

**Improving Sustainability: Biotechnology and Crop Management.
Sustainability: Key to the Australian cotton production practices.**

Richard Browne¹, Bruce Pyke² and Allan Williams³

¹ Deputy Chair, Cotton Research and Development Corporation, Narrabri, NSW, Australia

² General Manager Research and Extension, Cotton Research and Development Corporation, Narrabri, NSW, Australia

³ Principal Researcher Cotton EMS Pathways Project – Cotton BMP, Narrabri, NSW, Australia

SUMMARY

The Australian cotton industry can clearly demonstrate the capacity to support a productive, profitable and sustainable production system, but many challenges remain. There is a realization that future success will only be achieved by understanding the internal and external influences that will shape the future of the industry. Internal factors will include the pressure of ever increasing input costs and the cost of new technologies in particular. Competition for water will be an ongoing concern and of course commodity prices. Even more challenging perhaps will be external factors such as community perception and acceptance as well as a measure of environmental performance. This paper explores some of these issues within the Australian context, asks whether our conclusions have relevance to cotton production globally and, if they do, what might we do collectively to address them.

In the last ten years the adoption of biotechnology by Australian cotton growers has been extensive and this has led to a number of significant changes to production practices. Key outcomes have included significant reductions in the use of most insecticides and miticides as well as residual herbicides, and more certainty in management and costs for growers not withstanding ever increasing cost pressure. The positive impacts have included reduced pesticide contamination of river systems and neighbouring farms in cotton growing areas, improved worker safety and improved lifestyles of cotton growers and farm workers due to reduced pesticide application. (Critically however, while there has been an improvement in the public perception of the cotton industry in regional communities, the industry has yet to satisfactorily establish on-going indicators of environmental performance that are fully convincing to the community at large.) The negative impacts of biotechnology have been on some types of agribusiness (eg. pesticide application contractors and chemical suppliers/ distributors) and reduced requirement for casual labour (eg cotton chippers).

Biotechnology coupled with improvements to management have certainly contributed to a more sustainable system of cotton production in Australia. However these improvements and many others introduced over the past decade in production management (eg improved varieties and water management) and environmental stewardship (eg. Cotton Best Management Practice (BMP) programme), while essential, are not the only component of sustainability for the industry. These components have mainly been addressing the internal, or industry level, sustainability aspects, but they must coincide with additional external, or community level, components before an industry like cotton can be considered sustainable.

We have started with the term ‘sustainability’ as it is the most widely-used term in discussions about managing the impacts of human activity on the environment, and it is used here in a systemic sense, where sustainability incorporates an overlapping continuum of all aspects of human society: economic, social, institutional and environmental. Thus the aim of sustainability is to be a means of configuring human activity so that society, its members and its economies are

able to meet their needs and express their greatest potential in the present, while preserving biodiversity and natural ecosystems, and planning and acting for the ability to maintain these ideals in the very long term. *(Based on Wikipedia)*.

However, we would like to explore the notion of the “environmental performance” of a cotton production system as a more meaningful and practical approach as it better highlights the need for environmental and social trade offs, and how these can be managed by farmers, policy makers and communities.

The key issue to be considered in this paper therefore is this broader definition of sustainability, or environmental performance, and how it applies in the context of the Australian cotton industry.

The use of the term ‘environmental performance’ leads directly to the need for indicators that can be used to assess and measure that performance. Referring back to our broad definition of the aspects of sustainability, these indicators should be based on the triple bottom line elements of economic, environmental and social outcomes that can be framed against the values of “Landscapes, Livelihoods and Lifestyles”.

There are two very important elements to performance. The first, internally-focussed, relates to aspects of cotton production and conserving the natural resource base that underpins it, while the second, externally-focussed, deals with public perception and acceptability by not only the local community but the world community as a whole. In other words we recognise that the perception of those members of the community, including customers, far removed from the production side of the cotton industry, can and will have a huge impact on the future of the industry.

The challenge is to develop an agreed set of simple and meaningful performance indicators against which progress can be measured. These indicators must meet the expectations of not only the farming community but the broader community as well.

Cotton production systems will vary from country to country, but we contend, that in every instance, they should still be tested against the appropriate values of “Landscapes, Livelihoods and Lifestyles”. This could allow for an adaptive or “horses for courses” approach, but one which might provide us with a common language for measuring performance as a global industry. For much of the time the Australian cotton industry is called upon to defend itself against criticism for perceived wasteful exploitation of natural resources. Indeed this is just part of a trend in Australia in which agriculture in general finds itself in a struggle with conflicting values being expressed by society, with the farmer having to fund the achievement of higher standards of land and resource management expected by society on the one hand, yet still deliver cheaper food and clothing with ever increasing input costs on the other.

Cotton Production systems everywhere are supported by the following:

1. The productive capacity of the environment in which the crop is grown including the elements of soil, water, climate and biodiversity. All these elements come together in the LANDSCAPE. Any agricultural production system will modify the environment. If it results in a decline in natural resource condition the system is in danger of failing. In Australia the industry is dealing with environmental impacts of cotton production not only at farm scale but also with external impacts of agriculture generally at regional or catchment (watershed) scale. Australian cotton farmers are being called upon to show environmental stewardship beyond the farm gate, even though the link between the activities of any one farm (or even industry) and the catchment-scale impacts are tenuous.

It is essential therefore to have a set of environmental performance indicators to monitor production impacts on the environment or changes in natural resource condition so that responsibility for the impact can be correctly identified, and management practices to address that impact validated as appropriate.

2. A level of economic viability that will support reinvestment in technology and improved farming practices and allow for investment in natural resource management. A profitable and productive farming enterprise will also contribute to the wellbeing of regional rural communities by creating wealth, employment and community services. This contributes to a higher standard of LIVELIHOOD not only for the farm family but the community generally. Livelihood can be measured in terms of wealth, opportunity, choice and wellbeing.
3. A better LIFESTYLE is something we all value and aspire to. Cotton farming is from time to time very demanding and may limit lifestyle choices but it is none the less very important to get the balance right. A productive and profitable cotton farm can provide a good lifestyle for the farm family, its employees and the local community. Lifestyle is a value that goes way beyond the local dimension. The cotton industry has an impact on millions of people around the world many of whom are consumers of cotton garments. Many also have uninformed and negative perceptions about the environmental performance of cotton production and as a result will have the power to exert influence on the industry by various means. The main issue here is that, in Australia, the industry will only be able to maintain access to natural resources and the freedom to operate if it can maintain the “social licence” or community approval to operate. Combating negative perceptions – be they justified or not – is not possible without agreed indicators. Agreed indicators can identify a specific impact and link it to the resource base in question, as well as providing the basis for determining whether environmental performance has improved. Otherwise Governments may choose to respond to community pressures through regulation and restrictive practices.

We don't believe that these challenges are unique to the Australian cotton farmer. The future of cotton farming in many parts of the world is likely to be increasingly influenced by the level of acceptance of urban communities remote from the industry but whose values are more influenced by global environmental considerations than the triple bottom line.

The challenge is to have a sound basis upon which to defend the performance of the industry and the capacity to negotiate a position of acceptance. Quite often the final position will involve compromise on all sides. So how might we measure performance, and from this define indicators that the community can relate to? The following section provides some examples and indicators of performance from the Australian cotton industry and how some of these might be considered more broadly for reporting to the community.

CONTINUOUS IMPROVEMENT - THE KEY TO AUSTRALIAN PRODUCTION PRACTICES.

1. Production and area planted

Figure 1 shows annual production of cotton (227 kg bales) and area planted (hectares) in Australia over the last decade. Down turns in production in 2002/03 and 2003/04 were associated with drought and the impact it had on restricting water supplies for irrigation. In the immediate future drought and government policy will have the greatest impact on production capacity. In areas where cotton is currently produced in Australia, the land developed for irrigated cotton is

unlikely to expand due to the limitations on the available water resource. Regulations that govern land clearing for development and water access are both issues of concern to the Australian community. Consequently the Australian cotton industry continues to focus on continuous improvement and this has resulted in ever improving yields as shown in figure 2. While continuous yield improvement is important from the grower’s point of view, as an indicator to the community it needs to be described not so much in terms of bales per hectare, but “more bales per per megalitre (ML) or dollars per ML”, i.e. expressed in terms of the direct value being generated through the exploitation of the resource in question.

Figure 1. Australian cotton production and area planted 1996 to 2006.

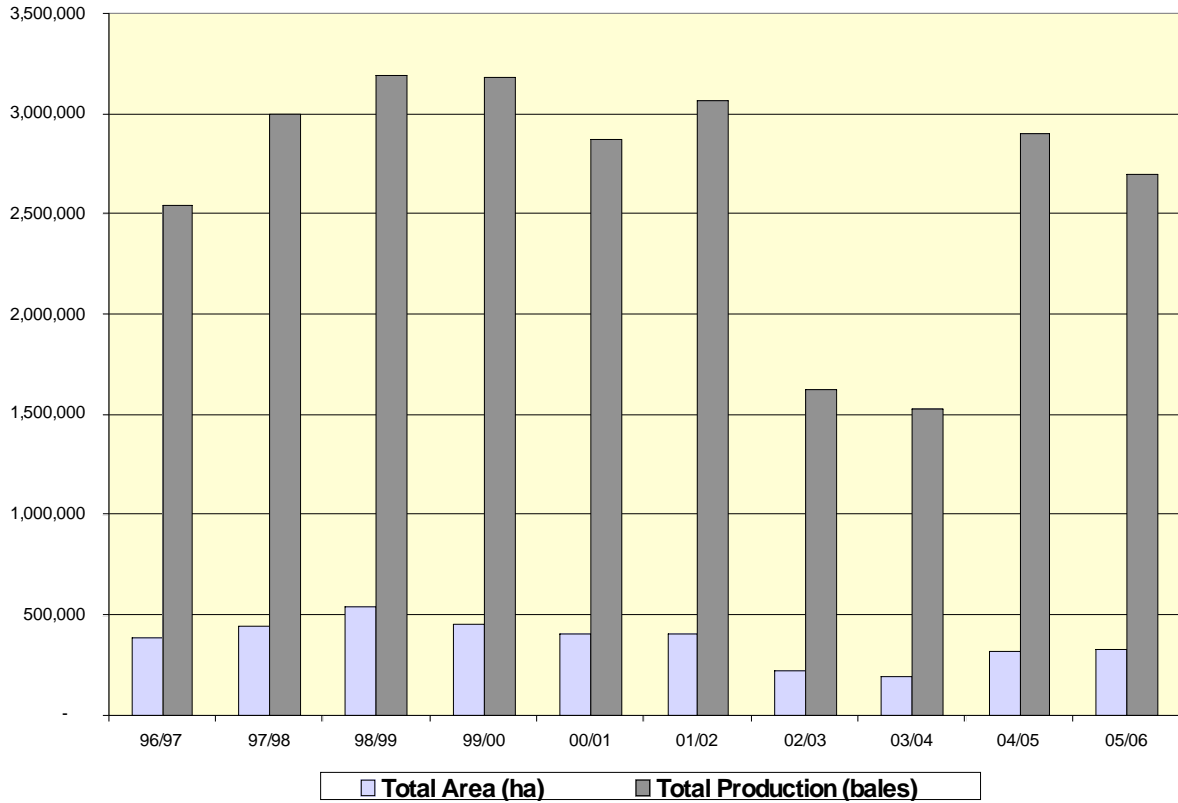


Figure 2. Cotton yield improvement in Australia 1963 to 2006.

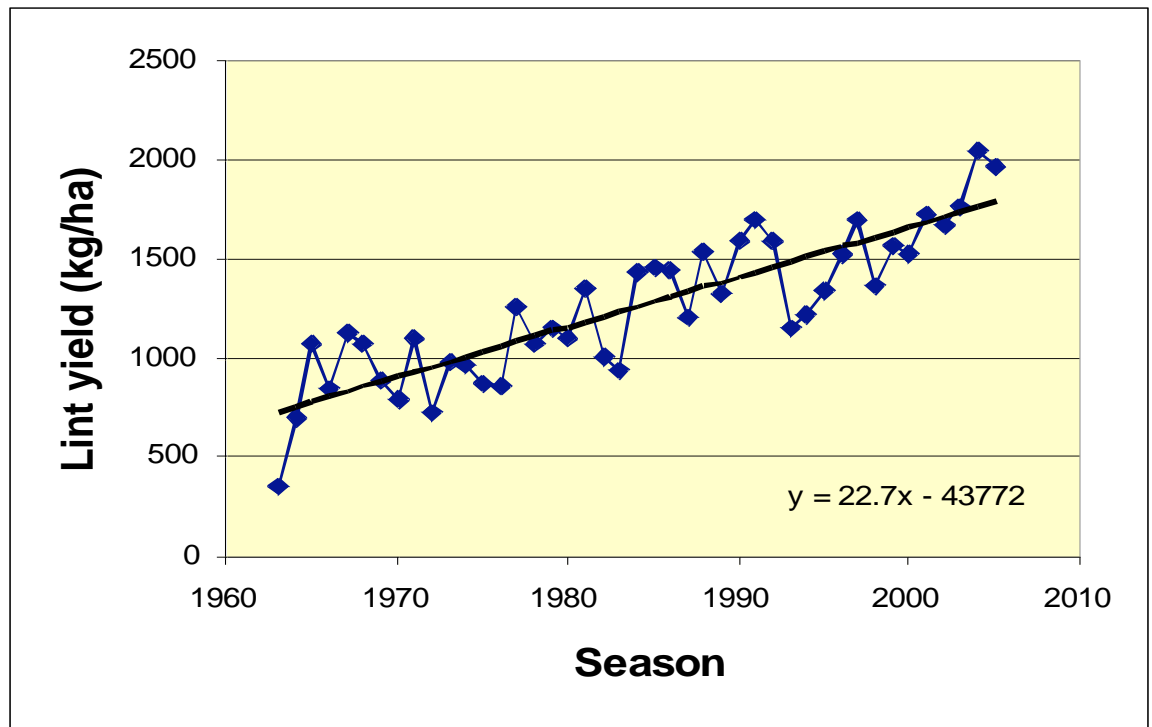
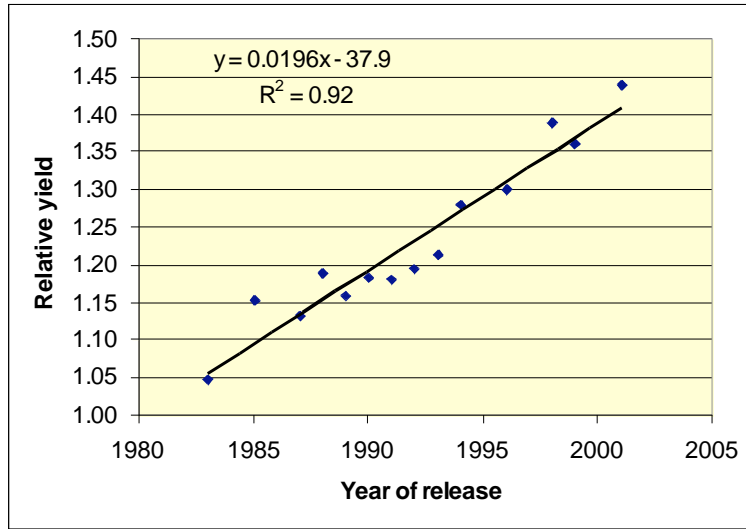


Figure 3. Improvement in relative yield of new cotton cultivars released in Australia
 (Source: Dr Greg Constable)



Yields have risen continuously since the establishment of the industry. CSIRO plant breeders have measured 45 percent of that increase as being due to higher yield of new cultivars (see figure 3) and the balance due to management of insects, diseases, soils and water.

2. Improvements in fibre quality

Figures 4 and 5 show the improvements that have been achieved in the key quality characteristics of length and strength in Australia since the early 1970s (source Dr Greg Constable). This has been important for the industry and for growers because it has helped to maintain the value of Australian cotton in the market place. However, as a performance indicator for reporting to the community, improved quality would have to be related to improved returns per hectare or ML to be properly appreciated and understood.

Figure 4. Improvement of fibre length in Australian cotton cultivars

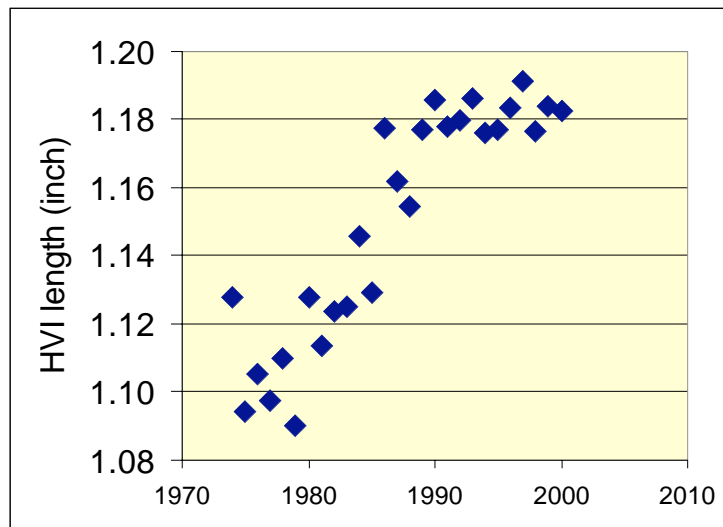
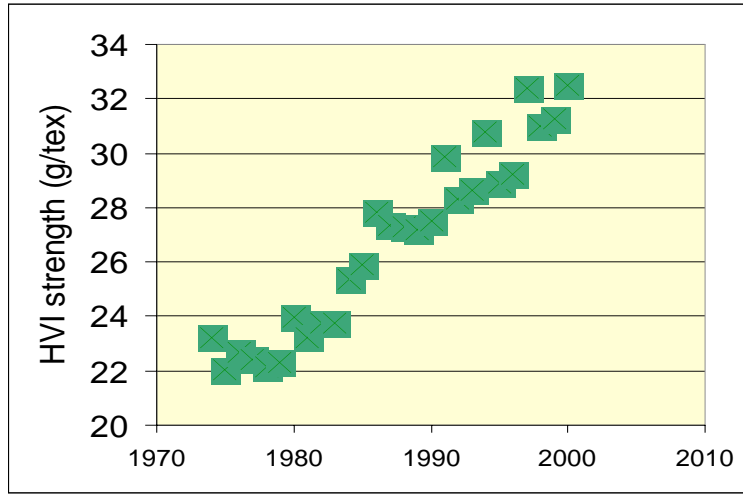


Figure 5. Improvement of fibre strength in Australian cotton cultivars

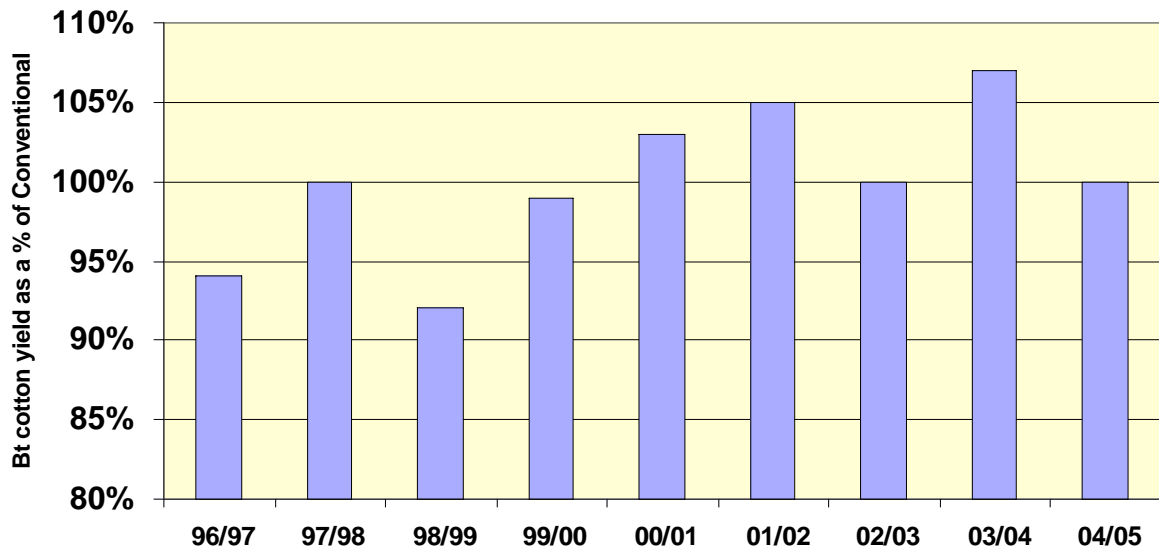


3. Impact of Bt Cotton

Bt cotton has been planted commercially in Australia since 1996 and over that period yield and quality have not differed significantly from conventional cotton (9 year means – 8.23 bales/ha Bt cotton and 8.24 bales/ha conventional).

Figure 6 compares the relative yield from surveys of Bt cotton and conventional crops conducted annually since 1996.

Figure 6. Bt cotton yield expressed as a Percentage of Conventional
(Source: Cotton Consultants Australia)



4. Improved water management

As previously indicated, water is our most limiting resource. The Australian climate is highly variable and therefore rainfall can be highly variable and this can directly impact on the reliability of water supply for irrigation. Consequently improving water use efficiency is essential not only from an economic point of view, but also to ensure environmental needs are also met. On average Australian cotton growers are now producing between 20 and 30 percent more cotton than they were a decade ago but in many cases are not using any more water per hectare. However, leading cotton growers are producing average yields about 30 percent above the national average and to do this they are using more water per hectare but importantly producing significantly more bales per ML. As mentioned, about half of the improvement has come from improved cultivars and the remainder from improved management practices. In recent years there has been an increased focus on improving the efficiency of how the water is managed on farm, particularly how it is applied. Many growers are now talking about bales per megalitre (ML) rather than bales per ha. A decade ago efficient growers were achieving around 1 to 1.4 bales per ML water pumped (excluding rainfall and soil moisture). Now the most efficient furrow irrigators are achieving 1.5 to 2 bales per ML and those who have installed overhead irrigation systems over 2 bales per ML. However, water use efficiency can be difficult to measure accurately particularly on large Australian cotton farms because most have their own on farm water storages which enables them to capture flows from limited local rainfall events and use storages to buffer supplies to enable more efficient application and timing of irrigations. New monitoring equipment and decision support tools are only just becoming available which allow the water volumes in these storages to be accurately monitored. It is clear that losses from farm storages and earthen channels are still high and have become a major focus for improvement.

Establishing an effective community indicator for water use efficiency is a difficult one for the cotton industry in Australia at present because many of our cities are suffering from drought induced water restrictions. Over 70% of the water extracted from rivers and streams for consumptive use in the Murray-Darling Basin in Australia is used by agriculture (around 90 percent of the Australian cotton crop is produced in the Murray-Darling River Basin). Cotton uses about 15 percent of the water extracted for irrigation. As a consequence cotton production is seen by many in the community as using as much water as our major cities which support two thirds of the nation's population or that the water could be used on more valuable crops. It has become an imperative for the Australian cotton industry to more clearly demonstrate that it is an efficient and productive user of water extracted for crop irrigation.

5. Soil management and precision farming

Australian cotton growers have continuously improved the management of their soils. In the 1980s they learned to avoid soil tillage and other operations when the soil was wet and thus reduced compaction. Around the same time they learned that waterlogging caused significant yield losses and set about laser levelling fields and improving irrigation management and application to minimize it. In the mid to late 1990s use of satellite navigation systems and GPS technology allowed for more precise management of their soils as well as the ability to accurately map yield. Precision agriculture has now become a reality as improved technology is starting allow ever more precise application of nutrients, pesticides and water. Cotton growers are now taking a much greater interest in all aspects of "soil health". In particular they are seeking to better understand the benefits of reduced cultivation, stubble retention and rotation crops. The introduction of Roundup Ready[®] cotton in 2000/01 has improved the flexibility for cotton growers to apply these changes to tillage and stubble management.

In a recent survey of Australian cotton growers, they were asked if they thought their soils had improved over the last 10 years. Sixty seven percent responded that it had improved and 28 percent indicated that it had remained the same. Growers can evidence this by observation and improvements in yield performance over time. It is a challenge though to capture such qualitative assessments as effective indicators of soil condition. However, recent research has shown that under irrigated conditions and using average rates of applied nitrogen, Australian cotton soils produce relatively low levels of nitrous oxide, a potent greenhouse gas (approximately 0.5 percent of applied N converted to N₂O under irrigated cotton in Australia compared to the Intergovernmental Panel on Climate Change (IPCC) benchmark of 1.25 percent). Cotton growers are now being provided with a simple tool for calculating their greenhouse gas emissions. If used effectively, this could provide a way for the industry to start reporting on its management of greenhouse gas emissions, an environmental indicator that is becoming much more of a community concern as the reality of global warming becomes more evident. There will also be an obvious payback to the grower in terms of efficiency improvements in nitrogen use and energy consumption.

6. Insects and Weeds

In the last decade new technology in the form of Bt cotton and new insecticides which are more compatible with the practice of Integrated Pest Management (IPM) have allowed Australian cotton growers to reduce the quantities of insecticides and miticides they use by around 70 percent. Figure 7 shows the trend in total quantities of insecticide and miticides applied per ha over a ten year period from 1995 to 2005.

Figure 8 compares estimates of the number of applications and quantities of insecticide applied to comparison crops of Bollgard II[®] cotton and conventional cotton in Australia since 2001. This shows that two gene Bt cotton has allowed Australian growers to reduce the number of insecticide sprays by 72 percent and the total quantities of chemical by 85 percent compared to conventional cotton. The impact of these reductions has become more significant in recent seasons as the area of the Australian crop planted to Bollgard II varieties has expanded to just over 80 percent.

The adoption of Roundup Ready technology has also contributed significantly to changes in weed management. Around 70 percent of the 2005/06 Australian crop was planted to varieties containing Roundup Ready technology. The following summary indicates some of the changes and impacts observed:

- Superior integrated weed management in fields with heavy weed pressure.
- A reduction in the overall use of residual herbicides (less applied pre-planting and at planting)
- A small increase in post-planting usage of residuals used as lay-by applications.
- A co-incidental lowering of detections of residual herbicides in our river systems.
- A significant reduction in the need for hand weeding (main area for cost savings)
- A small but significant reduction in cultivations.
- A change in the prevalence of some weeds (eg. more fleabane and Roundup Ready cotton itself, but less nut grass and post-emergence grasses).
- Less non-glyphosate over-the-top (OTT) sprays
- A need for additional care with over-the-top (OTT) sprays of glyphosate herbicide to minimise drift.
- No reduction in crop yield (provided spray application is managed effectively)

The image of the industry has improved as a result of the adoption of GM cotton and IPM and the consequent reduction of chemical use. It should be relatively simple to continue to measure chemical use and use it as a valid indicator of environmental performance.

Figure 7. Average quantities of insecticides used in Australian cotton crops over the decade 1995 to 2005.

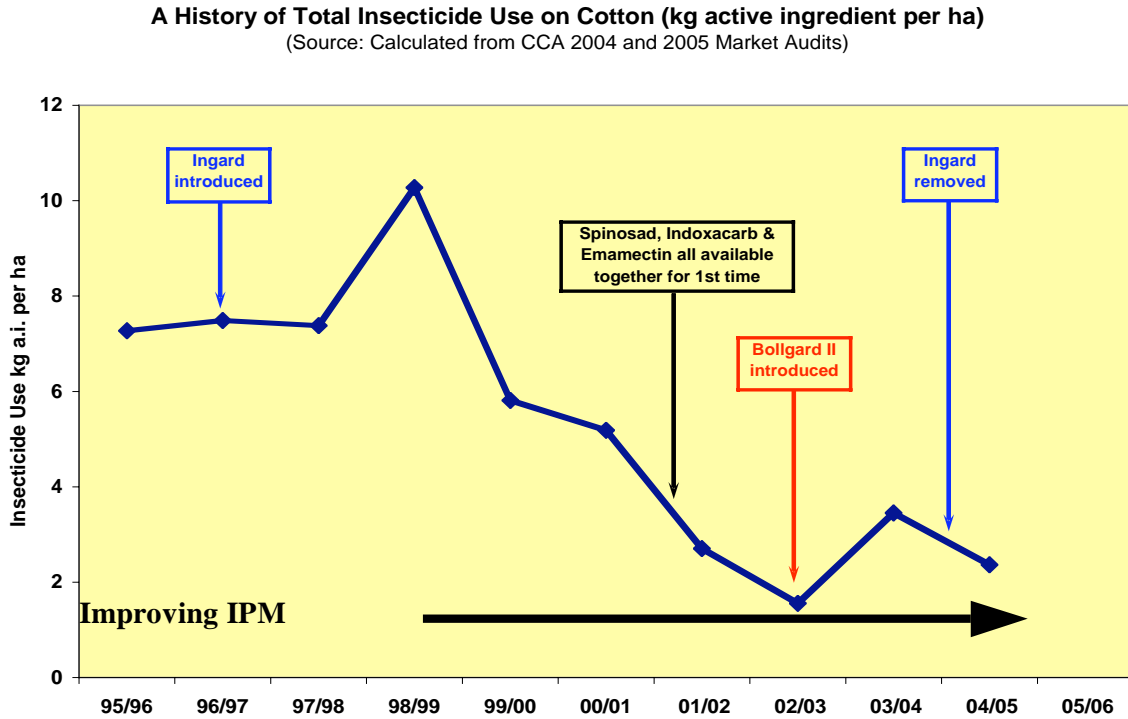
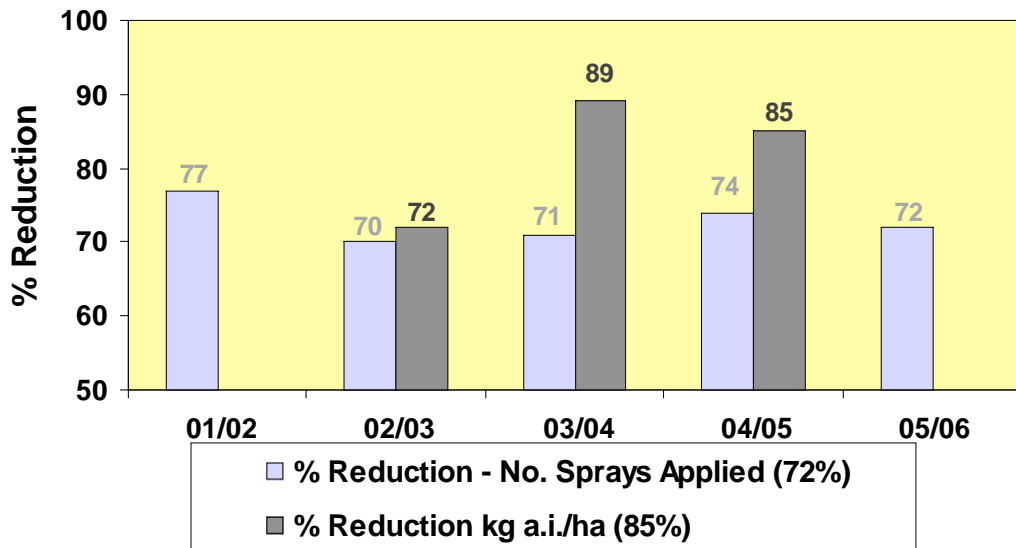


Figure 8. The reduction in the number of sprays and quantities of insecticide applied in Bollgard II[®] cotton compared to conventional cotton over a five year period.



7. Extension and Technology Transfer

The cotton industry has been leading Australian agriculture in the adoption of technology and application of research outputs to improve management practices. One contributor to this is the high level of education of Australian cotton growers: approximately 75 percent have achieved high school level or higher and over 50 percent have received a full or partial tertiary level education. In addition the cotton industry funds an active and successful extension team. Successes include the adoption IPM practices that have resulted in a reduction in the quantities of insecticide required in both Bt and conventional cotton. One key indicator for the effectiveness of IPM in Australia is the fact that there has been no increase in the need for insecticide applications for the control of sucking pests in Bollgard II over the five seasons that it has been grown in commercial scale trial and full commercial areas. Effective IPM has been a major factor in managing insecticide resistance to a range of pests.

Another success story in Australia has been the adoption of improved farm hygiene methods to reduce the rate of spread of diseases like Fusarium wilt and a range of weeds.

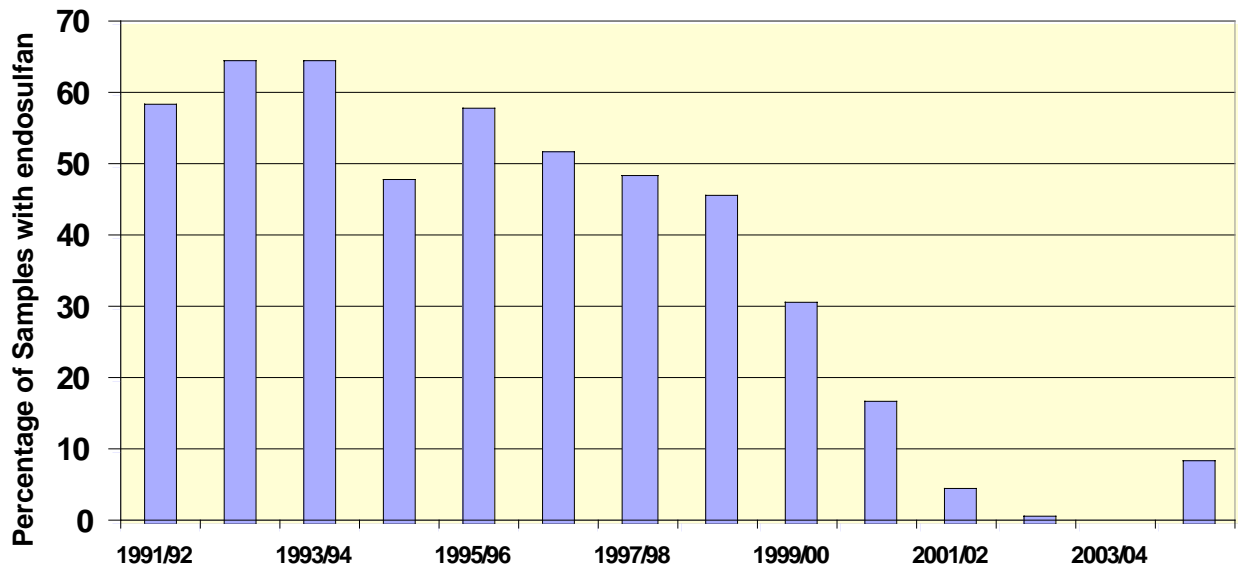
A third example of a successful integrated program is the Australian cotton industry's Best Management Practices (BMP) program which provides cotton growers with a decision support tool for identifying aspects of their management which could be associated with environmental risks and a process to allow them to develop action plans to reduce those risks. The BMP program is now very comprehensive having been developed in a staged manner by initially addressing pesticide management and now encompassing most aspects of land and water management. One of the benefits of the BMP approach is that it is flexible and thus meets the broad range of farming operations that exist. For growers wishing to have their operations audited, independent, environmental auditors have been trained to conduct certification of farms to BMP standards. At present about 21 percent of all cotton growers in Australia have voluntarily entered the BMP audit program.

8. Environmental monitoring.

In Australia government at state level is largely responsible for monitoring environmental impacts and natural resource condition. In many cases these monitoring programs are conducted with the support of the cotton industry and are driven by a common desire to manage undesirable impacts. In the early 1990's the industry was obviously performing poorly with pesticide contamination off farm a major common issue. A joint program between the State Government of New South Wales and the cotton irrigators to monitor water quality has since clearly indicated a vastly improved performance with there now being negligible detections of pesticides in rivers. In the first instance, poor performance gave rise to the need for the Best Management Practice (BMP) program as a risk management tool that was widely adopted by the industry with great success. Underpinning the success of BMP was a targeted investment in research to support growers.

Figure 9 shows the reduction in contamination of four north-western NSW rivers from the insecticide endosulfan between 1991 and 2005. BMP was introduced in 1998.

Figure 9. Percentage of river water samples containing the insecticide endosulfan (four north-western NSW rivers combined – Source: NSW Department of Natural Resources)



CHALLENGES FOR THE FUTURE

The Australian cotton industry can clearly demonstrate the capacity to support a productive profitable and sustainable production system, but many challenges remain. There is a realization that future success will only be achieved by understanding the internal and external influences that will shape the future of the industry. Internal factors will include the pressure of ever increasing input costs and the cost of new technologies in particular. Competition for water will be an ongoing concern and of course commodity prices. More challenging perhaps will external factors such as community perception and acceptance.

Some of the examples provided in this paper show that the Australian cotton industry can demonstrate improving environmental performance, but it must do more within Australia if it is to convince the community at large that cotton production is an industry to be valued as much as we do mining, tourism and manufacturing. We recognize this need but have yet to adopt a simple set of environmental performance indicators to satisfy the triple bottom line sufficiently and address public perception more effectively. To some degree the Australian cotton grower is not fully convinced that this is an issue. What are the risks associated with this allowing this situation to continue and what are the consequences of not responding adequately?

The following figures have been reproduced from a recent study on community perceptions of the Australian cotton industry. They are included here because they show that the assessment and interpretation of, as well as response to, public opinion is complex. For example, perceptions regarding the environmental impact of certain crop production practices can change in a positive way over time. On the other hand, when asked directly to comment about the cotton industry, it is generally perceived more poorly than other agricultural industries and people in major cities have a lower opinion of the industry than those in communities closer to where cotton is grown (i.e.

where community members are more familiar with the industry). This study, funded by Cotton Australia and the Cotton Research and Development Corporation, was conducted by Roy Morgan Research.

Figure 10 compares the responses in 1998 and 2004 from community members of towns and larger regional centres in cotton growing regions to the use of agricultural chemicals. It shows there has been a consistent reduction in the level of concern over this issue in these communities.

Figure 10. A comparison of community concerns in cotton growing regions regarding agricultural chemical use

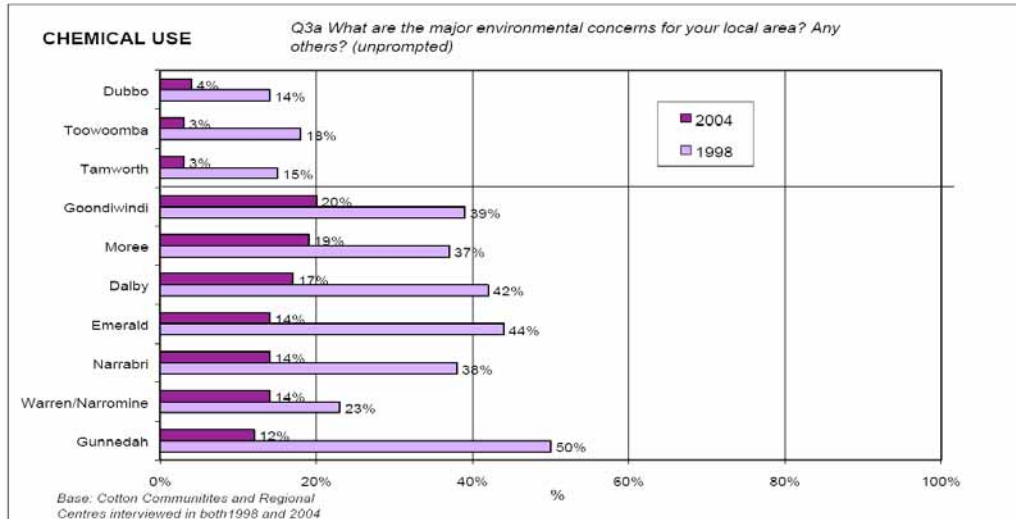


Figure 11 compares the responses in 1998 and 2004 from community members of towns and larger regional centres in cotton growing regions who were concerned over perceived high water use by irrigators. It shows there has been a reduction in the level of concern over this issue in these communities.

Figure 11. A comparison of community concerns in cotton growing regions regarding high water use by irrigators.

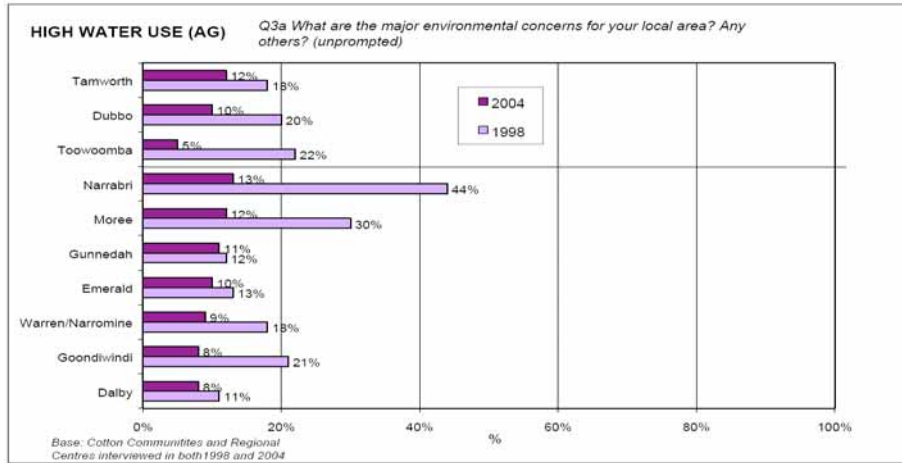


Figure 12 compares the responses from community members of the cities of Brisbane and Sydney as well as towns and larger regional centres in cotton growing regions regarding how effectively several agricultural industries are perceived in caring for the environment. It shows that the cotton industry is perceived to be less caring for the environment in all of these communities.

Figure 12. A comparison of community perceptions of the effectiveness by which different agricultural industries care for the environment

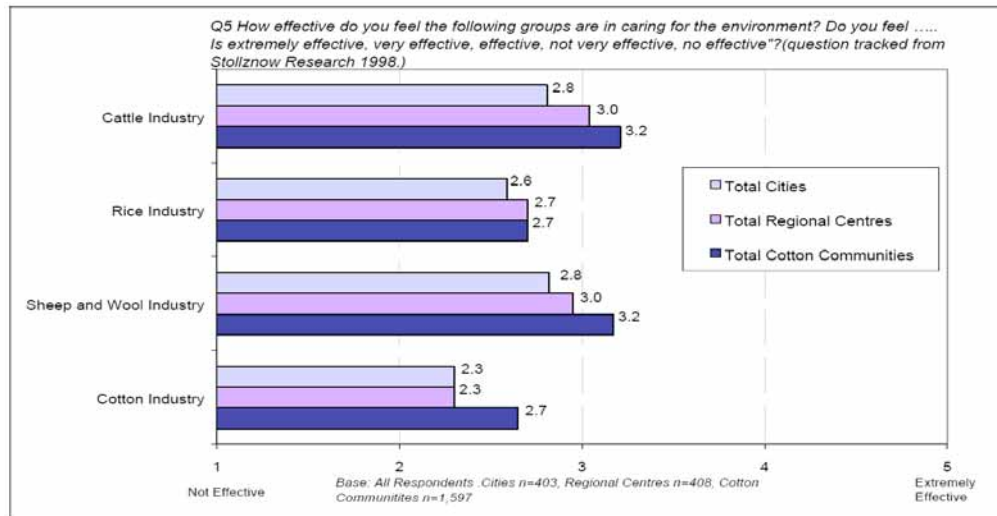


Figure 13 compares the responses from community members of the cities of Brisbane and Sydney as well as towns and larger regional centres in cotton growing regions regarding general their

opinion of the cotton industry. It shows that people in the major cities have a poorer opinion of the cotton industry than those in regional centres and cotton towns.

Figure 13. A comparison of community opinions of the cotton industry

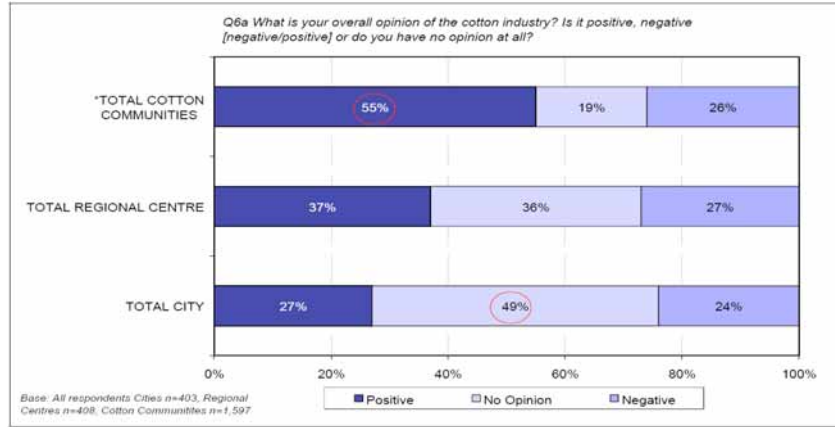
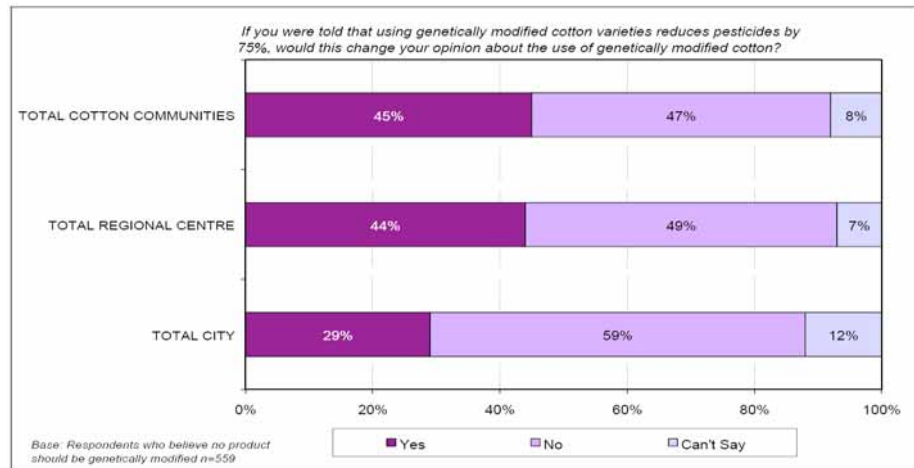


Figure 14 compares the responses from community members of the cities of Brisbane and Sydney as well as towns and larger regional centres in cotton growing regions to being informed about a positive impact of GM cotton – the reduction in pesticide use. It shows that while some community members would be prepared to change their attitudes over GM cotton crops in response to such positive information, the majority would not.

Figure 14. A comparison of community attitude change GM cotton



SOME CONCLUDING QUESTIONS FOR THE GLOBAL COTTON INDUSTRY

Do these same challenges of community or consumer perception also impact to some extent upon every cotton growing country in the world? How well are we managing our natural resource base? Are we meeting the expectations of the global community? Is there some basis for community concern? If so what is the collective responsibility of the world cotton community to respond? And if we do resolve to respond how could this be best facilitated through the ICAC forum?

Sustainability

Key to Australian Cotton Production Practices

Richard Browne, Bruce Pyke, Allan Williams

Australian Cotton Producing Areas



The Australian Cotton Industry and Sustainability

- ✓ Production of Fibre & Food
- ✓ Wealth generation
- ✓ Production based on good science and biotechnology
- ✓ Sound management of Natural resources

Defining Sustainability

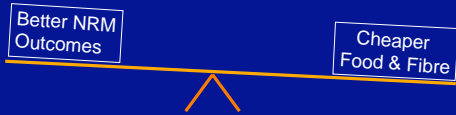
- Systemic concept
- Overlapping human activities (economic, social, environmental institutional)
- Meeting current needs
- Express greatest potential in present
- Preserving biodiversity and natural ecosystems
- Plan and act for the long term

How do we translate Sustainability into Environmental Performance?

Environmental Performance

- Meeting the need for social and environmental trade-offs
- Need for performance indicators
- Consider Triple Bottom Line
 - Economic, Environmental, Social
 - Or
 - Landscapes, Livelihoods, Lifestyles
- A test for everyone

Challenge for Australian Agriculture



Landscape The Foundation Stone

- Soil
- Water
- Biodiversity
- Climate

Stewardship

Livelihoods Wealth and Opportunity

- Profitable and Productive
- Drives Investment
- Higher standard of living
- Allows better Stewardship of natural resources

Lifestyles A Better Way of Life

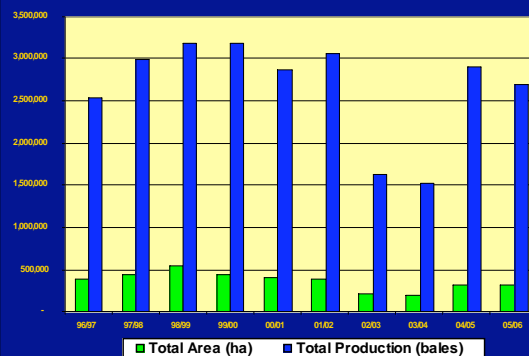
- Aspirations
 - Wellbeing and Opportunity
 - Balancing the demands
- Perceptions
 - Local and Global
 - "Social licence" to operate

Measuring Performance

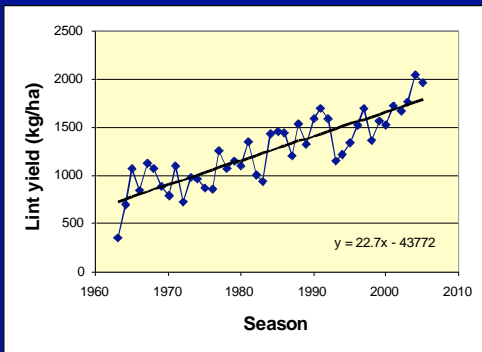
The Key to Australian Production Practices

Some Examples

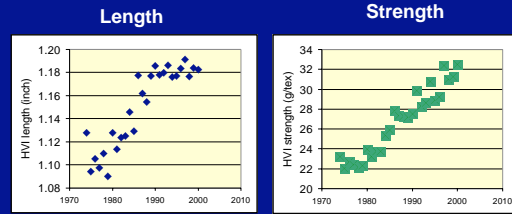
Planted Area and Production



Yield Improvement



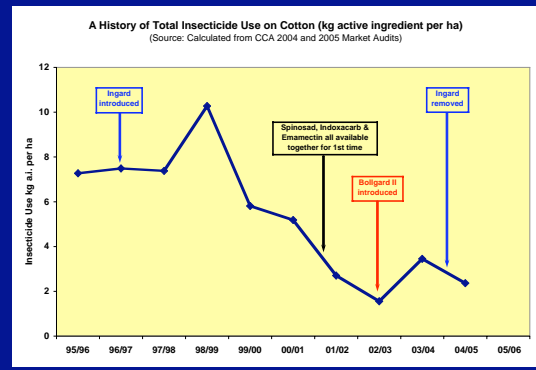
Quality Improvement



Source: Dr Greg Constable

Water & Soil

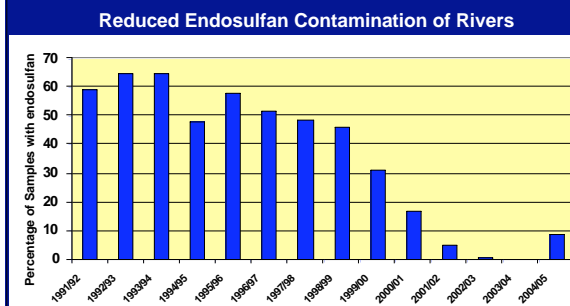
Insects



Extension & Adoption

- High level of Uptake
- Industry funded extension network
- Private consultants
- IPM
- Vital Role of BMP (*Best Management Practices*)

Environmental Monitoring



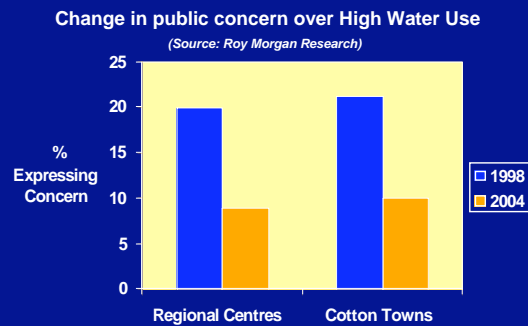
Challenges for the Future

- Internal vs External drivers
- Internal:
 - Input costs and cost of new technology
 - Competition for natural resources (especially water)
 - Cotton Prices
- External
 - Community Perception & Acceptance
 - Environmental performance

An External Challenge

Perception of The Cotton Industry

Public Perceptions Can Change if Real Improvements Are Seen



Some Final Questions

- Is Australia's Experience relevant to cotton production globally?
- If it is what can we do about it collectively?