AUSTRALIAN VARIETIES IN THE USA: BACKGROUND TO THE AUSTRALIAN GERMPLASM

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This paper briefly describes the background to the research which has positioned the Australian Cotton Breeding program as one of, if not the premier, cotton breeding program in the world. It discusses the development of several important phases of the breeding program and some of the significant milestones achieved.

The modern Australian cotton-breeding program, conducted by CSIRO, has only been in existence since 1972. It has however been so successful that the current Australian industry has benefited from the commercialization of 29 new varieties over the past 12 years. Varieties from this breeding program command greater than 92% of the Australian cotton planted area and currently there are 10 conventional and 5 transgenic varieties commercially available in Australia as a result of CSIRO's breeding efforts. Siokra (okra leaf varieties) occupy approximately 25% of the Australian area.

Some of the formative research, which has been the foundation on which the CSIRO Cotton breeding program is based, included: Reviews of available germplasm; Comparison of varieties; Heterosis & combining ability between African & American Germplasm; Intra-varietal variation & response to selection; HPR characteristics; HPR in plant breeding; Multi-site testing.

To help the development of a modern and sustainable industry, the CSIRO initiated research to determine the constraints to cotton production in Australia. An integral part of this research was the establishment of a cotton germplasm and screening program, which later developed into a comprehensive Breeding Effort.

CSIRO undertook screening of many genotypes from around the globe; firstly, to determine which types could be adapted to production in the Australian environment, and secondly, to identify germplasm suitable for inclusions in the breeding program. This germplasm was derived as follows: Sudan (9); Nigeria (4); Tanganyika (8); Uganda (5); Congo (8); South Africa (4); Argentina (12); Pakistan (11); India (2); Early introductions into Queensland, Australia (6); Russia (8), and; USA (24). At that time, Deltapine 16 was the dominate variety that was being grown both in Australia as well as in many other parts of the world including the US and hence was chosen as the comparator variety.

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Parameters by on which the differing cultivars were compared to the standard were: Seed cotton yield; Lint percentage; Boll weight; Maturity; Plant size; Bacterial Blight resistance, and; Fibre quality. You will note the inclusion of Bacterial Blight resistance as this disease severely impacted on the performance of susceptible cultivars in Australia. Note also the inclusion of quality parameters.

From the review of performance, it was concluded that many desirable characteristics could be gleaned from material from outside the traditional US based sources of germplasm. African varieties offered greater Bacterial Blight resistance and better fibre quality, particularly strength. Two of the Sudanese varieties had particularly outstanding fibre quality; Argentine material offered high quality; Indian/Pakistan varieties had earliness and short but strong staple, and; Russian material offered earliness, small plant stature, and stronger-finer fibre. The US material evaluated (other than DP16) offered some higher seed cotton yields and higher lint percentage. Agronomic performance generally reflected the breeding effort from the programs from which they were derived.

In an attempt to determine which sources of material and which germplasm would provide the widest genetic diversity to go into the breeding program, crosses were made between three distinct genetic materials: African upland; Ordinary quality American Upland, and; High quality American upland. These studies involved 9 parents and 36 x F1's. The General Combining Ability was highly significant between parents for: Lint yield; Seedling vigour; micronaire; and, Strength. It was determined that the African cultivars and Stoneville 7A provided a combining ability that made them suitable for breeding. There was only slight Heterosis exhibited for the Intra-American crosses.

The CSIRO breeding team also investigated the potential to look within a variety for genetic gain. From an extensive study it was determined that "Intra-varietal selection remains a valuable technique for varietal improvement".

The Australian environment lends itself to the rapid influx of large numbers of Heliothine moths. The chemicals used to control these pests have become less effective due to the development of insect resistance to them.

HPR traits were investigated as potentially valuable traits to incorporate into the breeding program. There are many HPR characteristics that have been identified. The Glabrous, Frego Bract, Okra leaf and Nectariless traits are those that offer opportunities to combat the environmental constraints and the pest spectrum that plague the Australian industry.

Breeding cotton containing HPR characteristics offers some distinct opportunities to decrease and compliment the

judicious use of chemicals. The Glabrous trait imparts cleaner lint and supports reduced egg lay by Heliothis. Frego Bracts result in cleaner lint and better insecticide spray penetration. The Okra leaf character enhances earliness, reduces boll rot, is less attractive to mites & Whitefly and, reportedly to Boll Weevils and, produces a high fruiting rate. The Nectariless trait reduces Plant Bugs & Heliothis.

Sixteen near-isogenic lines were evaluated to determine the effects of these mutant genes on yield and quality over three seasons and two insect control regimes.

Sicot 3 released in 1982, was a very successful example of combining the Glabrous and Frego bract traits into a commercial cultivar. The demise of this variety only came about by the change in the industry towards the production of higher strength cottons.

Siokra, released in 1984, was the first of many okra leaf varieties, which continue to command a significant percentage of the Australian planted area.

To summarize, the CSIRO breeding program has had 2 main sub-programs:

The Full season program.

Breeding Objective	1972-74	1975-91	1992-94	1994+
Full Season	HPR Frego; Glabrous	HPR Okra; Frego; Glabrous; Nectariless	HPR Okra; Frego; Glabrous; Nectariless; Allelo-chemical	HPR Okra; Frego; Glabrous; Nectariless Allelo-chemical

You can see how this component of the breeding program has developed, over time, a focus on environmental and insect constraints to the Australian industry.

The second of the two sub-programs is the Special Purpose breeding program. This sub-program has also developed to include new aspects of cotton breeding and production by the inclusion of transgenic traits and water-use efficient selections.

The following table indicates the development over time of the development and inclusion of components of this breeding sub-program.

Breeding Objective	1972-74	1975-91	1992-94	1994+
Special Purpose	Earliness Quality	Earliness Verticillium tolerance Dryland	Earliness *Verticillium* tolerance Dryland Bt Nutrition Cold tolerance	Earliness Cold tolerance *Verticillium* tolerance *Fusarium* tolerance Dryland (WUE) G. barbadense Nutrition Herbicide tolerance. Coloured Cotton Waterlogging tolerance

Note that inclusion of the objectives of:
Disease tolerance to *Verticillium* and *Fusarium*;
Physiological traits: WUE, Cold tolerance, Earliness, Nutrition
Transgenic traits: Bt; Herbicide tolerance; Waterlogging tolerance
Extra Long Staple cotton: Pima, and
Coloured cotton.

Finally, as a component of a sub-program is successfully incorporated, it becomes a part of the Overall Objective of the CSIRO Breeding Program.

Breeding Objective	1972-74	1975-91	1992-94	1994+
Special Purpose	Yield Adaptation	Yield Adaptation Quality Blight Resistance	Yield Adaptation Quality Blight Resistance	Yield Adaptation Quality Blight Res. *Verticillium* tolerance Bt

Validation of the Breeding program is achieved through an extensive Testing Program.

Each year there are many thousands of plots evaluated: Each year the breeding program conducts greater than 16,000 yield plots and more than 40,000 HVI tests on yield plots and Single Plant Selections. Evaluation begins on the Australian Cotton Research Institute (ACRI), then at 13 Australian Cotton Cultivar Trials (ACCT) sites across the Australian Cotton Belt.

As the variety nears final stage of evaluation, it is included in many of the 48 Cotton Seed Distributors (CSD) trials which are spread also across the Australian Cotton growing regions. The 1997 CSD trials comprised 25 conventional trials, 10 Raingrown trials sites and 13 trials designated to the evaluation of Ingard® varieties. By the time a variety is released it has gone through many years of multiple site performance trials and a great deal of selection pressure regarding quality attributes, each SPS has HVI performed on its fibre. A parallel, pre-release seed increase program runs in addition to these multi-year, multi-site evaluations.

There is no ‘Magic’ in cotton breeding. It is purely a function of the numbers you evaluate from the populations you are working with. For example the original Siokra was the result of screening 12,000 individual plants.

Breeding: It’s a numbers game!