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Transgenic cotton research paves the way for a new industry in the Kimberley

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The use of transgenic cotton varieties (INGARD®) in conjunction with integrated pest management (IPM) systems in the Kimberley region is producing excellent yield and quality prospects for an emerging cotton industry in Western Australia. Geoff Strickland and Amanda Annells report on the value of transgenic cotton and the additional benefits being gained from the use of multi-faceted IPM systems.

Agriculture Western Australia re-started Kimberley cotton growing trials in the Ord River Irrigation Area in 1994. A previous attempt to grow cotton in the region some 20 years ago was unsuccessful due to severe pest problems. The aim of the project, based at the Frank Wise Institute at Kununurra, is to develop sustainable pest management systems for cotton with low insecticide inputs.

The project signalled a break from traditional practices, where cotton, as one of the crops most susceptible to insect damage, required frequent spraying to ensure adequate yields. However, the use of transgenic cotton varieties containing the INGARD® gene (by Monsanto) and expanded IPM systems, has differentiated recent trials from previous cotton growing attempts in the region.

It was recognised that while INGARD® was a quantum advance for cotton pest management, it was not the complete answer to pest control. The approach in the Kimberley has focused on developing IPM systems that support and enhance the sustainability of the transgenic technology. Sole reliance on narrowly based pest management strategies is doomed to failure as documented in the past by Michael and Woods (1981).

Transgenic cotton is a result of genetic engineering which has enabled the insertion of Bt genes (Bacillus thuringiensis) into the cotton plant. Bt sprays have long been used by farmers and gardeners to safely control many caterpillar pests. However, now that the Bt gene is within the plant, that pest resistance to caterpillars is now a characteristic of the plant.
Test-farming of INGARD® started in the Ord River Irrigation Area in 1998 and expanded to almost 400 hectares, with promising results. Agriculture Western Australia is at the forefront of field evaluations of new transgenic cotton varieties with in-built pest defences.

**Recent progress**

New IPM in the Kimberley is multi-faceted, compared with the limited strategies used in the past. High summer populations of pests are avoided by switching to winter cropping. This also enables a five-month summer break in cropping, except for the almost pest-free sugarcane, which helps to reduce overall pest numbers in the district.

Trap crops, such as lucerne and niger, are grown within cotton crops to draw some pests (especially green mirids) away from the cotton and to provide a reservoir of beneficial insects. “Soft” insecticides are used early in the season to enable beneficial insects to flourish and contribute to the control of pests.

These and other strategies are being used in a novel system of pest control which is being assessed at a field scale through the involvement of local farmers.

For the past three seasons, several different pest management systems have been evaluated in paddock-scale trials. The research has been approved by the Genetic Manipulations Advisory Committee (GMAC), with Agriculture Western Australia responsible for adherence to GMAC conditions and protocols.

Participating farmers grow the crop using their standard management practices, but Agriculture Western Australia remains responsible for all pest control decisions and stipulates the type and scale of trap crop requirements. This arrangement ensures that the various management systems are replicated each year on collaborating farms.

Some of the key features of IPM systems included in the research have been:

- BT varieties containing the INGARD® gene by Monsanto
- Trap crops including lucerne and niger (niger is a yellow-flowering oilseed crop grown mainly in West Africa)
- Envirofeast® (Rhone Poulenc) – an insect food spray used to attract and retain beneficial insects in cotton
- entomoLOGIC – a computer-based pest control decision-support system developed by CSIRO.

**1996 and 1997 results**

Results from the 1996 and 1997 seasons are summarised in Table 1. A key finding from this research was that some IPM systems, especially those with lucerne trap crops, showed a trend to higher yield than crops grown without accompanying IPM systems.

In addition, IPM systems that included lucerne strips as a trap crop tended to require fewer insecticide sprays than other systems.

All INGARD® crops, regardless of the pest management system, required at least 60 per cent fewer sprays to control Helicoverpa (heliothis) than conventional cotton crops.
**Table 1** — The mean lint yields, number, and purpose of insecticide sprays in the IPM trials, Kununurra, 1996 and 1997 (from Strickland et al., 1998).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mirid sprays</th>
<th>Aphid sprays</th>
<th>Helicoverpa sprays</th>
<th>Total sprays</th>
<th>Yield bales/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Siokra L23i alone</td>
<td>2.13</td>
<td>0.25</td>
<td>2.25</td>
<td>4.63</td>
<td>6.98</td>
</tr>
<tr>
<td>2. Siokra L23i + Envirofeast® + lucerne</td>
<td>1.48</td>
<td>0.15</td>
<td>2.13</td>
<td>3.66</td>
<td>7.09</td>
</tr>
<tr>
<td>3. Siokra L23i + lucerne</td>
<td>1.25</td>
<td>0.13</td>
<td>1.75</td>
<td>3.13</td>
<td>7.74</td>
</tr>
<tr>
<td>4. Siokra L23i + niger</td>
<td>1.50</td>
<td>0.25</td>
<td>3.00</td>
<td>4.75</td>
<td>7.18</td>
</tr>
<tr>
<td>5. Conventional cotton + Envirofeast® + lucerne</td>
<td>3.0*</td>
<td>0</td>
<td>7.50</td>
<td>10.50</td>
<td>7.02</td>
</tr>
</tbody>
</table>

* all treatments were sprayed when entomological thresholds were reached

* includes rough bollworm as a target pest (grown 1996 only)

# grown 1997 only

**1998 results**

In the 1998 trials, only two different systems were compared - INGARD® alone and INGARD® with lucerne trap crops. The results were consistent with previous season trends, but not statistically significant.

Average yields were 7.27 bales per hectare and 7.36 bales per hectare, while the number of sprays required was 3.75 and 3.58 respectively for the INGARD® alone and INGARD® with lucerne treatments.

The role of insects

Monitoring and detailed sampling within each crop were undertaken to determine the reasons for differences seen in the overall performance of IPM systems.

The cotton ecosystem is complex with numerous insect species present. Some species are pests, but most are either beneficial or benign. Populations fluctuate throughout the season in response to many factors, including climate, crop growth, insecticide applications, and predator-prey relationships. Gaining a complete understanding of these interactions and manipulating them remains a challenge for the future (see Figure 1).

The most valuable beneficial insect in the cotton ecosystem is the tiny wasp, *Trichogramma pretiosum*. This barely visible insect often parasitises a large proportion (more than 70 per cent) of the eggs of cotton’s most serious pests *Helicoverpa spp.* (see Figure 2).

The wasp’s actions greatly reduce the number of caterpillars that would otherwise attack the crop, especially at times during the season when the expression of the Bt gene is inadequate to completely eliminate *Helicoverpa spp.*

Of equal importance to crop protection is the reduction of *Helicoverpa spp.* exposure...
to Bt. Reduced exposure lowers the selection pressure for resistance to the bacteria's transgenes.

**Future research activities**

Recent research has confirmed the potential to grow INGARD® cotton on a sustainable IPM basis in the Kimberley. On-farm yields averaging 7.4 bales per hectare and good fibre quality have also encouraged commercial interests and the prospects for an emerging cotton industry look sound.

Research priorities for the next few seasons have been established. They include improving trap crop options to make management easier for growers. Crops such as lab-lab and pigeon pea are easier to establish in hot conditions than lucerne and niger and may also be effective attractants for green mirids and beneficial insects.

There will also be a new research focus on a “trap and kill” approach for green mirids, using systemic soil applied insecticides. Green mirids have caused high levels of “tipping out” damage to cotton despite the use of trap crops to divert them.

The factors influencing the abundance of the egg parasitoid *Trichogramma* will also be studied with a view to improving its activity in cotton. Spray thresholds for *Helicoverpa* spp. and mirids will be refined for the winter growing system.

GMAC has approved an INGARD® research area of 1000 hectares for the 1999 growing season. Farmers will participate in the research by growing crops with four different pest management systems controlled by Agriculture Western Australia.

The scale of the test-farming program is significant and will provide clear directions for a future cotton industry.
Acknowledgements

The participation of farmers in large-scale research is possible due to the construction of a gin by Colly Cotton in partnership with the Ord River District Cooperative. The efforts of all farmers and support from commercial sources including Monsanto, Cotton Seed Distributors, Rhone Poulenc, Novartis, and Deltapine are also acknowledged. CSIRO and the Cooperative Research Centre for Sustainable Cotton Production are vital research partners who have contributed much to the project.

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Further reading


Figure 2 – Mean number of predatory insects per metre row collected by suction sampling from INGARD® cotton grown in different management systems, Kununurra, 1996.