A pestered industry turns to science

Australia's cotton crop is now worth around $1.7 billion per annum. But like most of the imported plant species on which Australian agriculture is based, it faced a difficult time adapting to local conditions. Early attempts to establish the industry were devastated by pests.

A CSIRO research program launched in the mid-70s changed this and helped build a billion dollar industry in only twenty years. Over 97% of the current national crop is grown from seed types tailored by CSIRO to deliver high yield and fibre quality in local conditions, while resisting pests and diseases. Seeds of these varieties are also now being sold internationally.

The Program has expanded from traditional plant breeding to encompass gene technology research. In 1997, the first gene-enhanced cotton crop was harvested, carrying a gene that made it unpalatable to heliothis, cotton's principal pest. This allowed farmers to cut insecticide use by nearly two thirds.

Cotton breeding program: trust in commercial relationships

CSIRO and the Australian cotton industry have developed a symbiotic relationship which has helped the industry build a competitive niche in the international cotton market. The relationship has lasted for over twenty years, but like any partnership, both parties have had to work hard to maintain trust and commit themselves to seeking mutual benefits.

The fledgling cotton industry had to come to terms with the long time horizons of research. CSIRO had to blend the skills of two Divisions and develop motivational techniques for researchers at remote stations, to ensure the best research outcomes. Both CSIRO and industry had to adapt as the relationship became increasingly commercial.

The results are impressive. Australia has a new billion dollar industry. The program has also become a net earner for CSIRO, contributing substantial amounts to CSIRO's external earnings.

Project origins

Cotton breeding in CSIRO quietly began in 1972 with a small program in Griffith, along the Murrumbidgee Irrigation Area. The failure of the infant industry along the Ord River in Western Australia had threatened to end the development of a serious cotton industry in Australia. The CSIRO Executive decided to start a significant program of research, to see if this potentially lucrative crop couldn't be adapted to local conditions in eastern Australia.

There was some rivalry within CSIRO as to who would manage the new program. The problems of the Ord were caused by insect pests that had become resistant to DDT, putting entomological issues in the spotlight. But the CSIRO Executive of the day took a longer term view: they went for an integrated breeding program that would take in factors besides pest control, including climate, soil, cotton yield and quality. Leadership of the program went to the Division of Plant Industry.

The problem with insects

In keeping with the traditions of Divisional autonomy prevailing in CSIRO at the time, the Division of Plant Industry promptly recruited its own entomologists, although it took on selected scientists from the Division of Entomology. These included Peter Room, who had been developing a computer program to help with decisions on when to spray crops.

When Dr Jim Peacock was appointed as Chief of the Division of Plant Industry in 1978, he recognised that the program would be strengthened if the two Divisions worked more closely together. He also recognised that CSIRO could only maintain its best talents if it provided them with a clear career path and scientifically rewarding experiences such as those involving multi-disciplinary efforts.

He cites the example of Gary Fitt, who was recruited to the cotton program as an entomologist. "He's a brilliant entomologist, but his career could only develop to its fullest if he worked with the Division of Entomology. That Division had then just acquired a new Chief, Dr Max Whitten, and I proposed that Entomology take on Gary, but that my Division would continue to pay part of his salary. Max accepted and that started a very positive relationship between our Divisions," he said.

"To cement that relationship, I later appointed Gary Fitt as the leader of the Plant Industry Division's cotton management and production program. So you had someone from Entomology leading a program under Plant Industry. Gary remains the program leader and has formed a strong teamwork with the chief breeder, Greg Constable."

Today, the two Divisions work closely in the Cotton Research Unit at Narrabri and at the Unit's laboratory in Canberra. Their mission is to support sustainable cotton production, with reduced dependence on pesticides.

Streamlining and motivating field researchers

One of the first issues Dr Peacock had to tackle upon becoming Division Chief, was the lack of integrated effort between the breeding programs at Griffith and Narrabri. He took the hard decision of merging the two programs, moving the Griffith staff and operations to Narrabri.

"It was most important that everyone understood that we were going for excellence in breeding – and we could only achieve that by consolidating our efforts and

concentrating on our strengths. The Narrabri station had a very strong and well managed program, and the high research standards of the program leader Brian Hearn and chief breeder Norm Thompson."

The merger, however, had its downside. As in any organisational merger, the cultural differences between the two programs brought out staff morale problems.

Dr Peacock: "Low morale and unhappiness are not uncommon among isolated research communities. Left to fester, they can detract from research excellence. So, I committed myself to visit the field office regularly and tried to attract and draw everyone together to go after a common goal. This goal had to be held high up for everyone to see and identify with, so I made quite a big deal of it in staff meetings and planning sessions – one thing I learned when I was doing my post doctorate research in the US was that, if you really want something to succeed, you have to give it a touch of Hollywood. You bring together disparate characters to produce a grand piece of work."

Having observed the activities of the research staff, he recognised a potential starting point for greater team cohesion. He decided to bring together the computer modelling work of Brian Hearn and the crop-spraying program of Peter Broom, to see if they could create a crop management tool to help farmers reduce insecticide use. The challenge got staff fired up and working as a team on the project. The result was a computer software package, which they named Siratac. It predicted the best time to spray by determining when and where pests would be most prevalent.

The exercise gave the staff an opportunity to work together, and consequently, to know each other better. Morale began to pick up. And what was originally devised as a people management tool led to a very successful crop management tool that was widely adopted by cotton growers. Siratac helped farmers reduce pesticide use by half cutting costs and making a tangible contribution to community concern about high pesticide usage.

Commitment from CSIRO management

Dr Peacock believed that it was important that he demonstrate his own commitment to the program's goal. "The staff needed to feel that CSIRO's leadership was genuinely interested as well."

And here he knew that actions speak louder than words. His support for the program and that of CSIRO's executive, was driven home by the significant level of resources dedicated to the program.

"The project has always been very well-resourced, and when you combine this with the talent and team work of the field researchers, we had a formidable program. Research excellence and staff morale have a way of building on each other. The more recognition the program received from both domestic and international cotton sectors, the greater was the motivation of the staff. We have come a long way from the days when it was very difficult to attract good staff to move to Narrabri. Today, being

associated with the program is as good a motivator as an excellent pay package," says Dr Peacock.

Persistence pays off

Narrabri in NSW was chosen to be the hub of the program because it was close to the Namoi Valley where successful crops were being grown by some American farmers. At that time, all commercial cotton crops grown in Australia were of the Delta Pine variety developed in the US, which was susceptible to a number of pests and diseases.

The program brief was to produce varieties suitable to Australian conditions. The cultivars sought were to be pest-tolerant and disease-resistant, in addition to giving high yield and high fibre quality.

But plant breeding rarely makes for overnight success. While it did not take long to bring Siratac onto the market, it took nearly 10 years before the first CSIRO cotton cultivar came out. Named Sicot, it didn't make much impact on the market. It offered improved performance, but the other cultivars that Norm Thompson's team had been developing were superior. These eventually became very successful, having shown better performance than the US-developed Delta Pine variety.

One of the pioneering results of the program was the creation of the okra-leaf cotton, whose unusual finger-like leaves provide better tolerance to damage from pests like mites and heliothis. In the US, the use of okra-leaf cotton had resulted in reduced yield, but Norm Thompson managed to produce a cultivar that was both pest-tolerant and high-yielding.

A key factor to the success of the cultivars was their built-in resistance to bacterial blight, a major problem during the early cotton-growing years in Australia. The blight caused lesions on plant leaves, and the rotting of cotton bolls. Blight resistance has since become mandatory in developing new cotton varieties, and the disease has now been eradicated in Australia.

The eradication of bacterial blight translated into a rise in the yield of the Australian cotton industry. It also increased the recognition of the work of CSIRO's breeding program, with growers becoming more receptive to CSIRO's cultivars. Today, CSIRO-developed varieties account for around 97% of cotton grown in Australia, achievbing this market dominance in only 13 years from the release of the first cultivar.

Cooperative partnership with cotton growers

The cornerstone of the commercial success of the breeding program is the cooperation that has developed with the domestic cotton industry, particularly through the Cotton Seed Distributors (CSD), a non-profit, cooperative venture among Australian cotton growers. According to Dr Peacock, CSD provided the systems and infrastructure necessary to conduct large-scale testing and distribution of new cultivars. "CSIRO could not have provided this on its own. We simply didn't have the resources. CSD enabled us to integrate our research with the conditions and actual operations of the industry."

CSD was originally established to test and distribute very good seeds to growers, at-cost. "When we started releasing our varieties, CSD proposed a partnership under which they'd prepare the seeds for distribution to growers. We accepted the offer as we recognised that they'd treat the seeds in the best possible way before releasing them," said Dr Peacock.

CSIRO was also attracted by CSD's offer to test and distribute several varieties at a time. It was willing to pull out an existing variety each time that CSIRO developed a new, better one – even if this increased its operating costs. CSD distributed the best possible seed at any time, instead of trying to maximise their short term profits by maintaining a variety in use for a longer period.

The system meant that CSIRO was able to continually develop varieties suitable to the different conditions and market demands. CSD was managing a bigger complement of cultivars, with a faster turnover than is usually done in commercial operations. Growers then had a choice between several cultivars. Another benefit arising from this arrangement was that, as the cotton industry spread into different irrigation areas in Queensland and New South Wales, CSIRO was able to develop and test varieties suitable for these areas.

"The arrangement was a fantastic way of transferring our research results to the industry," says Dr Peacock.

Trust: cornerstone of relationship with industry

CSIRO and CSD entered into the seed testing and distribution arrangement without a binding contract, at least during the first three years. "We just shook hands, then worked together very productively," said Dr Peacock.

These days, such an arrangement would be seen as a potential legal minefield. But in a less litigious era, it was a constructive de facto relationship based on a commitment to a common goal – the growth and development of the Australian cotton industry. Each party recognised the other's commitment to the goal, allowing mutual trust to take precedence over the commercial imperative.

Trust and rapport were strengthened in the field, where CSIRO scientists worked face-to-face with cotton farmers. "Our scientists made sure they consulted the

farmers regularly. They were never patronising and they genuinely learned from those consultations."

Dr Peacock: "There was mutual trust – I was convinced that the CSD Chairman at the time, Richard Williams, was passionately driven to help the cotton industry, and I believed that he saw our science as helping deliver that. There's no doubt that nowadays you have to have contracts and complex legal agreements, but it's the trust that you build up that really matters. If both partners are committed, and complement each other to achieve a common goal, then finding a way to get some reward from the partnership is not difficult."

This trust and mutual interest enabled the relationship to endure the changes that came as CSIRO became more commercially oriented. CSD did not hesitate at all when CSIRO first proposed a commercial agreement. "When CSIRO's varieties began to dominate the market around 1987, I approached Richard Williams and said: 'shouldn't we regularise this arrangement and get a contract? Don't you think it's fair that we get some royalty for the sale of our seed?' I was really just thinking aloud, but he said yes without blinking an eye. He told me he wanted to make sure we kept up the breeding program for the good of the industry."

"That was the first commercial arrangement I ever made. We had an initial three-year contract, and when the time came to re-negotiate that, I was emboldened to ask to raise the royalty. I was quite chuffed when they said yes."

Program expansion: gene technology

By 1987, Dr Peacock recognised that the cotton breeding program must step up its strategy to combat the continuing chemical resistance developed by insects. His gut-feel was to combine new gene technology with conventional breeding. He had been aware of the breakthrough achieved by scientists at Monsanto Ltd in the US. The company had been testing an insect-resistant transgenic cotton, which contains the gene called Ingard ™. The gene enables the cotton plant to express the toxin from *Bacillus thuringiensis* (Bt), a soil bacterium, which specifically kills caterpillar pests but has no effect on beneficial insects.

Dr Peacock wanted to incorporate the Ingard ™ gene in Australian cotton and test its performance, but such a program would require $100,000. He discussed the program with the CSD's Richard Williams, who readily agreed to provide half of the required funding.

CSD had initially deputised CSIRO to enter into a research agreement with Monsanto. As a result, the first field plots in Australia were planted in 1992 with approval from the Genetic Manipulation Advisory Committee. CSD itself later entered into a commercial relationship with Monsanto, as seed distributors. Three years after the project was launched, the Cotton Research and Development Corporation provided additional funding.

The first transgenic cotton was grown in late 1996, and required 70% less chemical insecticides than conventional varieties. A second crop, double the area of the first, has been planted for harvesting early in 1998. CSIRO will have to gain growers' confidence in the variety, and live by its reputation. "We have always selected for pest- and disease-resistance, yield and quality. When we first introduced the okra-leaf variety, we did encounter scepticism from the market, especially from Japan and international buyers. Okra-leaf had previously failed in the US, but the special variety we created gave both yield and pest-resistance. Even when the US dumped low-quality cotton on the market, our market share was hardly affected," said Dr Peacock.

Capturing the international market

The successful domestic CSIRO varieties attracted the attention of foreign competitors. Dr Peacock said there had been cases of unlicensed growing of Australian cotton overseas, and this had prompted him to encourage CSD to trial and sell seeds internationally. "They might as well profit from their work, instead of the seeds being pinched," he said.

He brokered CSD's first international joint venture, with the French company Groupe Limagrain, to distribute Australian cotton varieties in the international market. Limagrain has since been bought out by another international firm, AgrEvo. The new alliance, Australian Cotton Seed International, now sells CSIRO-developed cotton varieties, both conventional and transgenic. The varieties are being sold to the US, South Africa, Spain, Turkey and Greece.

Siratac re-born

Dr Peacock had been so impressed by the CSD's set-up that he tried to mimic its non-profit operation to run the Narrabri program's first success, the Siratac software. CSIRO established Siratac Ltd as a non-profit organisation, to give farmers access to the package, at-cost. The computer program was run from CSIRO's computers and farmers paid for accessing it through their telephones. However, Dr Peacock recalls that some farmers who refused to pay for access merely looked over the fence and copied what a paying farmer did. One informal survey had shown that 70% of farmers were using Siratac, but only 30% were actually licensed.

Siratac failed to earn enough money to continue operating and it was eventually disbanded. "It was a good lesson. We tried to copy the CSD's non-profit principle, but it doesn't work when you're running a software company."

After a few years, however, many farmers wanted Siratac back. Today, a new generation software has replaced Siratac, but with an expanded information base. The powerful program, entomoLOGIC, is being distributed on a commercial basis and is run on farmers' own computers. It contains models of the cotton plant and the life cycles of major pests, and these can help farmers predict pest pressures, yield and harvest date for better pest management and irrigation scheduling.