More efficient breeding of drought-resistant peanuts in India and Australia (CS1/1997/114)

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| Collaborating institutions | ■ Australia: Queensland Department of Primary Industries and Fisheries (QDPI&F)  
  ■ India: Indian Council of Agricultural Research (ICAR), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) |
| Funding | $ 591,423 (including extension phase) |
| Countries involved | Australia and India |
| Commodities involved | Peanut (groundnut) |
| Related projects | CS1/1992/016 – Selection for water-use efficiency in grain legumes |
Motivation for the project and what it aimed to achieve

Drought is a major constraint to peanut productivity in many regions of the world, including India and Australia, where peanut is grown under dryland conditions. While breeding of more drought-resistant genotypes by direct selection for yield can be effective for a given target environment, the limitations of this approach are high resource investment and poor repeatability of the results due to the large genetic–environment (G × E) interaction for yield. Plant breeders and physiologists believe that more rapid progress can be aided by a prior knowledge of the physiological basis of crop performance under drought conditions.

Although work done at ICRISAT and Australia revealed significant variation for the three traits—transpiration (T), transpiration efficiency or water-use efficiency (WUE), and harvest index (HI)—that were proposed by Passioura (1986) to explain yield variation in water-deficit environments, the application of this physiological model in peanut-breeding programs has not been possible because of practical difficulties associated with measurement of the traits under field conditions.


A Gujarat farmer group discusses aspects of peanut seed crop management with project staff. Gujarat farmers have selected for adoption four peanut varieties developed from the ACIAR project and a program of rapid seed production is underway.
Work done in precursor ACIAR project CS1/1992/016—Selection for water use efficiency in food legumes—had developed low-cost, rapid and easily measured surrogate measures for each of these traits, thus allowing their potential quantification in the large germplasm collection available at ICRISAT and in Indian breeding populations. Project CS1/1997/114 therefore aimed to implement and apply this physiological knowledge to test whether indirect selection using the trait approach could improve the efficiency of selection in large-scale peanut-breeding programs involving breeders, physiologists and modellers in a truly collaborative research program between QDPI&F, ICRISAT and ICAR. New breeding approaches utilising physiological traits (T, W and HI) have been proposed to improve the understanding and efficiency of selection for superior drought-tolerant genotypes. The project used a crop analytical model proposed by Passioura (1986), viz.

\[
\text{pod yield} = \text{water transpired (T)} \times \text{water-use efficiency (W)} \times \text{harvest index (HI)}
\]

to analyse pod-yield variation under water-limited conditions in three functional components.

The project CS1/1997/114 began in 1998 with the selection of elite parents possessing high levels of drought-resistance traits, as identified with the trait-based selection approach generated in CS1/1992/016.

What the research project produced

The research project resulted in several technical outputs as summarised below:

- The research found that both indirect selection (trait-based) and direct selection methods for yield were able to select out high-yielding genotypes under water-limited/non-limiting conditions. Their yields were significantly higher than local check varieties (e.g. from 10–30% higher, depending on location), suggesting that parental selection is more critical than the breeding methodology followed.

- Although there were small differences in the efficiency of selection (i.e. rate of genetic progress) between trait-based and empirical approaches, there was clear evidence that the trait approach was able to identify high-yielding genotypes with high levels of WUE, which it can be assumed must have yield benefits in environments subject to extreme water stress.

- Standardisation of SPAD chlorophyll meter measurements to minimise environmental effects resulted in increased heritability of the W term in the Passioura equation. This led to extensive application of SPAD measurement to screen for WUE in peanut-breeding programs in India.

- In Australia, the project allowed import of short-duration drought-resistant germplasm from India for use in the local peanut-breeding program. It was arguable that the Indian germplasm used in the crosses was not the most suitable (i.e. Spanish type and short stature) under local agronomic conditions, and it was always going to be difficult to beat the locally adapted varieties such as Streeton and Conder, which have superior adaptation in our water-limited environment. However, development of short-duration genotypes proved to be beneficial to dryland environments as well as for use in coastal cane-farming systems.
Current levels of adoption of outputs by initial and final users can be grouped under the following categories:

**Adoption of technical outputs by researchers**

Selection tools, especially the SPAD chlorophyll meter, are being extensively used at all collaborating centres as a surrogate measure for WUE in parental and progeny selection.

However, collaborating scientists acknowledged that they had not been using the ‘selection index’ approach developed in the project (which integrates the T, W and HI traits) because it was too laborious.

Collaborative research conducted with the University of Agricultural Sciences, Bangalore (UASB), on development of selection tools for drought-resistance traits in the precursor ACIAR project (CS1/1992/016), had a major influence on installation in 2000 of a national research facility by the Ministry of Agriculture, Government of India, to conduct research on the application of natural isotopes in crop-improvement programs. As a part of the mandate of the national research facility, UASB organised a number of training programs during 2002–07 for Indian National Agricultural Research System institutes, to raise awareness among crop scientists and research administrators about the trait-based approach for crop breeding that was originally introduced in the ACIAR (CS1/1997/114) project. As a result, a number of crop-improvement

‘Walter’ peanut variety is becoming a popular variety in cane rotation systems due to its early maturity, which fits in well with cane rotation. The photo shows ‘Walter’ planted during the 2008 season at Bundaberg ready for harvest at 110 days.
programs in India (e.g. peanut, soybean, rapeseed, mustard, sunflower and finger millet) are now currently using selection tools and methodologies developed in the original project (e.g. rain out shelters, carbon isotope discrimination, O¹⁸ analysis and SPAD meters).

Adoption of project outputs (varieties) by farmers through a farmer-participatory approach.

The promising varieties generated in the ACIAR project are being evaluated using a farmer-participatory model in Andhra Pradesh, Gujarat, Maharashtra and Orissa states under an ICRISAT–NRCG project commissioned by the Government of India. These farmer-participatory trials resulted in identification by growers of four improved varieties (ICR3, ICR4, JAL42, JUG 16) based more on better yield and quality performance than local checks. Farmers are undertaking seed increase of these varieties for further large-scale adoption in Gujarat and Andhra Pradesh.

Release of promising genotypes to growers for adoption under state-sponsored schemes

Collaborating universities (particularly Acharya N.G. Ranga Agricultural University (ANGRAU), Andhra Pradesh and Mahatma Phule Krishi Vidyapeeth, Maharashtra) have pursued further selection and release of the material developed in the project using funds from state-sponsored schemes. As a result, ANGRAU released a new variety TIR 25 (‘Abhaya’) in Andhra Pradesh in 2006, which it expected would cover large areas in the Chittoor district of Andhra Pradesh in the following 2 years. In the state of Maharashtra, a variety (JALW 02) is at pre-release stage. These releases represent an intermediate step before adoption of outputs by end users.
**Variatel release through the national network system—All India Coordinated Research Project (Groundnut)**

In order to disseminate the project outputs (varieties) to wider peanut-growing regions throughout India, the national network program (i.e. the All India Coordinated Research Project (Groundnut)) initiated a series of national drought nursery trials during 2004, in which a number of drought-resistant lines, including the varieties developed in the ACIAR project, were evaluated at 11 drought-prone sites throughout India. As a result of these trials, four varieties (ICR 24, ICR 48, ICR 09) developed in the ACIAR project have been selected for further evaluation in advanced varietal trials in 2009, followed by possible release at the national level.

**Impact—the difference the project has made or is expected to make**

In India, the impact of the project was evident by (a) continued adoption of selection tools for drought-resistance traits (particularly for TE) in peanut-breeding programs, (b) further selection and rapid dissemination of promising varieties to farmers through a farmer-participatory approach and the national and state network systems, (c) adoption of trait-based selection approaches by other food and plantation crop breeding programs and (d) enhanced ability and expertise of scientists to apply for and access large external-funding grants to pursue trait-based selection programs, including the search for molecular markers for drought-resistance traits in peanut and other crops.

Some major project impacts during the post-project phase have included the release of one variety (TPT 25) in 2007 in Andhra Pradesh, identification of a variety (JALW 02) for release in Maharashtra state, further identification of four drought-resistant genotypes (ICR 24, ICR 48, ICR 09) using a farmer-participatory approach for possible release in the states of Gujarat, Andhra Pradesh and Orissa, and possible release of one or two genotypes in 2008 at the national level under the All India Coordinated Research Project (Groundnut).

In Australia, this project has introduced a range of elite germplasm from India having high levels of drought-resistance traits (T, W and HI) as well as very early maturity, the latter assisting attainment of the project’s additional objective of drought avoidance.

The project also resulted in improved understanding of the major traits associated with drought resistance in peanuts and development of ‘easy-to-use’ surrogate tools to select for these traits in the breeding programs. The Australian peanut-breeding program at Kingaroy has also used the Indian introductions and other germplasm, in conjunction with selection tools and drought-resistance breeding knowledge, in a rapid backcrossing program to introgress the high oleic fatty acid gene over the past 6 or so years.

The project has led to release in Australia of two drought-resistant peanut varieties (Walter and Middleton) for the Australian program. Although Walter was intended for use in dryland regions of Burnett, it is rapidly gaining ground in coastal cane-farming systems due to its shorter duration characteristics, which allow growers to return to the cane-cropping cycle up to 4 weeks earlier than with conventional varieties.