of research should include rotations, weed/disease management, plant compensation mechanisms, phosphorus nutrition, soil compaction.

Pest management work will expand in area with an anticipated 1000 ha to be sown in 1999. This expansion has two objectives: First, to evaluate IPM stratergies at a realistic scale. Second, it provides a 'test farming' phase, which has been shown in the past to be essential for new industry development in NW Australia. The availability of two gene Bt varieties combined with reliable activity of the egg parasitoid*Trichogramma pretiosum* is critical to the sustained success of dry season cotton growing in NW Australia.

Background:

Limitations on the availability of irrigation water in eastern Australia has sparked considerable interest in the possibility of re-establishing cotton in the Ord River area of NW Australia, where extensive supplies of water and land are available. With a history of major insect problems any proposal to re-establish cotton production required a new perspective.

A feasibility report, prepared by Strickland, Thomson, Fitt and Constable in 1993, recommended that the re-establishment of a cotton industry in the Kimberley should be seriously considered. However, due to the severe pest pressure associated with summer cropping, a new industry should be based on a winter cropping strategy and transgenic (Ingard) varieties. To this end a joint CSIRO/ Agriculture WA research project was developed to make preliminary judgements concerning agronomic potential and pest management scenarios.

The Ord dry season is the reverse in terms of temperature and daylength to the typical summer season in the established cotton growing areas. The major agronomic issue was to determine the effect of cool to cold night temperatures combined with reduced daylength during boll development on yield and fibre quality. In addition suitable varieties needed to be identified as was optimal plant nutrition and the role of growth regulators.

Most funding for the project was provided by CSIRO, though a Multi-Divisional project on Tropical Agri-Exports, and by Agriculture WA. Supporting funds were provided by CRDC to ensure all experiments could be run effectively and to cover the staff training needed to provide a solid base of technical expertise in cotton research in the NW.

Aims:

1. Identify the most appropriate cotton plant types or varieties for dry season production in NW Australia based on characteristics of yield, quality and maturity

2. Investigate the effects of specific agronomic/ physiological factors on cotton growth and performance in the dry season and integrate those factors into a robust agronomic package tailored to the most appropriate varieties

3. Develop and evaluate pest management systems with minimal inputs of pesticide, maximal use of natural mortality factors based on transgenic cottons expressing Bt genes for management of Lepidopteran pests.

4. Integrate appropriate varieties, agronomy and pest management to provide a technological package for the establishment of an irrigated dry season cotton production system in NW Australia.

Expected outcomes at the commencement of the project.

The major outcome was the development of a technical package for growing dry season cotton which could provide the basis for future work and the commitment of capital necessary for the development of irrigation and ginning infrastructure.

Research Plan.

In the absence of commercial ginning facilities, research in 1995 and 1996 revolved around a series of replicated field experiments of 15 ha in total. Two broad series of experiments covered (i) aspects of agronomy and varietal performance and (ii) pest management options for dry season cotton production. .

The work was in collaboration with trials conducted by NTDPIF at Katherine, NT.

The instillation of a 'research gin', at a cost of $800,000 by Colly Farms in partnership with the Ord River District Co-operative in 1997 facilitated the expansion of integrated pest management studies (IPM) to commercial scale areas on-farm (250ha total). In 1997 a set of 'best bet' agronomic practices, derived from trials in 1994 to 1996, were tested in these on-farm IPM areas.

Results.

Crop adaptation.

Over three seasons experimental yields were found to be very comparable with summer grown crops in temperate Australia (Table 1). Sowing from mid March to mid April was optimal for yield and permitted harvest from mid September to early October well prior to the likely commencement of wet season rains in November. A synchronous boll opening, which was due to rising end-of-season temperatures reducing the boll periods of later pollinated flowers, ensured a prompt harvest.

Table 1: Comparison of small plot lint yields (kg/ha). Summer grown are the mean of 17 trials in 1996/1997, winter grown is the mean of 3 years 1995 to 1997 inclusively.

	Summer grown temperate Australia	Winter grown tropical Australia
Average Top 10 Varieties	2069	2043
Best	2529	2483
Range	1650-2529	1829-2483

Good progress has been made in identifying suitably adapted varieties, sowing date, nitrogen nutrition, in quantifying the effect of night temperatures on fiber quality, sowing densities and the management of growth regulators (Table 2). Moreover, the outcomes of this research have achieved the intended objective in providing the basis for future work and the commitment of capital necessary for the development of irrigation and ginning infrastructure.

The expansion of pest management research on-farm in 1997, helped to fine-tune practices, but most importantly knowledge gaps and areas of further research were identified. For example, late scheduling of the final irrigation in a climate with rapidly increasing temperatures created difficulties with defoliation and resulted in trash discounts for lint. A greater understanding of the water usage and ripening processes in this climate is required. Other important knowledge gaps identified include: the interaction of early season Pix with tipping out by mirids; the need to understand compensatory growth mechanisms in response to mirid damage; weed management; the need for varieties that produce a longer fibre when grown in the dry season

Interaction with Pest Management Research

To be compatible with the pest management strategies being developed some compensation for insect damage must be assumed. Removal of early fruit by mirids has been a common occurrence in our experiments to date. Plant mapping data collected from a range of experiments of the past three seasons has found that, where fruit is removed prior to flowering, and there is minimal removal of late fruit, yields are rarely affected. This is because the crop has compensated for early fruit loss by producing additional fruiting branches; a situation that in southern Australia or the USA would result in later maturity. However, in NW Australia due to the greater synchrony in ripening between early and late fruit and delays in maturity are minimised. Further research is required to evaluate compensation under other types of pest damage such as tipping of the mainstem terminal and the interaction of damage with growth regulator use.

Table 2: Summary of specific agronomic experiments conducted and their outcomes.

Experiment	Seasons (s)	Aim	Delivered outcomes / key findings	Future work (if required)
Crop Growth and Development	1995, 1996, 1997	The effect of the reverse season on growth, development and fibre quality.	Mid-March – Mid-April optimum sowing period. Interaction between sowing date, cold nights and fibre length. Locally derived heat unit sums for predicting time to growth stages.	Data to be used to calibrate CERCOT for dry season tropics Scientific publication of results
N fertiliser	1995, 1996, 1997	N fertiliser recommendations.	200 kg N / ha optimal, yield at this rate very similar over 3 years. Splitting applications did not improve yield over equivalent basal rate.	N uptake and partitioning data to be incorporated in CERCOT. Scientific publication of results
Growth regulation	1995, 1996, 1997	Pix. Recommendatios Foliar and seed treatment was evaluated	' Best bet' recommendation for on-farm areas of 400ml Pix /ha pre squaring. Early Pix reduced height but there was no yield response. Seed treatment: high rates reduced height by delaying node development, maturity was delayed, yield and crop establishment lower.	Identified the need for more research; that is, new rules for NW Australia. The interaction between early Pix use and compensation from insect damage was identified as an important area for further research.
Plant Density	1995	Within row response to plant density	Response similar to USA and SE Australia. 8 – 11 plants / m of row recommended and adopted.	Scientific publication of results
Water Use / Irrigation Scheduling	1997	Measure plant available water content and compare irrigation schedules	Plant available water of Cununurra clay and water use measured. Draft report, local growers made aware of cotton's unique water relations.	More research covering seasons, variations in soil type and including pre-flowering treatments. Calibration of established scheduling tools. Emphasis on end-of-season water use.
Varietal Screening	1995, 1996, 1997	To identify superior varieties / genotypes based on yield, quality and maturity.	Later maturing, higher temperature types have yielded better. Fibre length reduced by about 0.1" compared to same variety grown in SE Australia. Bt gene introduced in lines with superior quality and yield. Pima (*G. barbadense*) varieties have yielded well and are good morphologically (Pix not needed). However, fibre length of all lines screened was unsatisfactory.	Screening is ongoing. Emphasis should move to INGARD varieties with 2 Bt genes as more become available. These should be the basis for establishing an industry.

Pest Management

INGARD® efficacy

Two years of field evaluations at Kununurra have demonstrated excellent efficacy of INGARD® varieties against a range of lepidopteran pests for most of the season. Pests almost totally controlled included pink bollworm (*Pectinophora gossypiella*), rough bollworms (*Earias huegeliana* and *E. vittella*), cluster caterpillar (*Spodoptera litura*) and cotton loopers (*Anomis flava* and *A. planalis*).

Helicoverpa spp were effectively controlled for most of the season, INGARD® efficacy is greatest early in the season but declines when the plant approaches full boll load, thus the requirement for late season *Helicoverpa* control.

IPM evaluations

The development of an IPM system to complement transgenic varieties is essential to sustainable production. An effective IPM system reduces the risk of pests developing resistance to Bt by lowering the number of pests surviving and / or being exposed to the transgenic crop. IPM should also include trap and refuge crops to minimise the necessity for insecticide use whilst providing a source of beneficial insects which can be recruited to assist in pest control.

The results in Table 3 show the lepidopteran pest control potential of INGARD® with or without supporting IPM. All systems based on transgenic varieties required an average of between 1.75 and 3 insecticide applications to control *Helicoverpa* compared to 7.5 sprays on conventional cotton. No conventional cotton was produced in 1997 but, in trials conducted during the preceding 3 years, between 10 and 15 insecticide applications had been necessary. Thus a significant reduction in pesticide requirement of at least 70% is inferred through the field performance of INGARD®.

Table 3. The mean yields and number and purpose of spraying in the IPM trial, Kununurra, 1996 and 1997.

Treatment	Mirid sprays	Aphid sprays	Helicoverpa sprays	Total sprays	Yield kg/ha
1. Siokra L23i alone	2.13	0.25	2.25	4.63	1,584
2. Siokra L23i + lucerne + Envirofeast®	1.48	0.15	2.	3.66	1,610
3. Siokra L23i + lucerne	1.25	0.13	1.75	3.13	1,756
4#. Siokra L23i + niger	1.5	0.25	3.0	4.75	1,630
5*. Conventional cotton + Envirofeast® + lucerne	3.0*	0	7.5	10.5	1,594

* includes rough bollworm as a target pest, grown 1996 only

grown 1997 only

[1] all treatments were sprayed when entomoLOGIC thresholds were reached

In both seasons all IPM treatments achieved adequate yields that were similar to conventionally sprayed conventional and INGARD® cotton. There was also a trend towards a lower insecticide requirement for IPM cotton than for stand alone INGARD® paddocks. Coincident with the lower spray requirement in IPM plots is a trend for higher numbers of predatory insects. Although predatory insect populations fluctuated during the season there was a trend during the mid and late season for numbers to be higher in the IPM treatments which included lucerne strips and / or the insect food spray Envirofeast®. A wide range of predatory insect fauna was identified in the samples. The most common were lady beetles (*Coccinella spp*), hover flies and lacewings (*Chrysopa spp*).

Trichogramma pretiosum abundance

Trichogramma pretiosum is recognised as the most important of parasitoids limiting the impact of *Helicoverpa spp* in northwestern Australia. The parasitoid often infests 60% or more of *Helicoverpa* eggs and can therefore limit the damage potential of the pest. In terms of resistance management in INGARD® cotton the wasp is particularly important because it reduces the hatch rate of *Helicoverpa* eggs and consequently reduces the numbers of caterpillars exposed to Bt protein toxins.

In 1996 and 1997, the level of *Trichogramma* parasitism was measured in a range of pest management systems for INGARD® cotton. A summary of results for 1997 is shown in figure 1. Levels of activity fluctuated during the season and between the various pest management situations. Generally egg parasitism levels were approximately 60% with the best level of 92% of eggs being recorded in early May.

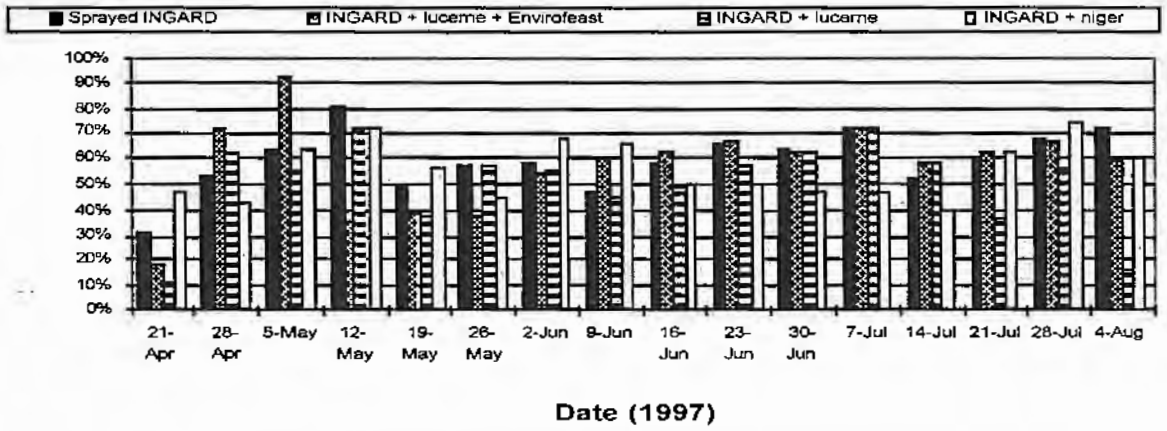

Figure 1: The percentage of *Helicoverpa spp* eggs parasitised by *Trichogramma pretiosum* in a range of pest management systems at Frank Wise Institute, Kununurra, 1997

Conclusions / Future Research.

The project successfully achieved its stated objective of *'developing a technical package for growing dry season cotton which could provide the basis for future work and the commitment of capital necessary for the development of irrigation and ginning infrastructure'.*

There is a need for continued agronomic research in the areas of varietal performance, management of growth regulators, analysis of management scenarios with simulation models and irrigation management. New areas of research will emerge from farm scale pest management areas. However, rotational systems, weed/disease management, plant compensation mechanisms, phosphorus nutrition, and soil compaction have already emerged as areas for future research.

Pest management work will expand in area with an anticipated 1000 ha to be sown in 1999. This expansion has two objectives: First, to evaluate IPM strategies at a realistic scale. Second, it provides a 'test farming' phase, which has been shown in the past to be essential for new industry development in NW Australia, (see Robertson G.A., and Chapman A.L. (1985). The Ord Irrigation Scheme. P 485. In: R.C. Muchow (ed), *Agro-research for the semi-arid tropics: North-west Australia*, University of Queensland press, St Lucia, Queensland.).

The availability of two gene Bt varieties combined with reliable parasitism of *Helicoverpa* spp. eggs by *Trichogramma pretiosum* is critical to the sustained success of dry season cotton growing in NW Australia.

Project Publications.

Strickland, G.R., Yeates S.J., Fitt, G.P, Constable, G.A. and Addision, S.J. 1998. Prospects for a sustainable cotton industry in tropical Australia using novel crop and pest management. In: *Proceedings, 2nd world Cotton Conference*, Athens, Greece, September 7-11, 1998.

Yeates S.J and Constable G.A. 1998. Ord update: Refining the production system. *The Australian Cottongrower*, **19**, 2, p 45-47.

Strickland G.R, Addision S.J. and Annells A. 1998. IPM and Ingard in the Ord. *The Australian Cottongrower*, **19**, 2, p 48-53.

CSIRO (1996). Cotton grows again on the Ord River Scheme, *Rural Research*, 171, winter 1996, p 4-8.

Yeates S.J., Constable G.A., Strickland G.R. and Fitt G.P., 1996. Development of agronomic and varietal options for dry season cotton production in NW Australia. pp 577-584. In: *Proceedings of the 8th Australian Cotton Conference*, Broadbeach Qld. The Australian Cotton Grower's Research Association.

Strickland G.R., Lacy I., Heading L., and Yeates S.J. 1996. Preliminary pest management studies in winter grown cotton in the Ord River Irrigation Area (ORIA) pp 189-198. In: *Proceedings of the 8th Australian Cotton Conference*, Broadbeach Qld. The Australian Cotton Grower's Research Association.

Agriculture WA (1996). Cotton rising from the ashes. *Journal of Agriculture – Western Australia*, 37, 3, 1996, p 70-75

Strickland G. and Constable G. A. 1995. Cotton on the Ord again? *The Australian Cottongrower*, September-October, p 54-60.

Yeates S.J. and Kahl M. 1995. Katherine cotton research inspired by Vietnamese success. *The Australian Cottongrower*, November – December, p 54-58.