In general, crop performance in terms of number of mature pods was better in the second date of sowing and ICGV 86031 and NCAc 343 were identified as tolerant and susceptible to high temperature stress, respectively (Table 1). The HI declined drastically in all the culivars, irrespective of date of sowing and locations; for example, HI was only 0.28 in TKG 19A in first date of sowing at Hanumangarh. Such a low HI was mainly due to greater reduction in number and size of the reproductive sink than the vegetative mass. Several advanced breeding lines developed at Hanumangarh and Durgapura such as RS 1, RGs 332, 335, 337, 340, and 280, and DRGs 101, 102, and 103 were included as local checks. In general, these lines performed better than other lines and RG 335 gave highest pod yield (419 g $m^{-2}$) in first date of sowing at Durgapura. DRG 101 and RS 1 were also among the high pod yielding lines at Durgapura in the second date of sowing (Table 1). Thus the genotypes with less number of pegs may be considered susceptible for high temperatures during the pollination phase, whereas the genotypes with higher number of mature pods and mass may be considered as tolerant to high temperature both during pollination and pod development phase.

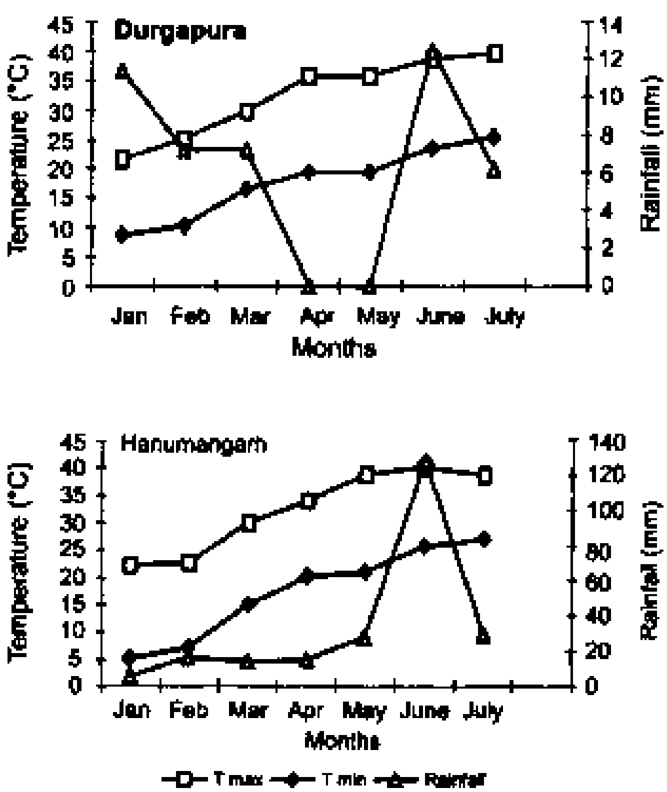


**Figure 1. Weather parameters during groundnut crop growth period at Durgapura and Hanumangarh in Rajasthan, India, 1996 summer season (February-July).**

Pod yield, in general, was high in some genotypes irrespective of locations and dates of sowing [specific leaf area (SLA) (cm $g^{-1}$) is given in parentheses for each genotype]: TKG 19A (170), CSMG 84-1 (185), Kadiri 3 (205), ICGV 86031 (140), ICGS 76 (145), and TG 22 (150). The SLA of some of these genotypes, when compared with others like ICG 476 (210) and ICG 4747 (201) showed that except Kadiri 3 all the genotypes fall in the medium and low SLA group, i.e., thicker leaves. Also, ICGS 76 was found to be tolerant to high temperature on the basis of studies conducted on leaf membrane thermostability at the National Research Centre for Groundnut (NRCG), lunagadh, Gujarat, India. We feel there is a need to study the relationship between SLA and high temperature tolerance and if such relationship is discovered then it would be easier to identify heat tolerant genotypes. The genotypic variations may also be exploited to enhance genetic resources for high temperature tolerance.

## More Efficient Breeding of Drought Resistant Groundnut in India and Australia

**GC Wright[1], Nageswara Rao Rachaputi[1], SN Nigam[2], and MS Basu[3]**(1. Queensland Department of Primary Industries (QPDI), Kingaroy, PO Box 23, Qld 4610, Australia; 2. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India; 3. National Research Centre for Groundnut (NRCG), PB no. 5, Junagadh 362 001, Gujarat, India)

The yield of groundnut *(Arachis hypogaea)* in India and Australia is usually severely constrained by drought during crop growth, arising from unpredictable rainfall combined with high evaporative demands and production on low water-holding capacity soils where they are grown. The breeding of more drought resistant genotypes has been a long-term goal of groundnut improvement research in the Indian Council of Agricultural Research (ICAR), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India, and Queensland Department of Primary Industries (QDPI), Australia.

New opportunities to develop higher yielding drought tolerant groundnut genotypes emerged in the Australian Centre for International Agricultural Research (ACIAR)-funded project on "Selection for water-use efficiency (VVUE) in Food Legumes" (PN 9216) implemented in India during 1993-98, which developed a detailed understanding of the physiological factors determining yield in water-limited environments (Wright and Nageswara Rao 1994, Wright et al. 1996). A simple crop analytical model has been used to analyze pod yield variation under water limited conditions into three functional components following the framework proposed by Passioura (1977):

Pod yield = Water transpired (T) x Water-use efficiency (TE) x Harvest index (HI)

A major outcome of this project was the development of economical, rapid, and easily measured surrogate measurable for each of these traits, thus allowing their potential quantification in large numbers of germplasm and breeding populations.

Plant breeders and crop physiologists now believe more rapid progress can be aided by *a priori* knowledge of the physiological basis of crop performance under drought conditions. This strategy involves the breeding of better adapted and higher yielding cultivars by identifying reliable traits of drought tolerance to complement conventional breeding programs. This knowledge, the germplasm sources, and enthusiastic team spirit as well as continued support from ACIAR, ICAR, and ICRISAT provided an excellent opportunity for development and implementation of another follow-up ACIAR-funded project (CS 97/114) "More Efficient Breeding of Drought Resistant Peanuts in India and Australia" during 1997-2000 in India and Australia. This project involved collaboration between research centers of the All India Coordinated Research Project (AICRP), agricultural universities in India, ICRISAT, and QDPI (Table 1).

The project CS 97/114 was aimed to implement and apply the physiological knowledge generated in the previous project to test whether indirect selection using the trait approach can improve the efficiency of selection for drought resistance in large-scale groundnut breeding programs, involving breeders, physiologists, and modelers in a truly collaborative research program.

## Specific Objectives of the Project

1. To develop more efficient screens and selection methods for yield component traits through better physiological understanding, and giving special attention to the soil-plant analyses development (SPAD) chlorophyll meter readings (SCMR).
2. To make crosses involving parents identified for high TE, T, and HI as well as combining them in the background of locally adapted varieties, then evaluate and validate the use of physiological selection traits to achieve superior yield performance in appropriate target environments in both Australia and India.
3. To make a quantitative assessment of the cost-benefit of using indirect selection methods compared to conventional yield selection approaches for the identification of drought resistant groundnut cultivars.

## Project Implementation and Progress

The breeding and selection program was implemented at four centers in India [ICRISAT, Patancheru; National Research Centre for Groundnut (NRCG), Junagadh; Oilseeds Research Station, Jalgaon; and Regional Agricultural Research Station, Tirupati] and at one center in

**Table 1. Partners involved in the ACIAR-funded groundnut project.**

| Institution | Personnel |
|---|---|
| **Australia** | |
| Queensland Department of Primary Industries<br>Farming Systems Institute<br>PO Box 102<br>Toowoomba<br>Qld 4680 | Dr GC Wright<br>Dr Rao CN Rachaputi (RCN)<br>Mr AL Cruickshank<br>Mr R Strahan<br>Mr J Page<br>Mr D Fresser |
| **India** | |
| International Crops Research Institute for the Semi-Arid Tropics<br>Patancheru 502 324<br>Andhra Pradesh | Dr SN Nigam<br>Dr S Chandra<br>Dr HS Talwar<br>Mr B Manohar<br>Ms K Sridevi Rupa |
| All India Coordinated Research Program (AICRP) on Groundnut<br>National Research Centre for Groundnut (NRCG)<br>PB no. 5<br>Junagadh 362 001<br>Gujarat | Dr MS Basu<br>Dr A Bandyopadhyay<br>Dr RK Mathur<br>Dr Manivel |
| Regional Agricultural Research Station<br>Acharaya NG Ranga Agricultural University<br>Tirupati 517 502<br>Andhra Pradesh | Dr PV Reddy<br>Dr RP Vasanthi |
| Agricultural Research Station<br>Acharaya NG Ranga Agricultural University<br>Anantapur 515 001<br>Andhra Pradesh | Dr T Yellamanda Reddy<br>Dr S Vasundhara |
| Oilseeds Research Station<br>Mahatma Phule Krishi Vidyapeet<br>Jalgaon 425 001<br>Maharashtra | Dr MP Deshmukh<br>Dr RB Patil |
| Regional Research Station<br>Tamil Nadu Agricultural University<br>Vriddhachalam 606 001<br>Tamil Nadu | Dr SE Naina Mohammed<br>Dr Vindhiya Varman |
| Agricultural Research Station<br>AICRP on Groundnut<br>Durgapura<br>Jaipur 302 018<br>Rajasthan | Dr SN Sharma<br>Dr KN Sharma |
| Maharana Pratap University of Agriculture and Technology<br>Udaipur 313 001<br>Rajasthan | Dr AK Nagda |
| University of Agricultural Sciences<br>GKVK Campus<br>Bangalore 560 065<br>Karnataka | Prof M Udayakumar<br>Dr MS Sheshshayee<br>Dr H Bindu Madhava |

Australia (QDPI, Kingaroy) during 1997-99. The selected progenies were evaluated during 2000-2001 seasons at 8 locations in India and 6 locations in Australia.

The project has made significant progress in several areas, and highlights of outputs to date are summarized below:

More efficient screens and selection methods for yield component traits:

The current project assessed the possible application of a hand-operated portable SPAD-chlorophyll meter in assessing specific leaf area (SLA), specific leaf nitrogen (SLN), and TE in pot culture and field experiments. The results have shown that when protocols for leaf sampling and SLA measurements were followed, SCMR can be a very effective surrogate measure of SLA and hence TE in groundnut genotypes (Nageswara Rao et al. 2001). Further studies at the University of Agricultural Sciences, Bangalore, India have reconfirmed these findings by establishing strong relationship between SCMR, TE, and carbon isotope discrimination (Sheshshayee et al., in press).

Evaluation and validation of the use of physiological selection traits to achieve superior yield performance in appropriate target environments in both Australia and India:

- Parents identified in the previous Project (PN 9216) have been used to make bi-parental crosses; crosses of these with locally adapted varieties were made in the four breeding centers in India and in the breeding program in Australia.
- The trait-based selection method used "Selection Index" as a criterion to identify progenies with high levels of desired traits (T, TE, and HI) as well as seed yield (Chandra et al., unpublished), whereas in the empirical method conventional selection methods were used.
- Overall, there was no difference between empirical and physiological trait-based selection in development of higher yielding genotypes in either India or Australia. However, trait-based selection retained high-yielding progeny that also had higher transpiration efficiency; i.e., trait-based selection retained useful genotypes that would have been discarded with conventional empirical selection.
- In India, progenies have been developed that are significantly higher yielding than locally adapted varieties in each of the main groundnut growing regions of India in both rainy (rainfed) and postrainy (irrigated) seasons.
- In Australia, some short-season progenies with very low aflatoxin levels in drought environments and a few other progenies with high blanchability (a desirable quality attribute) have been identified.

Cost-benefit analysis of using indirect selection methods compared to conventional yield selection approaches:

An economic scenario analysis of the benefits of the ACIAR research project in developing elite groundnut genotypes showed that the adoption (25% after 10 years) of a variety with an average yield advantage of 137 kg $ha^{-1}$ seed over the best local check variety, would yield economic benefits equivalent to a net present value of Rs 7197 million (Australian $ 287 million) in 10 years after release of the variety in India.

A similar analysis with elite groundnut genotypes with the yield advantage of those identified in the Indian research component (e.g., 20% yield benefit over local checks) in Australia showed that the adoption (25% after 10 years) would yield economic benefits equivalent to a net present value of Australian $ 4.8 million in 10 years after release of the variety in country.

## Review Report

The project has concluded with the final review meeting held during 25-27 February 2002, at ICRISAT, India. The review team members were Dr Ray Shorter, CSIRO Plant Industry, Brisbane, Australia, and Prof. Arumugakannu Narayanan, Emeritus Scientist (ICAR), Sugarcane Breeding Institute (SBI), Coimbatore, India.

A few excerpts from the Review Report follow:

"The Project Leaders have developed a very strong cooperative and collaborative culture among research managers from the participating institutions and scientists in both countries engaged in Project activities. Project management has been effective in ensuring that financial and human resources were available to undertake the agreed research activities in ICAR, ICRISAT, and collaborating universities in India, and in QDPI in Australia."

"There have already been significant capacity building and scientific impacts from the Project: skills of Indian scientists have been enhanced through numerous training activities, additional infrastructure has been made available particularly in India, and scientific knowledge of the physiology and breeding of peanut for adaptation to drought has been advanced. There are significant potential community impacts that will be realised when genotypes developed in the Project with, on average, 20% higher yields than local checks in India are released and adopted by Indian farmers."

"Overall the Project has competently addressed the three objectives as specified in the Project proposal. However some additional data analysis is required to fully extract valuable information from the Project results and so enhance the benefits of the Project for continuing peanut breeding and research activities in both countries."

The outputs from the project and the proceedings of the final review meeting are soon to be published as an ACIAR Technical Report.

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## Performance of Introduced Medium-duration Groundnut Genotypes in Eastern Sri Lanka


**Kumuthini D Harris and V Arulnandhy** (Faculty of Agriculture, Eastern University, Chenkalady, Sri Lanka)


Although groundnut {*Arachis hypogaea)* is a minor crop in Sri Lanka, there is good scope to increase its cultivation in the country. Currently, it is grown on 9896 ha with a production of 5912 t. The average national productivity is 597 kg ha[1] (FAO 1996). Because of its low yield, farmers do not embark on its large-scale cultivation. The primary reason for low yield in Sri Lanka is the non-availability of suitable varieties for cultivation. Therefore, the Eastern University located at Chenkalady in eastern Sri Lanka has been testing groundnut varieties through a collaborative