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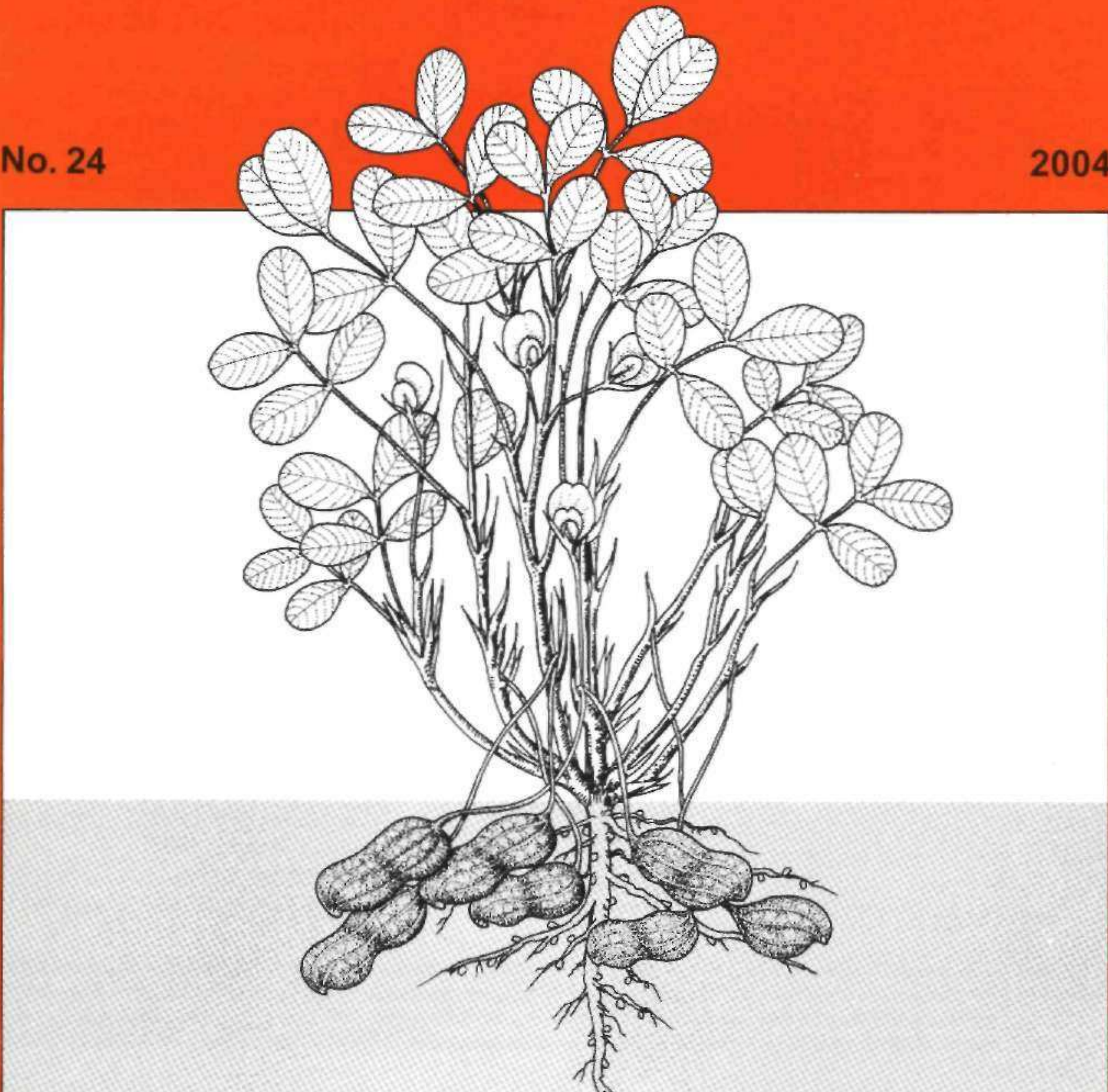

International *Arachis* Newsletter (IAN)

Co-publishers

Peanut CRSP
Peanut Collaborative Research Support Program
(www.griffin.peachnet.edu/pnutcrsp.html)

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
(www.icrisat.org)

About Peanut CRSP

The Peanut Collaborative Research Support Program is an international program supported by USAID Grant LAG-G-00-96-00013-00 to The University of Georgia. The research supported seeks environmentally sound, sustainable agriculture production and food delivery systems for peanut. The program has five thrusts addressing priority constraints to the global peanut industry (aflatoxin, production efficiency, socioeconomic forces, postharvest processing, and utilization). Peanut CRSP also works to foster human resource development and the communication of research results.

The Peanut CRSP provides support for collaborative research, training, and exchange of information through grants to 14 universities in USA linked to 15 host countries in the developing world. Both host countries and USA are expected to benefit from the activities of Peanut CRSP. Peanut CRSP actively collaborates with other organizations with interest in advancing development through the application of science and technology.

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political, international organization for science-based agricultural development. ICRISAT conducts research on sorghum, pearl millet, chickpea, pigeonpea and groundnut - crops that support the livelihoods of the poorest of the poor in the semi-arid tropics encompassing 48 countries. ICRISAT also shares information and knowledge through capacity building, publications and ICTs. Established in 1972, it is one of 15 Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

IAN Scientific Editor

SN Nigam

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News and Views

From the Editor

Dear Readers,

Let me first welcome you to LAN 24. Our efforts to bring this issue out as per schedule were successful this time. I hope you will enjoy reading it and find the information contained in various articles useful. We received 36 contributions to this issue. Of these, only 25 were found acceptable for inclusion, in some cases after a thorough review. A few contributors failed to submit their revised manuscripts even after repeated reminders. I urge the contributors to read the information given for IAN contributors on the inner back cover of this issue very carefully. All contributions should conform to the guidelines given therein. A careful preparation of your contribution will avoid a lot of back and forth correspondence and follow up and will enhance the acceptability of your submission. The last date for submission of contributions for 2005 is 31 August. I solicit your cooperation in improving the quality and timely publication of IAN. You will find a detachable survey form attached to this Newsletter. Please do not forget to complete it and return it to us. You can also respond electronically. Your feedback will help us to develop a suitable strategy to sustain the publication of newsletters by ICRISAT and improve their quality further. Also, please see another form on the last page of this issue seeking your interest in IAN. To receive future issues of IAN, you are requested to return this form promptly or respond electronically.

I seek more contributions to IAN from the scientists of Africa and the Americas and also from the private sector and farmers. The farmer-scientist-private sector partnership is essential to promote and expand the horizon of groundnut crop in the world.

I would like to acknowledge R Aruna, P Lavakumar, S Pande, P Parthasarathy Rao, GV Ranga Rao, TJ Rego, P Singh, V Vadez, F Waliyar (ICRISAT, Patancheru, India); Devi Dayal, T Radhakrishnan [National Research Centre for Groundnut (NRCG), Junagadh, India]; Rao CN Rachaputi (Department of Primary Industries and Fisheries, Kingaroy, Australia); Shashi Sharma (Department of Agriculture, South Perth, Australia); and AK Singh [National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India] who reviewed IAN articles and the Library at ICRISAT for compiling SATCRIS listing.

I wish you the best in all your endeavors in research, development and promotion of groundnut in the world.

SN Nigam

The New CLAN

The Cereals and Legumes Asia Network (CLAN) was formed in 1992 by merging the erstwhile Asian Grain Legumes Network (AGLN) and Cooperative Cereals Research Network (CCRN). CLAN hosted by ICRISAT has been operating in Asia for the past 12 years, with members from 13 countries. CLAN is an effective and successful agricultural research and development (R&D) network in the Asia-Pacific region.

There is a continuous need for improving income and nutrition of the poor people in developing countries and to increase productivity (15-20%) and area (10-15%) under legumes in both irrigated and rainfed cropping systems in Asia. There is also a need for enhanced regional coordination for enhanced R&D for food legumes and crop diversification and poverty reduction in Asia.

Food legumes are considered as 'secondary' crops, and do not get adequate funding support for R&D nationally. Concern was expressed at various regional forums on the need for regional coordination of R&D, with technical backstopping from international agricultural research centers (IARCs) or strong national programs in the Asia-Pacific region. Asia-Pacific Association of Agricultural Research Institutions (APAARI) took the initiative and debated the issue at the third APAARI Executive Committee Meeting held on 3 February 1996 in New Delhi, India and recommended that CLAN should be expanded to include other major legumes in Asia.

The strongest recommendation for concerted regional effort to facilitate regional R&D of major food legumes was made at the APAARI General Assembly Meeting held in Penang, Malaysia during 2-4 December 2002. The APAARI General Assembly recommended that lentil [International Center for Agricultural Research in the Dry Areas (ICARDA) mandate crop] and mung bean [Asian Vegetable Research and Development Center (AVRDC) mandate crop] should be included in CLAN.

It was suggested that ICRISAT, ICARDA and AVRDC provide the necessary technical and financial backstopping to CLAN. APAARI also indicated its support to the network through financial support for coordination and capacity building in APAARI member countries.

The three IARCs namely ICRISAT, Patancheru, India; AVRDC, Shanhua, Taiwan; and ICARDA, Aleppo, Syria agreed to request APAARI, to include lentil and mung bean as additional legume crops of CLAN, for coordination of regional R&D of CLAN mandate crops and related natural resource management research in Asia.

At the seventh CLAN Steering Committee meeting held at ICRISAT, Patancheru, 10-12 November 2003, partners stressed the need for enhancing the scope of CLAN and endorsed the inclusion of mung bean and lentil in addition to sorghum, pearl millet, chickpea, pigeonpea and groundnut. The overall objective of the 'New CLAN' is to support, coordinate and facilitate research collaboration and technology exchange involving CLAN mandate crops and their resource management among NARS scientists in Asia. The ultimate goal is to improve the well being of the Asian farmers by improving production and productivity of these crops.

Dr NB Singh (Assistant Director General, Indian Council of Agricultural Research) is the Chairperson for 2004-05. The enlarged CLAN will be co-facilitated by ICRISAT, ICARDA and AVRDC. ICRISAT will be the nodal institution to host CLAN Coordination Unit, in consultation with partner IARCs.

Contributed by: CLL Gowda
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Scientists Honored for Groundnut Technology

Three scientists of Acharya NG Ranga Agricultural University (ANGRAU), Andhra Pradesh, India, T Yellamanda Reddy (Principal Scientist (Dryland Agriculture), Agricultural Research Station (ARS), Anantapur], D Balaguravaiah [Principal Scientist (Water Management), ARS, Garikapadu, Krishna District] and Y Padmalatha [Senior Scientist (Agronomy), ARS, Reddipalli, Anantapur District] received the Vasant Rao Naik Award for Research Application in Agriculture in 2003 for significant contributions of the project "Development and transfer of improved dryland technology for higher economic returns". The project was implemented at ARS, Anantapur. It was also implemented in the watershed villages of Nusikottala and Pampanur in Anantpur district. The project generated significant outputs which were recommended by ANGRAU. Suitable contingency crops were identified for late onset of monsoon and to replace normal-sown groundnut. Application of sand at 40 t ha^{-1} to hard-setting sandy loam soils of groundnut increased infiltration.

A systematic soil survey for nutrient status of farmers' fields of the district revealed that there was 30% phosphorus build-up and depletion of available potassium up to 25%. Soil test based fertilizer application was developed for groundnut crop to reduce cost of cultivation. This technology was tried in farmers' fields for over 3 years in 75 farmers' fields.

During the crop season prolonged dry spells and terminal droughts are very common in the district. Due to moisture stress, shelling outturn and test weight of groundnut are greatly affected resulting in high proportion of small and shriveled seeds in the produce of the farmers for undertaking sowing during the succeeding/following season. But farmers of the district think that such type of seed is unfit for sowing and sell away the produce immediately after harvest of the crop at low price (Rs 12.50 kg^{-1} pods) and buy new seed at high cost (Rs 20 kg^{-1} pods). This increases the cost of cultivation as seed is a costly input in groundnut cultivation constituting 30% of cost of cultivation of groundnut. Studies on use of small and shriveled seeds were quite encouraging and were accepted by the farming community. Thus the cost of cultivation was reduced and high net returns were obtained.

In addition to the generation of economically viable and easily adoptable technology, the efforts made in transferring the same by adopting the innovative extension methodologies through action learning techniques, focus group interactions, large number of on-farm demonstrations and training programs carried out across the district proved successful in percolating the technology.

Groundnut Genomics Workshop

With support from the Oil Crops Research Institute (OCRI) of the Chinese Academy of Agricultural Sciences (CAAS), a workshop on groundnut genomics was held during 18-19 May 2004 in Wuhan, China. Groundnut scientists from major institutions for groundnut improvement in China, namely Shangdong Peanut Research Institute, Guangdong Academy of Agricultural Sciences, Henan Academy of Agricultural Sciences, Fujian Agricultural University and OCRI attended the workshop. Corley Holbrook and Baozhu Guo from Tifton, USA and specialists on plant genomic research from China also participated in the workshop. Fifteen presentations covering various aspects were delivered. After discussion, aflatoxin resistance, resistance to diseases, quality traits and germplasm assessment were determined as key traits to be addressed by genomic approaches. Issues related to formation of an international groundnut genomics committee and the next workshop were also discussed. Liao Boshou, Coordinator of the workshop, also gave a report of the workshop to ICR1SAT during an ADB-project review meeting in July 2004 for further coordination.

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International Peanut Conference

The Fifth International Peanut Conference on Prospects and Emerging Opportunities for Global Peanut Technology will be held from 9 to 13 January 2005 at Kasetsart University, Bangkok, Thailand. The Conference is organized by Kasetsart University, USAID Peanut CRSP, University of Georgia, Khon Kaen University, Department of Agriculture and Department of Agricultural Extension, Thailand. Experienced scientists and marketing personnel from Asia, Australia, Pacific, South and North America, Europe and Africa will present developments in groundnut production and utilization technologies from their unique perspectives. The topics proposed to be covered are: economics and marketing; production and breeding; postharvest handling; aflatoxin; health, nutrition, functional foods and allergy; utilization; and impact assessment of groundnut. The Conference will be a platform for participants to exchange information and have an insight into technology application worldwide, in order to enable the successful development, production and marketing of groundnut products for the improvement of health and quality of life. The deadline for submission of abstract and paper is 12 November 2004. For more details contact: Penkwan Chompreeda, Peanut SATT Center, Kasetsart Agricultural and Agro-Industrial Product Improvement Institute (KAPI), Kasetsart University, Bangkok, Thailand (email: peanutsatt@ku.ac.th).

News from West Africa

Market prospects for groundnut in West Africa

A study on market prospects for groundnut in West and Central Africa was commissioned by ICRISAT, with support from the Common Fund for Commodities (CFC). The study was implemented in Africa, Europe and USA from 16 June to 15 December 2003. The findings were presented at the First Regional Planning and Steering Committee Meeting of the Groundnut Seed Project in Bamako, Mali. The main conclusion was that aflatoxin is the major problem for groundnut marketing. It is also a major public health issue in this region. The report will be published in both English and French and widely distributed in groundnut producing countries in West Africa.

First regional meeting

The first meeting of the Regional Steering Committee of the Groundnut Seed Project was held at ICRISAT, Bamako during 2-4 March 2004. Representatives of ICRISAT, participating NARS of Mali, Niger, Nigeria and Senegal, the African Groundnut Council (AGC), the West and Central Africa Council for Agricultural Research and Development (CORAF/WECARD) and representatives of farmers' associations, private sector (Olga Oil, Niger) and seed networks (ASN) participated in the meeting. Representatives of the supervisory body, FAO and CFC attended as observers. This meeting was preceded by the planning meeting with the National Project Coordinators to harmonize activities.

ICRISAT and IER Groundnut Improvement team honored

ICRISAT honored the Groundnut Improvement team of ICRISAT and the Institut d'Economie Rurale (IER), Mali with the Doreen Mashler Award 2004 for the outstanding contribution towards building better livelihoods for farmers through improving groundnut production in Mali. The ICRISAT team included F Waliyar (Plant Pathologist), BR Ntare (Breeder) and J Ndjeunga (Economist), while the IER team included O Kodio (Agronomist/Breeder) and B Diarra (Aflataoxin Specialist).

Training on impact assessment

A training workshop on Impact Assessment of Agricultural Technologies in West Africa was held at ICRISAT, Bamako from 12 to 17 July. J Ndjeunga and BR Ntare organized the workshop which was sponsored by the CFC and ICRISAT's Global Theme - SAT futures. A total of 17 participants from ICRISAT and NARS of Burkina Faso, Mali, Niger, Nigeria and Senegal attended the workshop.

The general objective of the workshop was to provide an overview and hands on use of economic surpluses and econometric approaches framework for economic impact assessment. The specific objectives were to: (i) provide workshop participants methods and models used for carrying out economic impact assessment based on the SL (Session Leader) framework; (ii) identify strategies to build and/or strengthen partnerships and information sharing between agricultural research institutions in West and Central Africa; and (iii) help participants develop relevant impact assessment studies in West and Central Africa. The first series of studies will focus on groundnut technologies.

The Groundnut Seed Project launches a website

William D Dar, Director General, ICRISAT launched the Groundnut Seed Project website. It can be accessed on http://www.groundnutseedproject.org.

Contributed by: BR Ntare
ICRISAT
Bamako, Mali

Groundnut Development in Eastern and Southern Africa

In Malawi a major initiative has been started by the National Smallholder Farmers' Association of Malawi (NASFAM), with technical backstopping from ICRISAT and the Department of Agricultural Research and Technical Services, to reestablish the country as a premium exporter of confectionery groundnuts. Marketing research in the United Kingdom and the Republic of South Africa has identified the type of seed that is required in these respective markets and the quality standards that have to be met - most notably maximum allowable levels of aflatoxin. To take advantage of these opportunities breeder and foundation seed of the improved medium-duration varieties CG7 and ICGV-SM 90704, and the short-duration variety ICG 12991 have been bulked with pre-financing from a seed revolving fund. In 2003 a commercial seed company agreed to purchase 50 tons of foundation seed for further multiplication after discussions were negotiated by ICRISAT between partners who are working with farmers to establish better market linkages. Coordinated action by private sector players to address the seed supply constraint is a new strategy for Malawi, but the importance of good quality seed to meet the stringent market requirements has led to a breakthrough in overcoming the seed supply bottleneck that was a major constraint to improving quality.

Although CG7 has been released for several years (in 1990), its susceptibility to groundnut rosette is leading to its replacement by the rosette resistant variety ICGV-SM 90704 as there is always a risk that farmers and development agencies will take seed of this variety to areas where rosette is endemic. The rosette resistant short-duration variety ICG 12991 is similarly replacing older varieties such as JL 24 that are susceptible to rosette. Market research has determined the suitability of these new varieties for confectionery purposes and the excellent collaboration that now exists between researchers, processors and producers bodes well for the future of the groundnut industry in the region.

Contributed by: RB Jones
ICRISAT
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Groundnut Varieties Identified by the PMIC

Four early-maturing, high-yielding groundnut varieties were identified by ICRISAT's Plant Materials Identification Committee (PMIC) for use as improved lines. ICGV 93437. an early-maturing, high-yielding variety performed well and was released in 1999 as Nyanda in Zimbabwe. ICGV 93437 has shown good adaptability to the drier environments in Zimbabwe. It is also capable of producing high yields in areas of moderate rainfall and under irrigation. In Zimbabwe, ICGV 93437 *produced* 13.5% more pod yield than the local control cultivar Falcon in 51 trials during 1996/97 to 2000/01. ICGV 93437 matures in 85-90 days after sowing (DAS), 10 days earlier than the popular early-maturing cultivar JL 24, in the rainy season at ICRISAT, Patancheru. At 1240°Cd (equivalent to 75 DAS in the rainy season at ICRISAT, Patancheru) harvest, ICGV 93437 produced 29.8% more pod yield than JL 24 and 48.1 % more than Chico, an early-maturing germplasm line. At 1470°Cd (equivalent to 90 DAS in the rainy season at ICRISAT, Patancheru) harvest, the pod yield superiority of ICGV 93437 was 13.1 % over JL 24 and 47.8% over Chico. Increase in pod yield at 1470°Cd harvest over 1240°Cd harvest in ICGV 93437 was 26.1% compared to 44.6% in JL 24 and 26.4% in Chico. Low increase in pod yield in ICGV 93437 reflects its inherent early-maturity compared with JL 24.

ICGVs 96466, 96468 and 96469 are early-maturing, large-seeded and high-yielding varieties. They can be used as improved breeding lines in programs targeting areas where growing season is short and seed size is an important consideration. ICGVs 96466,96468 and 96469 mature in 100 DAS, similar to the popular early-maturing control cultivar JL 24, in the rainy season at ICRISAT, Patancheru. Seeds are tan colored and at 1605°Cd (equivalent to 100 DAS in the rainy season at ICRISAT, Patancheru), 100-seed mass was 54 g in ICGV 96466,62 g in ICGV 96468 and 49 g in ICGV 96469 compared to 45 g in JL 24 and 62 g in Somnath. At 1470°Cd harvest at ICRISAT, Patancheru, ICGVs 96466, 96468 and 96469 produced on average 3.9-18.8% more pod yield than the early-maturing large-seeded control cultivar JL 24 and 16.7-33.3% more than the medium-long duration large-seeded control cultivar Somnath. At 1605°Cd harvest, these lines, except ICGV 96466, produced 7.6-26.4% more pod yield than JL 24, and all except ICGV 96469 produced less yield than Somnath. The increase from 1470°Cd to 1605°Cd in pod yield, shelling outturn and 100-seed mass indicated early-maturing potential of these lines.

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Current ICRISAT Groundnut Research and Integrated Projects

Investor	Project title	Project coordinator	Grant (US$'000)	Duration
Australia/ACIAR	Improving yield and economic viability of peanut production in Papua New Guinea and Australia using integrated management and modeling approaches	HD Upadhyaya	14	Jul 2002-Jun 2005
Belgium	Towards sustainability of groundnut and cereal production in West Africa: management of peanut clump virus	F Waliyar	853	Mar 2000-Feb 2005
CFC	Development of sustainable groundnut seed systems in West Africa	F Waliyar BR Ntare	2,153	Apr 2003-Mar 2007
CGIAR/ICARDA/CAC	Germplasm enhancement for diversification and intensification of agricultural production	SN Nigam	24	2001-2004
CGIAR Global Challenge Program - HarvestPlus	Genetic engineering of groundnut for enhanced ß-carotene production to combat vitamin A deficiency in the semi-arid tropics	KK Sharma	95	2003-2004
IFAD	Farmer-participatory improvement of grain legumes in rainfed Asia	SN Nigam	1,300	Sep 2001-Sep 2005
India/ICAR/NATP	An integrated approach to control stem necrosis disease of groundnut	SN Nigam	30	2001-2004
India/Effem India Pvt Ltd	To promote collaborative research and related activites	F Waliyar	37	2003-2005
Norway/Development Fund	Enhancement of groundnut production in the non-traditional and dryland areas of Malawi for improved nutrition and poverty alleviation	M Siambi	43	2004
Philippines	Enhancing adoption of ICRISAT legume varieties and technologies in the Philippines	CLL Gowda	54	2004-2006
PLAN International	Collaborative project on groundnut and pigeonpea in Malawi	RB Jones M Siambi	155	2003-2005
Rockefeller Foundation	Market, technology and institutional innovations for improving food security and incomes of poor farmers growing grain legumes in Malawi and Mozambique	RB Jones	630	Oct 2002-Sep 2004
UK-DFID/CPP/NRIL	Aflatoxin contamination in groundnut in southern India: Raising awareness and transferring and disseminating technologies to reduce aflatoxin	F Waliyar	189	Apr 2003-Mar 2005
USA/University of Georgia (Peanut CRSP)	Support for regional workshop and publications	F Waliyar	61	2000-2006
USAID/TARGET	More bang for the research buck: Raising fanners' incomes through use of profitable grain legume technologies and better linkages to markets	RB Jones SN Silim	600	2002-2004
USAID/US Univ Linkages	Quantifying yield gaps and abiotic stresses in soybean- and groundnut-based production systems	P Pathak	90	2001-2004
USAID/US Univ Linkages	Comparative legume genomics: Translating progress in model systems for impacts in staple crops of the semi-arid tropics	JH Crouch	65	2004
USAID/NASFAM	Promoting growth in Malawi's groundnut and pigeonpea trade through technology and market improvement	M Siambi RB Jones	850	Jan 2004-Sep 2006
USAID/ABSPII (Sathguru/Mahyco)	TSV resistant oilseeds - Bio-engineered sunflower and peanut genotypes with resistance to tobacco streak virus	KK Sharma	23	May 2004-Oct 2005

Research Reports

Genetic Resources and Enhancement

Meiotic Study of Intersectional Hybrids between *Arachis hypogaea,* A. *duranensis* and A. *diogoi* with A. *glabrata*

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Wild species, which are compatible and closely related to cultivated groundnut *(Arachis hypogaea)* are diploid and are classified into section *Arachis.* The tetraploids in the genus *Arachis* are *A. hypogaea,* the cultivated groundnut, *A. monticola,* a wild species belonging to section *Arachis,* and *A. glabrata,* belonging to section *Rhizomatosae.* There are very few reports on intersectional hybrids between members of section *Arachis* and *A. glabrata* (Shen et al. 1995, Mallikarjuna 2002, Mallikarjuna and Sastri 2002). This article reports meiotic analysis of the hybrids between *A. duranensis* and *A. diogoi* (= *A. chacoense)* (section *Arachis)* and tetraploid *A. glabrata* and the backcross progeny of the hybrid between *A. hypogaea* and *A. glabrata.* It corroborates the assumption that one genome of *A. hypogaea* and the A genome of section *Arachis* is closely related to R genome of *A. glabrata.*

Immature flower buds of hybrids *(A. hypogaea* x *A. glabrata)* x *A. hypogaea, A. duranensis* x *A. glabrata* and *A. diogoi* x A. *glabrata* were fixed in Carnoy's II mixture (6:3:1 alcohol : acetic acid : chloroform) at 4°C for meiotic analysis. After 24 h in Carnoys's II, buds were transferred to Carnoy's I (3:1 alcohol: acetic acid). Buds were squashed and stained in 2% acetocarmine and meiotic analyses were made on suitable preparations. Pollen fertility counts were made on well stained pollen grains.

The details regarding crossability and introgression of DNA from *A. glabrata* into *A. duranensis, A. diogoi* and *A. hypogaea* have been dealt in detail by Mallikarjuna (2002). The hybrid between A. *duranensis* and A. *glabrata* was a triploid and had 8-11 bivalents with a mean of 10 bivalents per meiocyte (Table 1). Ten bivalents were observed in 30% of the cells analyzed. Formation of 10 bivalents could be due to the homology between the diploid genome (A genome) of *A. duranensis* and the R genome of A. *glabrata.* Trivalents were rarely observed. The occurrence of a mean of 9 univalents in the hybrid may be the non-homologous R chromosomes of A. *glabrata.*

Forty-eight percent of the pollinations formed pegs when A. *duranensis* x A. *glabrata* was pollinated with A. *hypogaea* pollen. Morphologically the hybrid had erect growth habit and resembled A. *hypogaea.* Flower buds had short hypanthium and flowers were pale yellow as seen in A. *duranensis.* Of the 485 pegs formed, 3 pods were obtained. Two of the pods had large but immature seeds and one pod had a mature seed. One BC_1 hybrid plant was obtained.

Triploid hybrid A. *diogoi* x A. *glabrata* was obtained when A. *diogoi* was crossed with A. *glabrata.* Bivalent formation in the hybrid ranged from 7 to 10 with a mean of 9 per meiocyte. The number of univalents ranged from 10 to 16 with a mean of 12 per meiocyte (Table 1). Both ring (4 per cell) and rod (6 per cell) bivalents were present. The occurrence of more number of rod than ring

Table 1. Chromosome configuration in the hybrids *Arachis hypogaea* (A) x *A. glabrata* (G), *A. duranensis* (D) x *A. glabrata* (G), *A. diogoi* (C) x *A. glabrata* (G), and (*A. hypogaea* x *A. glabrata)* (A X G) x *A. hypogaea* (A).

	A x G		D x G		C x G		(A x G) x A	
Chromosome association	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Pentavalent	0-1	0.04	0	0	0	0	0	0
Tetravalent	0-2	0.6	0	0	0	0	0-1	0.1
Trivalent	0-2	0.6	0-1	0.1	0	0	0-1	0.1
Bivalent	9-19	15.3	8-11	10	7-10	9	10-20	15
Univalent	1-12	05.0	8-18	9	10-16	12	9-14	11

bivalents and of 12 univalents in 30% of the cells showed that there was some restriction in chromosome pairing in the hybrid A. *diogoi* x *A. glabrata.*

Meiotic pairing in *A. hypogaea* was normal with 20 ring bivalents in more than 95% of the meiocytes analyzed. Although tetravalents (2.3 per cell), univalents (1.13 per cell) and occasionally univalents (0.2 per cell) are observed in *A. glabrata,* 20 bivalents in a cell was not an uncommon feature. Chromosome association in BC_1 hybrid *(A. hypogaea* x *A. glabrata)* x *A. hypogaea* was more stable than its F_1 hybrid (Mallikarjuna and Sastri 2002). Occurrence of 20 bivalents was rare in F_1 hybrid whereas 7% of the meiocytes analyzed showed the occurrence of 20 regular bivalents (Table 2) and regular anaphase separation of chromosomes. The number of bivalents in A. *hypogaea* x *A. glabrata* ranged from 9 to 19 with a mean of 9.8 ring and 5.5 rod bivalents. In the BC_1 hybrid the number of bivalents ranged from 10 to 20 with a mean of 11 ring bivalents and 4 rod bivalents. The occurrence of more number of ring bivalents in BC, hybrid showed greater homology compared to A. *hypogaea* x A. *glabrata.* This is an expected phenomenon as more of A. *hypogaea* chromosomes have had the opportunity to pair with the genome of A. *hypogaea* x *A. glabrata.* Hence, majority of the cells analyzed showed 14—15 bivalents per cell (Table 2). Only 4% of the cells analyzed showed bivalent formation of less than 13 per cell. Trivalents and tetravalents were more in A. *hypogaea* x A. *glabrata* than in its BC, hybrid (Table 1). The number of univalents in BC, was more than in A. *hypogaea* x *A. glabrata.* This may be due to preferential pairing of modified A genome of A. *hypogaea* x A. *glabrata* with A genome of A. *hypogaea* and non-homology between B genome of A. *hypogaea* and R genome of A. *glabrata* (Mallikarjuna and Sastri 2002). According to Stalker and Simpson (1995) one of the genomes of A. *hypogaea* (made up of A and B genomes) (Smartt et al. 1978) is related to the R genome of A. *glabrata.* Efforts to cross A. *batizocoi* and A. *ipaensis* (B genome species) with A. *glabrata* were not successful thus suggesting that A genome is closely related to R genome than the B genome.

Production of 15 bivalents in 23% of the meiocytes and more than 15 bivalents in 24% of the meiocytes in the hybrid (A. *hypogaea* x *A. glabrata)* x *A. hypogaea* show that there is some amount of homology between the genomes of A. *hypogaea* and the R genome of A. *glabrata.* The hybrid A. *duranensis* x *A. glabrata* had 10 bivalents in 30% of the meiocytes analyzed while the hybrid A. *diogoi* x *A. glabrata* had 10 bivalents in 50% of the meiocytes analyzed. These configurations can only be obtained when A and R genomes are closely related. Thus it further proves that A genome of section *Arachis* is homologous with R genome of A. *glabrata.* Crossing the hybrid A. *duranensis* x *A. glabrata* with A. *hypogaea* gave rise to the hybrid plant with 58% pollen fertility. This is possible only if the genome of the hybrid A. *duranensis* x *A. glabrata* has homology with the genome of A. *hypogaea.* Cytological information on close relationship between A and R genomes was lacking, which is provided by this study.

Table 2. Chromosome association in the backcross hybrid *(Arachis hypogaea* x *A. glabrata)* x *A. hypogaea.*

Chromosome association				No. of cells
II	I	III	IV	(%)
20	0	0	0	9(7)
19	2	0	0	4(3)
18	4	0	0	1(1)
17	6	0	0	1 (1)
16	8	0	0	16(12)
15	10	0	0	29 (23)
14	12	0	0	54 (43)
13	14	0	0	8(6)
11	11	1	1	2(2)
10	13	1	1	2(2)

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Premature Precocious Hybrid Embryo Development in an Interspecific Derivative between *Arachis hypogaea* and A. *cardenasii*

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Arachis cardenasii is a wild species from section *Arachis* to which cultivated groundnut *(A. hypogaea)* belongs. There are fifteen accessions of *A. cardenasii* in the genebank at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and all the accessions are natives of Santa Cruz state of Bolivia. The species in general has many desirable characters such as resistance to fungal foliar diseases (rust, late leaf spot, early leaf spot) and viral diseases (caused by tomato spotted wilt virus and peanut mottle virus). The accession ICG 11558 of A. *cardenasii* is the only source of resistance to peanut stripe virus (Prasad Rao et al. 1991).

Crosses between ICG 11558 and cultivated groundnut produced an average of 29% pods and 47% of the pods had small seeds which were physiologically immature. These pods did not germinate in vivo but when the embryos were dissected and cultured, they germinated in vitro. A total of 18 hybrid plants were obtained.

Pollen fertility in the F_1 hybrids ranged from 4 to 8%. Backcross between the hybrids and cultivated groundnut produced pegs in large numbers (68%) and 8% of the pegs formed pods. In one F_1 hybrid, backcross produced pegs but pod formation was not observed. Instead, when the pegs entered the soil, ovules germinated to form shoots. Well developed shoots emerged out of the soil. Pegs with shoots when placed on the surface of soil grew further and produced flowers. Flowers were tripped to encourage self-fertilization. Pegs were observed from these flowers too. Some of the pegs directly produced shoots instead of pods.

In a normal ovule, fertilization leads to the development of a pro-embryo (stage 1) having few cells. The pro-embryo becomes quiescent but the peg begins to grow by the activation of the intercalary meristem located at the base of the ovule (stage 2). The peg is positively geotropic and enters the soil after growing a few inches (stage 3) (Fig. la). Pod formation commences after the peg has entered the soil and then the pro-embryo (Fig. 1b) resumes cell division (stage 4) to form a mature seed.

In the pegs formed on the hybrid, growth of the embryo continued irrespective of peg growth. The embryos continued to grow and form shoots whether the peg was in the soil or not, foregoing the stages 3-4 (Fig. 1c-f). Shoots formed in the soil were white but when brought out of the soil these turned green. Many of these shoots set flowers and pegs. Microtomy of the pegs from hybrid plant showed the formation of multiple shoot buds at the peg tip instead of developing seeds. Some of the shoot buds had flower buds (Fig. 1g).

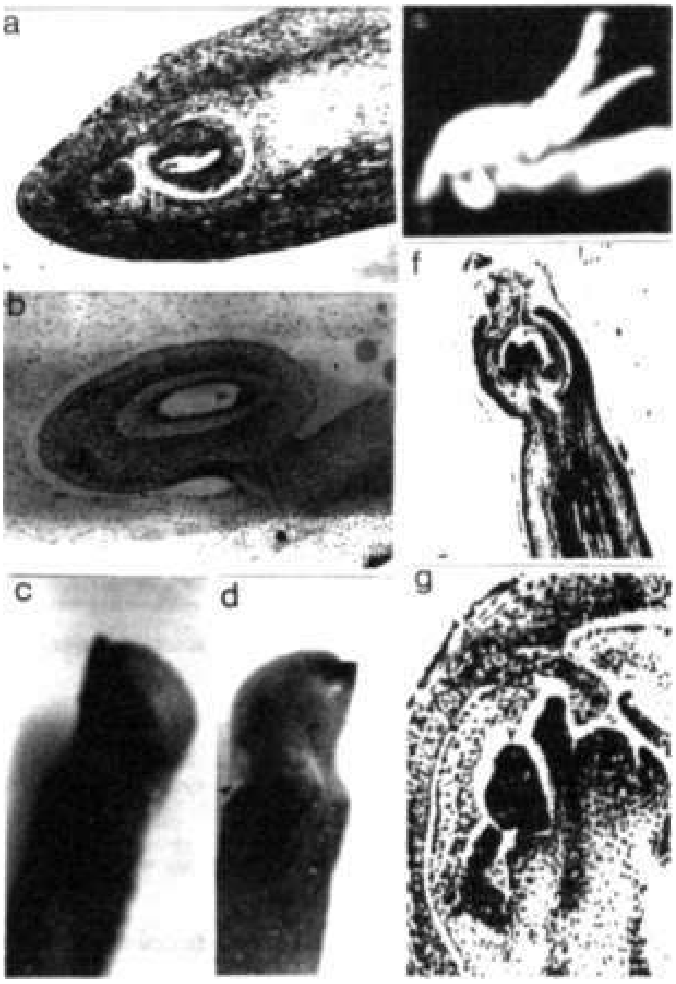

Figure 1. Precocious germination of ovules from the cross *Arachis hypogaea* x *A. cardenasii:* (a) Cross section of *A. hypogaea* peg tip at 15 days after pollination (DAP); (b) Cross section through a single ovule of A. *hypogaea* at 25 DAP (arrow points at the tiny embryo); (c) Swollen peg tip from the cross *A. hypogaea* x*A. cardenasii* at 20 DAP; (d) Swollen peg tip from the cross *A. hypogaea* x *A. cardenasii* at 22 DAP (arrow points at the shoot-like structures); (e) Well developed shoots emerged out of the peg from the cross *A. hypogaea* x *A. cardenasii;* (f) Cross section through the peg with shoots from the cross *A. hypogaea* x *A. cardenasii* at 25 DAP; (g) Close up of 'f' (arrow indicates presence of anther-like structures).

It will be of interest to check if precocious germination of hybrid pro-embryo is a heritable trait. Although such a phenomenon has been observed in interspecific crosses, only shoot buds were seen. But for the first time, it was observed that shoot buds produced flowers and pegs were formed. Sixty percent of the pegs formed shoots on this hybrid plant. The phenomenon of precocious germination of embryo can be exploited for rapid advancement of interspecific derivatives. Interspecific derivatives in general and those between *A. hypogaea* and *A. cardenasii* in particular take a minimum of 60 days for seed maturation and another 6 months for vegetative growth before the initiation of flowers. By the application of this method two generations can be obtained within 3 months thus completing the generation faster than ever achieved before.

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Screening Advanced Breeding Lines of Groundnut for Resistance to In Vitro Seed Colonization *by Aspergillus flavus*

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One of the serious food quality problems associated with groundnut *(Arachis hypogaea)* and its products is the aflatoxin contamination by *Aspergillus flavus* not only in the field but also during drying, storage and transit. Aflatoxin causes liver cancer in livestock as well as in human beings. Management of aflatoxin contamination requires both preventive and curative approaches throughout crop production during sowing, harvesting, processing and storage. Lack of single effective control measure further enhances the risk of aflatoxin contamination. Resistant variety is an essential component of any integrated disease management system and is considered as one of the viable and economic approaches to reduce aflatoxins in groundnut (Swindale 1989). This study was undertaken to screen a set of 30 advanced groundnut breeding lines (known to possess resistance to different stresses) for resistance to in vitro seed colonization by *A. flavus* (IVSCAF). Two entries TMV 2 (susceptible) and J 11 (resistant) were included as checks.

Sixty sound matured seeds (with intact seed coat) from each of the 30 entries were surface sterilized with 0.1 % aqueous solution of mercuric chloride for 2 min and washed twice with sterilized distilled water. Seeds were uniformly wounded by pricking with a sterile needle to facilitate the invasion by *A. flavus* (isolate Af 11-4) spores. Seeds were placed in a sterilized petri dish (9 cm diameter) and spray inoculated with *A. flavus* spore suspension at 1×10^6 spores ml^{-1} and incubated at 25± 1 °C under high humidity (>95% relative humidity) and in dark for 10 days. The experiment was conducted in two replications with 30 seeds per replication. Individual seeds were scored for surface colonization using 1-4 rating scale (Thakur et al. 2000) and the mean of two replications was expressed as colonization severity. Based on the reaction of genotypes to *A. flavus* seed colonization in the preliminary screening assay, nearly 67% of the genotypes showed susceptible reaction with high seed colonization comparable to the susceptible check TMV 2 (Table 1). Eleven genotypes showed low to moderate levels of seed colonization (<3) revealing their resistance to IVSCAF. Some genotypes show variable reactions in different assays (Bartz et al. 1978), necessitating repeated assays to select genotypes that show high degree of stable resistance.

Of the 11 genotypes, ten genotypes were assessed for the confirmation of resistance in four subsequent screening assays (Table 2). ICGV 87378 was not included in confirmation assays due to lack of seeds for testing. Six genotypes showed consistent reaction in all the four assays with seed colonization severity lower than or equal to J 11 (2.85). Among them, ICGV 86155 (1.20), ICGV 86699 (1.28) and ICGV 96266 (1.40) were significantly superior to the resistant check. ICGV 86699 also combines resistance to late leaf spot, rust, bud necrosis and iron chlorosis (Reddy et al. 1996). ICGV 96266 is resistant to rust and late leaf spot (Motagi 2001). ICGV 86155 is a Spanish bunch with high yield potential and fresh seed dormancy (Upadhyaya et al. 1997).

Genotypes ICGV 96262 (2.32), ICG 1697 (2.82) and R 9227 (2.90) were comparable to J 11 for resistance to IVSCAF. These genotypes are known to possess resistance to multiple stresses (Naidu 2002). All the three genotypes

Table 1. *Aspergillus flavus* seed colonization severity of groundnut advanced breeding lines in a preliminary screening assay.

Genotype	Botanical group[1]	Pedigree	Colonization severity[2]
ICGV 86699	VB	*(Arachis batizocoi* x *A. duranensis)* x *A. hypogaea* (NC 2 x CS 29)	1.28
ICGV 87165	VB	*(A. hypogaea* var *fastigiata* (PI 261942) x *A. cardenasii* x CS 9	2.87
ICGV 88256	VB	CS 9 x (Robut 33-1 x NC Ac 316)	3.28
ICGV 93023	VB	(Robut 33-1 x NC Ac 2214) x Cyto 213-2	3.53
A 30b	VB	KRG 1 x ICGV 87165	2.89
ICGV 86031	SB	F 334 A-B-14 x NC Ac 2214	3.88
ICGV 87264	SB	Manfredi x NC Ac 17133RF	3.21
ICGV 87807	VL	(MK 374 x Robut 33-1) x FESR 2	3.48
ICGV 90266	VB	(J 11 x (M 13 x NC Ac 2214)) x ICG 2271	3.06
ICGV 91173	VB	(NC Ac 343 x NC Ac 2214) x ICG 5240	3.27
ICGV 91177	VB	(F 334 A-B-14 x NC Ac 2232) x ((TMV 7 x FSB 7-2) x NC Ac 2214)	3.18
ICGV 91180	VB	((TMV 2 x FSB 7-2) x NC Ac 2232) x (F 334 A-B-14 x NC Ac 2214)	3.00
ICGV 92188	VB	(Robut 33-1 x (M 13 x Nc Ac 2214)) x JL 24	2.93
ICGV 93008	VB	(Mani Pintar x (Robut 33-1 x NC Ac 2232)) x ICG 2320	3.10
ICGV 93020	SB	(Manfredi 68 x NC Ac 343) x (Mani Pintar x (Robut 33-1 x NC Ac 2232))	3.33
ICGV 93021	VB	(F 334 A-B-14 x NC Ac 2214) x 9/136	3.49
ICG 2271	VB	NC Ac 343	3.93
ICG 1697	VL	NC Ac 17090	2.83
ICGV 96262	VB	89 R/52-8 x PI 270806	2.30
ICGV 96266	VB	ICGV 86577 x ICGV 86594	1.39
Dh 73	SB	Dh 3-30 x ICGV 87264	2.97
R 8972	SB	ICGS 59 x NC Ac 2240	3.63
R 9214	SB	(ICGS 7 x NC Ac 2214) x ICGV 86031	3.95
R 9227	SB	(ICGS 7 x NC Ac 2214) x ICGV 86031	2.75
ICGV 86155	SB	ICGS 30 x (TMV 10 x Chico F_6)	1.16
ICGV 86156	SB	ICGS 30 x (TMV 10 x Chico F_6)	3.37
ICGV 86158	SB	ICGS 30 x (TMV 10 x Chico F_6)	3.20
ICGV 87378	SB	Kanto No. 40-B1-B1-B1-B1	2.98
ICGV 87921	SB	ICGS 21 x (TMV 2 x Chico)	3.41
TMV 2	SB	Mass selection from "Gudhiatham bunch"	4.00
J 11	SB	Ah 4218 x Ah 4354	2.89
CD (at 5%)			0.37
CV(%)			6.0

1. SB = Spanish bunch; VB = Virginia bunch; VL = Valencia.
2. Scored on a 1-4 rating scale, where 1 = <5% seed surface colonized with scanty mycelial growth and no sporulation; 2 = 5-25% seed surface colonized with good mycelial growth and scanty sporulation; 3 = 25-50% seed surface colonized with good mycelial growth and good sporulation; and 4 = >50% seed surface colonized with heavy sporulation.

Table 2. Confirmation of resistance to seed colonization by *Aspergillus flavus* in selected groundnut lines by repeated screening assays.

	Mean seed colonization severity[1]				
Genotype	Assay I	Assay II	Assay III	Assay IV	Overall mean
iCGV 86699	1.24	1.31	1.28	1.30	1.28
1CGV 87165	2.87	3.62	3.54	3.66	3.40
A 30b	2.93	3.57	3.47	3.50	3.35
ICGV 92188	2.98	3.63	3.55	3.65	3.43
ICG 1697	2.43	2.96	3.11	2.78	2.82
ICGV 96262	2.30	2.37	2.21	2.46	2.32
ICGV 96266	1.39	1.33	1.48	1.39	1.40
Dh 73	2.97	3.50	3.38	3.77	3.37
R 9227	2.80	2.92	3.06	2.78	2.90
ICGV 86155	1.13	1.22	1.28	1.18	1.20
TMV 2 (susceptible check)	4.00	3.94	3.95	3.97	3.97
J 11 (resistant check)	2.89	2.87	2.75	2.88	2.85
CD (at 5 %)	0.35	0.42	0.27	0.29	
CV (%)	6.29	6.86	4.36	4.80	

1. Scored on a 1-4 rating scale, where 1 = <5% seed surface colonized with scanty mycelial growth and no sporulation; 2 = 5-25% seed surface colonized with good mycelial growth and scanty sporulation; 3 = 25-50% seed surface colonized with good mycelial growth and good sporulation; and 4 = >50% seed surface colonized with heavy sporulation..

have resistance to *Sclerotium rolfsii.* ICG 1697 and R 9227 also combine resistance to rust and *Spodoptera.* ICGV 96262 and R 9227 are iron absorption efficient and tolerant to bud necrosis. ICGV 96262 also carries resistance to late leaf spot.

The results of this study demonstrate a need for repeated assays to identify stable sources of resistance to seed colonization by *A. flavus.* The identified sources could be profitably exploited for incorporation of resistance to multiple stresses in general and infection to *A. flavus* in particular.

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Evaluation of Advanced Groundnut Breeding Lines for Resistance to Jassids

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Sucking insects, especially jassids and thrips cause considerable damage to groundnut *(Arachis hypogaea)* throughout crop growth during rainy and postrainy seasons by decreasing the photosynthetically active leaf area. Patel and Vora (1981) reported jassids as serious pests of groundnut in India. They cause 9% reduction in pod yield and 18% reduction in haulm weight. Severe yield loss occurs if the crop is infested during early stage. Farmers especially in rainfed areas do not take up any chemical control measures against jassids. Hence identification or development of groundnut varieties with resistance to sucking insects especially jassids is the best and cheapest method to avoid yield loss.

The stabilized breeding lines which have jassid resistant/tolerant lines as parents are given in Table 1. These were evaluated in the field under natural pest pressure to identify jassid resistant breeding lines with

Table 1. Evaluation of advanced groundnut breeding lines for resistance to jassids and yield at Tirupati, Andhra Pradesh, India during rainy season in 2002 and 2003.

		Leaflets (%) showing yellowing due to jassids			Special morpho-logical features[1]			
Genotype	Pedigree	2002	2003	Mean	LH	SH	Pod yield[2] (kg ha^{-1})	Shelling outturn[2] (%)
TCGS 735	TCGS 645 x TCGS 635	40	48	44.0	M	M	1424	63
TCGS 736	TCGS 645 x TCGS 635	38	43	40.5	M	M	652	70
TCGS 737	TCGS 645 x TCGS 635	34	31	32.5	P	P	1970	70
TCGS 738	TCGS 645 x TCGS 635	29	35	32.0	M	M	1404	64
TCGS 739	TCGS 645 x TCGS 635	36	34	35.0	P	M	1703	69
TCGS 740	TCGS 645 x TCGS 635	44	41	42.5	S	S	1355	66
TCGS 741	TCGS 645 x TCGS 635	28	37	27.5	S	s	1302	66
TCGS 742	TCGS 645 x TCGS 635	15	12	13.5	P	M	1820	73
TCGS 743	TCGS 596 x TCGS 635	31	48	36.0	S	S	947	54
TCGS 744	TCGS 596 x ICGV 86031	38	42	40.0	S	s	1220	51
TCGS 745	TCGS 596 x ICGV 86031	29	46	37.5	S	s	911	52
TCGS 746	TCGS 645 x TCGS 635	26	41	33.5	s	s	1218	66
TCGS 747	TCGS 596 x ICGV 635	39	44	41.5	s	s	1172	52
TCGS 748	TCGS 320 x TCGS 635	47	42	44.5	s	s	1464	64
TCGS 749	TCGS 245 x ICGV 86031	40	43	41.5	s	s	1017	61
TCGS 750	Tirupati 3 x ICGV 86031	7	5	6.0	P	P	1549	68
TCGS 750 A	TCGS 320 x TCGS 635	29	25	27.0	M	M	1317	68
TCGS 750 B	TCGS 645 x TCGS 635	18	20	19.0	P	P	1749	69
TCGS 750 C	TCGS 645 x TCGS 635	53	49	51.0	M	s	688	62
TCGS 750 D	TCGS 645 x TCGS 635	36	42	39.0	S	M	1390	69
TCGS 750 E	TCGS 645 x TCGS 635	38	40	39.0	M	M	1681	67
TCGS 750 F	TCGS 645 x TCGS 635	15	21	18.0	M	M	1168	69
TCGS 750 G	TCGS 645 x TCGS 635	18	17	17.5	P	M	1150	61
TCGS 750 H	TCGS 645 x TCGS 635	29	34	31.5	S	S	1273	64
Tirupati 1	Selection from EC 106983/3A	37	46	41.5	s	S	1029	64
Tirupati 4	JI 24 x Ah 316/S	36	39	37.5	s	S	1155	68
JL24	Selection from EC 949493	41	45	43.0	s	s	1379	70
Vemana	JL 24 x Kadiri 3	37	39	38.0	s	s	1502	68
Mean							1308	
CD (at 5%)							206.9	
CV(%)							8.3	

1. LH = Leaf hairiness; SH = Stem hairiness; P = Profusely hairy; M = Moderately hairy; S = Slightly hairy.
2. Data are means of 2002 and 2003.

high yield potential. The experiment was laid out in a randomized block design with three replications during rainy season in 2002 and 2003 at the Regional Agricultural Research Station, Tirupati, Andhra Pradesh, India. A spacing of 30 cm between rows and 10 cm between plants within a row was adopted. The plot size was 5.0 m x 0.9 m with three rows per plot. The normal recommended package of practices for groundnut production was followed. Jassid incidence was recorded by noting percentage of leaflets showing characteristic symptoms of yellowing.

The genotype TCGS 750 (Tirupati 3 x ICGV 86031) was found resistant to jassids with least damage of 6.0%. This entry had a pod yield of 1.55 t ha^{-1} with shelling outturn of 68% (Table 1). The donor parent ICGV 86031 is a high-yielding improved germplasm line with multiple resistance to insect pests and bud necrosis (ICRISAT 1992). Two genotypes, TCGS 742 (TCGS 645 x TCGS 635) and TCGS 750 G (TCGS 645 x TCGS 635), were moderately resistant to jassids with an incidence of 13.5% and 17.5%, respectively. The pod yields of these two genotypes were 1.82 t ha^{-1} and 1.15 t ha^{-1}, respectively.

The resistant genotype TCGS 750 has narrow, long, dark green leaflets folding downward and dense trichomes on leaves and stems. The moderately resistant genotypes TCGS 742 and TCGS 750 G have dark green foliage, broad, long leaves with dense trichomes on leaves and moderate pubescence on stems. TCGS 737 had highest pod yield as well as highest seed yield with moderate resistance to jassids. TCGS 739 and TCGS 750 B had more than 1.7 t ha^{-1} pod yield. Though the line TCGS 750 E had 39% jassid damage it gave more than 1.6 t ha^{-1} pod yield reflecting its tolerance to jassids. From this study it can be concluded that it is possible to develop jassid resistant lines with high yield and other desirable yield attributes.

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Evaluation of ICRISAT Groundnut Genotypes for End-of-season Drought Tolerance and Aflatoxin Contamination in Indonesia

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The evaluation of groundnut genotypes for tolerance to drought and aflatoxin contamination was a part of the Australian Centre for International Agricultural Research (ACIAR) project (PHT 1997/017) entitled "Reducing aflatoxin in groundnut using agronomic and bio-control management in Indonesia and Australia". We received 13 groundnut (*Arachis hypogaea*) genotypes from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India (Table 1). The seeds were bulked to get enough material for planting. Seed of ICGV 86031 was not enough to include in the

Table 1. Characteristics of ICRISAT groundnut lines used in field trials at Muneng, Indonesia.

Genotype	Remarks
ICGV 86590	Resistant to rust and tolerant to late leaf spot; a released cultivar in India
ICGV 89104	Tolerant to pre-harvest seed infection by *Aspergillus flavus*
ICGV 93280	Resistant to in vitro seed colonization by *A. flavus*
ICGV 93291	Short duration
ICGV 95322	Short duration
ICGV 95494	Tolerant to in vitro seed colonization by *A. flavus*
ICGV 99029	Large seed size; suitable for confectionery uses
ICGV 86031	Resistant or tolerant to insect pests (*Spodoptera,* leaf miner, jassids and thrips), bud necrosis and iron chlorosis
ICGV 86158	Fresh seed dormancy, Spanish type
ICGV 91284	Short duration
ICR 48	Tolerant to drought (from Water-use efficiency project)
ICGS 76	High yielding and tolerant to drought; a released cultivar in India
J 11	Resistant to in vitro seed colonization by *A. flavus*

Table 2. Performance of groundnut genotypes grown during July to November 2003 at Muneng, Indonesia.

Genotype	Plant population at harvest (%)	Pod yield[1] (t ha^{-1})	Sound mature seed (%)	Shelling outturn (%)	Seeds infected by *A. flavus* (%)	
					Average	Range
ICGV 86590	94	2.75 a	41.3	32.9	7.7	4-10
ICGV 89104	77	2.05 def	46.2	29.7	14.7	5-29
ICGV 93280	90	2.60 abc	33.1	31.6	9.7	4-14
ICGV 93291	86	1.88 def	47.1	32.7	10.3	2-27
ICGV 95322	88	2.67 ab	39.5	33.1	9.7	8-11
ICGV 95494	92	2.23 bcde	34.9	36.1	11.0	5-22
ICGV 99029	84	2.28 abcde	27.1	36.1	8.3	6-10
J 11	89	2.00 def	41.5	28.7	5.0	3-8
ICR 48	78	2.13 cde	22.3	33.7	3.3	2-4
ICGS 76	59	1.60 f	24.1	31.3	10.0	1-25
ICGV 86158	88	2.05 def	38.3	28.7	11.0	7-18
ICGV 91284	84	2.23 bcde	31.9	52.5	4.7	2-6
Local Lamongan	90	2.38 abcd	44.2	28.6	4.3	2-6
GH 51	89	1.81 ef	46.4	28.4	10.3	5-18

1. Values in the same column followed by same letters are not significantly different at 5% level

Table 3. Seed and soil moisture content of groundnut genotypes under progressively drying condition grown during July to November 2003 at Muneng, Indonesia[1].

Genotype	Seed moisture content at 100 DAS (%)	Seed moisture content before ELISA test (%)	Soil moisture content[2] (% dry weight)	
			At 80 DAS	At harvest
ICGV 86590	53.93 ab	6.62 b	24.55 bc	20.79 ab
ICGV 89104	41.70 c	6.95 b	37.57 a	32.97 a
ICGV 93280	48.56 bc	6.70 b	25.35 bc	17.48 b
ICGV 93291	47.35 bc	7.68 b	23.33 bc	21.85 ab
ICGV 95322	43.28 c	6.69 b	24.31 bc	18.97 b
ICGV 95494	46.78 bc	6.49 b	23.94 bc	23.00 ab
ICGV 99029	59.54 a	6.59 b	25.18 bc	22.02 ab
J 11	50.08 bc	7.13 b	21.48 c	27.29 ab
ICR 48	55.13 ab	7.36 b	27.04 bc	29.24 ab
ICGS 76	60.40 a	8.89 a	29.99 abc	23.39 ab
ICGV 86158	46.74 bc	7.50 b	26.65 bc	17.01 b
ICGV 91284	46.93 be	6.99 b	24.59 bc	25.26 bc
Local Lamongan	43.22 c	6.79 b	31.24 ab	23.07 ab
GH 51	46.91 be	7.10 b	25.33 bc	25.78 ab

1. Values in the same column followed by same letters are not significantly different at 5% level.
   DAS = Days after sowing.
2. Field capacity: 32%; Permanent wilting point: 19%.

experiment and hence the field trial consisted of a total of 14 entries with 12 ICRISAT genotypes and two genotypes from Indonesia, ie, Local Lamongan and GH 51 (promising line, resistant to drought stress). The field trial was conducted at Muneng Research Station, East Java, Indonesia during July to November 2003 under rainfed condition but irrigation water was available to ensure survival of crop and good vegetative and generative growth. The trial was sown on 21 July 2003 and harvested on 1 November 2003. A randomized block design with 14 genotypes as treatments and three replications was applied in 42 plots. The plot size was 12.5 m x 5 m where at least 5 kg of fresh pods could be obtained. The trial received chemical fertilizers (23 kg N ha^{-1} + 45 kg P_2O_5 ha^{-1} + 22.5 kg K_2O ha^{-1}) that were applied in the furrows at planting time. Dolomite at the rate of 500 kg ha^{-1} was broadcast at flowering stage to ensure good pod filling. Flood irrigation was applied at 14, 28, 42, 48 and 68 days after sowing (DAS) with the average amount of 72,66.7,72,63.7 and 69.7 m^3 of water, respectively in each replication. The trial was under progressively drying condition from 69 DAS until harvest at 102 DAS. The genotypes, therefore, were under reduced soil moisture content for 33 days. During the growing season there was no rainfall. The soil temperature ranged from 25.8 to 29.6°C during the last 42 days before harvesting.

Some of the ICRISAT genotypes performed significantly better than the local checks under end-of-season drought (Table 2). ICGV 86590, ICGV 93280 and ICGV 95322 had pod yields of more than 2.5 t ha^{-1}. On the other hand, ICGS 76 had lowest pod yield mainly due to poor plant stand of 59%. During the growing season, many plants died because of wilting due to *Ralstonia solanacearum* infection. Therefore, the plant population at harvest was presented as percentage of full plant population obtained at establishment, ie, 15 DAS.

All genotypes had poor seed filling and a low proportion of sound mature seeds resulting in low shelling outturn (Table 2). Seeds in all the genotypes were damaged due to rotting and were discolored.

Seed moisture content among genotypes at 2 days before harvest ranged from 41.7 to 60.4% suggesting that the pods had high moisture content at harvest (Table 3). The moisture content was low (ranging from 6.49 to 8.89%) in all genotypes, before aflatoxin analysis was undertaken, suggesting that the pods were dried to safe moisture content (Table 3). Both conditions indicated that seeds were beyond the risk of aflatoxin contamination. Dorner et al. (1989) and Wright and

Table 4. Aflatoxin content (ppb) in sound mature seeds, shriveled seeds and damaged seeds of 14 groundnut genotypes at Muneng, Indonesia, 2003.

	Sound mature seeds		Shriveled seeds		Damaged seeds	
Genotype	Average	Range	Average	Range	Average	Range
ICGV 86590	5.07	3.95-6.94	1.02	0.34-1.70	2.79	1.79-4.43
ICGV 89104	4.52	0.95-7.51	0.72	0.16-1.44	2.65	1.61-3.94
ICGV 93280	3.16	1.89-4.33	1.44	1.06-2.12	4.02	2.15-5.48
ICGV 93291	5.06	3.59-7.30	1.06	0.13-2.23	1.74	1.49-2.16
ICGV 95322	3.69	2.59-4.59	1.12	0.56-1.91	3.37	2.77-4.16
ICGV 95494	2.49	1.77-3.88	0.64	0.56-0.71	3.88	1.17-6.33
ICGV 99029	2.83	1.86-3.64	1.25	0.76-1.54	4.94	2.98-6.79
J 11	3.10	0.96-4.79	1.26	0.78-1.58	2.65	2.14-2.97
ICR48	2.10	1.55-2.61	3.21	2.42-3.66	3.50	2.75-4.28
ICGS 76	2.66	1.52-4.11	2.95	1.77-3.65	5.33	4.60-6.53
ICGV 86158	3.33	3.03-3.70	1.35	1.01-1.56	3.34	2.19-4.90
ICGV 91284	4.77	4.50-5.13	0.81	0.68-0.96	2.81	2.09-4.00
Local Lamongan	3.54	1.81-5.68	0.94	0.40-1.69	3.68	2.59-5.82
GH 51	4.31	1.65-6.35	0.71	0.48-1.09	2.62	2.16-3.47

Cruickshank (1999) reported that seed moisture content was crucial in the incidence of aflatoxin contamination and 18 to 28% moisture content was a critical level suitable for aflatoxin production. Crop Link (1999) mentioned that seed moisture content of 15 to 30% and soil temperature higher than 28°C during pod-filling period in the pod zone favored aflatoxin contamination. Cole et al. (1995) reported that aflatoxin contamination was observed when the crop was subjected to water shortage for 30-50 days during pod maturation period and high (average 29-31°C) soil temperature. In our study, though the pods were under favorable soil temperature for aflatoxin production (28-30°C) around harvest, the seed moisture content in all the genotypes was outside the favorable range. It was higher before harvest and lower after sun drying. Hence, low aflatoxin contamination was observed in all genotypes (Table 4) in spite of seed infection by *A. flavus* ranging between 3.3 and 14.7% (Table 2).

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Participatory Selection of Groundnut Genotypes Under Rainfed Conditions in Kurnool District of Andhra Pradesh

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Groundnut (*Arachis hypogaea)* has the second largest cultivated area of 241,202 ha (32% of the total cultivated area) in Kurnool district of Andhra Pradesh, India after Anantpur district (Directorate of Economics and Statistics 2001). The productivity is about 1.0 t ha^{-1}, which is lower than the average productivity of Andhra Pradesh (1.15 t ha^{-1}) and far below the potential productivity of 4-5 t ha^{-1} (McDonald 1984). Non-availability of suitable high-yielding varieties and non-adoption of improved soil, water and nutrient management (SWNM) practices are the main causes of low productivity. Groundnut is sown in the rainfed uplands during the rainy season (June-November). The agroecosystem of the region is characterized by unpredictable weather, limited and intense rainfall with long intervals of dry spells. The crop, therefore, generally suffers from mid- and end-season drought. Suitable high-yielding genotypes with good tolerance to drought need to be tested. Efforts were made to achieve this endeavor in the project of the Andhra Pradesh Rural Livelihoods Programme (APRLP) being implemented by the Government of Andhra Pradesh and technically supported by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) with the funding support from APRLP and the UK Department for International Development (DFID). One of the objectives of the project is to help reduce poverty through increased agricultural productivity and improved livelihood opportunities.

Nucleus watersheds for undertaking on-farm research were selected based on representative typology, extent of rainfed area, crop productivity and willingness of the community to participate in the on-farm research activities. The detailed participatory rural appraisal (PRA) in the nucleus watershed helped us to understand the constraints for increasing the productivity from the farmer's perspective. Based on the results from the earlier varietal trials conducted jointly with the Krishi Vignan Kendra

Table 1. Performance of some selected groundnut varieties in on-farm trials, Kurnool district, Andhra Pradesh, India, rainy season 2002.

Genotype	Pod yield ($t\ ha^{-1}$)	Haulm yield ($t\ ha^{-1}$)	Harvest index	Shelling outturn (%)	100-seed mass (g)	Developed pods $plant^{-1}$
ICGS 11	1.9	2.7	0.41	69	34.7	15.9
1CGS 76	2.4	2.8	0.46	68	39.2	18.8
1CGV 86590	1.8	2.7	0.41	66	31.5	16.3
TMV 2 (control)	1.3	2.2	0.37	61	28.5	11.5
SE±	0.10	0.10	0.01	0.54	1.85	0.80
CV(%)	24	18	11	3	23	18
LSD (5%)	0.47	0.50	0.05	2.56	8.85	3.94

(KVK) of the Hanumantharaya Education and Charitable Trust, Yaganti, Banaganepally in Ralla Kothur and Thammada Pally villages of Kurnool district, we selected groundnut genotypes ICGS 11, ICGS 76 and ICGV 86590 with maturity duration of 120 days, and which can cope with drought for on-farm evaluation together with the local cultivar TMV 2.

Thirty farmers evaluated improved groundnut cultivars along with their normal variety (TMV 2) through on-farm participatory trials (1000 m^2 for each treatment) during the rainy season of 2002. The objective was to evaluate the performance of improved groundnut varieties and identify suitable cultivar(s) to develop improved production technologies for harnessing the agroecological potential. The soils are Alfisols and the long-term average annual rainfall is 612 mm. Sowing was done in the last week of June with 30-cm interrow spacing and 10-cm intra-row spacing. A fertilizer dose of 20 kg N, 40 kg P_2O_5, 0.5 kg B and 10 kg Zn ha^{-1} was applied together with split application of gypsum at 500 kg ha^{-1} (200 kg ha^{-1} as basal and 300 kg ha^{-1} as top dressing at pegging stage) to all the test cultivars including the check cultivar TMV 2. Adequate plant stands, free from weeds and pests were maintained. The crop experienced a long (28 days) dry spell from the beginning of pod initiation to full seed development. Data on yield and ancillary characters were recorded.

All the three improved groundnut cultivars yielded 40-85% more pods (1.8 to 2.4 t ha^{-1}) than TMV 2 (1.3 t ha^{-1}) (Table 1). Among the improved cultivars, ICGS 76 differed significantly from the rest in terms of pod yield and ancillary characters, viz, 100-seed mass, developed pods $plant^{-1}$ and harvest index. However, its superiority was not reflected in case of shelling outturn and haulm yield. In terms of farmers' preferences, ICGS 76 ranked first followed by ICGS 11 because of their drought tolerance and high yield potential. Among the cultivars, ICGS 76 was most preferred despite its low shelling outturn and haulm yield over ICGS 11. The cropping season of 2002 was a sub-normal year and recorded 340 mm rainfall as against the average annual rainfall of 612 mm. ICGV 86590 was not preferred because of its bitter seed coat. Although all the three improved genotypes fetched a lower market price of Rs 1 kg^{-1} pods compared to local varieties, due to apprehensions of the traders that bold seeds contain low oil content, the farmers preferred these genotypes because of their drought tolerance and high yield potential. ICGS 11 and ICGS 76 were favored by the farmers for rainy season cultivation and can be included in the improved production technologies for scaling-up and scaling-out in Kurnool district.

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Seed Releases

TG 37A - A New Trombay Groundnut Variety with Wide Adaptation

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A Trombay groundnut (TG) variety, TG 37A, was released in 2004 by the Central Sub-Committee on Crop Standards, Release and Notification of Varieties, Ministry of Agriculture, Government of India for rainy season (June to September) cultivation in Haryana, Punjab, northern Rajasthan and Uttar Pradesh (Zone I). It is a high-yielding, Spanish *(Arachis hypogaea subspfastigiata* var *vulgaris)* variety developed at the Bhabha Atomic Research Centre (BARC), Trombay, Mumbai, Maharashtra, India. It is a derivative of a cross between TG 25 and TG 26. TG 25 is a breeding line from a cross between TGE 2 and TG 23. TG 23 is a sister line of the popular groundnut variety TAG 24. Both TAG 24 and TG 26 are early-maturing, semi-dwarf, erect in growth habit with high pod growth rate, high harvest index and greater partitioning efficiency (Badigannavar et al. 2002).

During initial evaluation at BARC in 1995 and 1996, TG 37A gave a mean pod yield of 3375 kg ha^{-1} with 55% superiority over JL 24 in the rainy season and 4425 kg ha^{-1} with 35% increase over SB XI and 9% increase over TG 26 in summer.

During rainy season in 2000-02, in the All India Coordinated Research Project - Groundnut (A1CRP-G) trials in Zone 1, TG 37A recorded a mean pod yield of 1963 kg ha^{-1} and seed yield of 1246 kg ha^{-1} with a superiority of 26% and 40%, respectively over the best check ICGV 86590 (Table 1). In these trials, TG 37A had an average maturity duration of 114 days, 64% shelling outturn, 39 g 100-seed mass and 51% oil content. It showed 1.5% incidence of collar rot as against 20.4% in the test entry Dh 2000-1 at Hanumangarh, Rajasthan and 6.7% incidence of bud necrosis as against 39.8% in the check variety JL 24 at Raichur, Karnataka, India.

During rainy season in 2000,2001 and 2003, in AICRP-G trials in Zone II (comprising Gujarat and southern Rajasthan), TG 37A performed well with pod yield of 3048 kg ha^{-1} and seed yield of 2173 kg ha^{-1}; it showed an increase in pod yield of 22% over ICGS 37 and 23% over JL 24, respectively (Table 2). In these trials, TG 37A had an average maturity duration of 97 days, 71% shelling outturn, 45 g 100-seed mass and 50% oil content. This variety will soon be identified for release in Zone II.

TG 37A continued its good performance in *rabi* (postrainy)/summer season also. In AICRP-G trials conducted during 2000, 2002 and 2003 in Zone IV representing Orissa, West Bengal and northeastern states

Table 1. Performance of TG 37A in All India Coordinated Research Project - Groundnut trials in Zone I during rainy season[1].

					Increase (%) over check	
Year	No. of trials	TG 37A	JL 24 (check)	ICGV 86590 (check)	JL 24	ICGV 86590
Pod yield (kg ha^{-1})						
2000	3	2059	1318	1644	56	25
2001	3	1749	1306	1352	34	29
2002	3	2081	1228	1667	69	25
Mean		1963	1284	1554	53	26
Seed yield (kg ha^{-1})						
2000	3	1294	795	943	63	37
2001	3	1097	760	695	44	58
2002	3	1347	758	1018	77	32
Mean		1246	771	886	61	40

1. Trials were conducted at Durgapura and Hanumangarh in Rajasthan and Mainpuri in Uttar Pradesh, India.

Table 2. Performance of TG 37A in All India Coordinated Research Project - Groundnut trials in Zone II during rainy season[1].

					Increase (%) over check	
Year	No. of trials	TG 37A	JL 24 (check)	ICGS 37 (check)	JL 24	ICGS 37
Pod yield (kg ha^{-1})						
2000	2	2889	2589	2306	11	25
2001	2	2983	2656	2344	12	27
2003	5	3138	2341	2641	34	19
Mean		3048	2466	2500	23	22
Seed yield (kg ha^{-1})						
2000	2	2057	1938	1668	6	23
2001	2	2146	1945	1664	10	29
2003	5	2231	1644	1795	35	24
Mean		2173	1776	1737	22	25

1. Trials were conducted at Amreli, Junagadh and Talod in Gujarat and Pratapgadh and Udaipur in Rajasthan, India.

Table 3. Performance of TG 37A in All India Coordinated Research Project - Groundnut trials in Zone IV during *rabi/summer* season[1].

					Increase (%) over check	
Year	No. of trials	TG 37A	JL 24 (check)	ICGS 44 (check)	JL 24	ICGS 44
Pod yield (kg ha^{-1})						
2000	3	3545	2446	2969	45	19
2002	3	3125	3057	2556	2	22
2003	3	2889	2119	2472	36	17
Mean		3186	2541	2666	25	19
Seed yield (kg ha^{-1})						
2000	3	2439	1698	1960	70	24
2002	3	2286	2282	1862	0	23
2003	3	1968	1462	1740	34	13
Mean		2231	1808	1854	23	20

1. Trials were conducted at Beharampur, Jhargram and Mohanpur in West Bengal, India.

of India, TG 37A had pod yield of 3186 kg ha^{-1} and seed yield of 2231 kg ha^{-1} with superiority of 19% and 20%, respectively over the best check ICGS 44 (Table 3). In this zone, TG 37A had an average maturity duration of 122 days, 68% shelling outturn, 48 g 100-seed mass and 53% oil content. Based on its superior performance, TG 37A has been identified for release in Zone IV.

TG 37A has an erect growth habit with sequential branching, semi-dwarf height and medium-size leaflets. It has compact pod setting, smooth pod surface and more number of three-seeded pods. Seeds are rose-colored and spheroidal. The seed contains 48% oil, 23% protein, 19.3% carbohydrate, 4.5% sucrose, 2.8% crude fiber and 2.4% ash. The oil contains 40.7% oleic acid, 39.8% linoleic acid, 12.3% palmitic acid and 2.7% behenic acid. It is the genetic plasticity which makes TG 37A perform better over years and across agroclimatic situations.

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TPG 41 - A New Large-seeded Groundnut Variety Released in India

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Groundnut *(Arachis hypogaea)* is an ideal food crop to reduce malnutrition due to its rich nutritional properties. Large seeds of groundnut have greater consumer preference and fetch higher price in domestic and international markets. Value addition will further enhance their market price. The groundnut export trade in India is restricted to handpicked selected (HPS) seeds in the absence of suitable varieties with large seeds and good quality (Dwivedi and Nigam 1995, Kale et al. 2000a). The existing varieties have long maturity duration, prolonged fresh seed dormancy and low shelling outturn, yield and proportion of large seeds. Mutation and recombination breeding at the Bhabha Atomic Research Centre (BARC), Trombay, Mumbai, Maharashtra, India succeeded in developing several large-seeded genotypes of which TG 1, TKG 19A and Somnath (TGS 1) were released for cultivation in India (Kale et al. 2000b).

TPG 41, a new confectionery, large-seeded groundnut variety was released during 2004 for cultivation by the Central Sub-Committee on Crop Standards, Release and Notification of Varieties, Ministry of Agriculture, Government of India. It was derived from a cross between TG 28A and TG 22 using pedigree method at BARC. TG 28A is a breeding line from a cross between TAG 24 and BARCG 1 and TG 22 is a released variety. TPG 41 is a collaborative product between BARC and Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra.

TPG 41 was evaluated in yield trials in summer (January-May) and rainy (June-October) seasons during 1996 and 1997 at BARC. The net plot size in rainy and summer seasons was 15 m^2 and 10 m^2 and plant spacing 50 cm x 10 cm and 45 cm x 10 cm, respectively. In irrigated summer trials, TPG 41 recorded 3900 kg ha^{-1} pod yield and 2640 kg ha^{-1} seed yield with 20% and 23% superiority over the best check variety TKG 19A (3260 kg ha^{-1} pod yield and 2150 kg ha^{-1} seed yield), respectively. In heavy rainfall (>2,000 mm) situation, TPG 41 gave 41% higher pod yield and 51 % higher seed yield. The expected yield of large seeds (100-seed mass >80g) was estimated according to Kale et al. (2000a) for summer and rainy season 1997. The mean was 910 kg ha^{-1} in TPG 41 as against 610 kg ha^{-1} in the best check BAU 13. At BARC, it matured in 115-120 days with a shelling outturn of 70%

Table 1. Mean performance of TPG 41 in All India Coordinated Research Project - Groundnut trials during rabi/summer season at seven locations in India[1].

Year	No. of trials	TPG 41	TKG19A (check)	B 95 (check)	Increase (%) over check	
					TKG 19A	B 95
Pod yield (kg ha^{1})						
1998/99	4	1709	1374	1503	24.4	13.7
1999/2000	4	2241	1819	1798	23.2	24.6
2000/01	4	2200	1761	2008	24.9	9.6
2002/03	6	2839	2265	2281	25.3	24.5
Mean		2313	1856	1940	25.3	19.2
On-farm trial 2002/03	26	4551	-	3046	-	49.4
Seed yield (kg ha^{-1})						
1998/99	4	1110	901	947	23.2	17.2
1999/2000	4	1533	1223	1204	25.3	27.3
2000/01	4	1506	1091	1218	38.0	23.6
2002/03	6	1994	1439	1450	38.6	37.5
Mean		1586	1194	1232	32.8	28.7

1. Handpicked selected (HPS) seed trials were conducted at Chintamani, Dharwad, Digraj, Jalgoan, Rahuri, Junagadh and Vriddhachalam.

and 100-seed mass of 73 g as compared to 67% shelling outturn and 66 g 100-seed mass of the best check.

In the All India Coordinated Research Project - Groundnut (AICRP-G) HPS seed trials during *rabi* (postrainy) season/summer 1998/99 to 2000/01 and 2002/03, TPG 41 was evaluated at Chintamani and Dharwad in Karnataka; Digraj, Jalgoan, and Rahuri in Maharashtra; Junagadh in Gujarat; and Vriddhachalam in Tamil Nadu. In these trials, TPG 41 produced a mean pod yield of 2313 kg ha^{-1} and seed yield of 1586 kg ha^{-1} registering 19% and 29% increase over B 95 (Table 1). It also recorded 49% increased pod yield as compared to B 95 in 26 on-farm trials spread over Maharashtra. In AICRP-G trials, it matured in 122 days with an average 100-seed mass of 65 g and 69% shelling outturn.

TPG 41 belongs to the Spanish group *(A. hypogaea* subsp *fastigiata* var *vulgaris).* It is characterized by erect growth habit with semi-dwarf height, sequential flowering and medium green leaves. The plant has 5 primary and 4 secondary branches. Pods are mostly two-seeded with compact setting, medium constriction, medium reticulation and medium to prominent beak. Seed is rose in color. Seed contains 48.6% oil, 25.0% protein, 20.3% carbohydrate and 3.94% sucrose. The oil contains 62.4% oleic acid and 19.3% linoleic acid. TPG 41 has a fresh dormancy of 25 days, an important trait, which prevents in situ seed germination due to unseasonal rains when the crop is ready for harvest.

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ICGV 93468 Ushering in New Hope for Revival of Groundnut in Uttar Pradesh, India

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The riverine alluvial soil of Uttar Pradesh (UP), India having loamy sand, sandy loam and light loam texture is famous for rainy season groundnut *(Arachis hypogaea)* cultivation. In early 1980s, groundnut was grown in UP on 0.3 million ha with a production of 0.19 million t. Since then, both area and production have shown a steady decline due to various reasons. In 2000-01, the groundnut area was reduced to 0.12 million ha with a total production of 0.1 million t and an average productivity of 0.84 t ha^{-1}. Efforts to arrest this decline in area and production did not succeed due to various biotic and economic reasons. A strong need was felt to develop a suitable technology for groundnut cultivation under water limited conditions to revive groundnut in the State. The scientific team of the National Agricultural Research Project, Mainpuri, UP discussed this important issue with SN Nigam, Principal Scientist (Groundnut), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India and a plan for introducing summer cultivation of groundnut in the State was developed. ICRISAT supplied 29 improved groundnut genotypes for evaluation during summer season in 1998. Under leadership of the author, the work was started on summer groundnut in UP. Twelve of the 29 genotypes performed well in summer cultivation. This was the first success of summer groundnut cultivation in UP due to early maturity (85-90 days) of the test genotypes.

A varietal trial of 12 improved genotypes and a local check G 201 (Kaushal) was laid out during summer season of 1999 and 2000 at the Regional Research Station, Mainpuri. The trial was sown on 9 March in 1999 and on 10 March in 2000. It was harvested after 87 and 89 days, respectively, on 4 June in 1999 and on 7 June in 2000. The sowing was done in rows 30 cm apart with 10 cm plant spacing. Recommended dose of 20 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 45 kg K_2O ha^{-1} was applied at the time of land preparation. Gypsum was applied at 300 kg ha^{-1} with 50% quantity applied at sowing and the remaining 50% top dressed between flowering and pegging stage to create the fragile condition at pegging and conservation of moisture in situ.

Table 1. Yield and growth parameters of selected short-duration groundnut genotypes at the Regional Research Station, Mainpuri, Uttar Pradesh, India, summer season 1999 and 2000[1].

Genotype	Height of main axis (cm)	Number of branches $plant^{-1}$	Number of pods $plant^{-1}$	Pod mass $plant^{-1}$ (g)	Number of seeds $plant^{-1}$	Number of seeds pod^{-1}	Seed mass $plant^{-1}$ (g)	100-seed mass (g)	Pod yield ($t\ ha^{-1}$)		
									1999	2000	Average
ICGV 93468	41.0	6.8	13.8	10.0	17.2	1.3	6.9	40.0	2.23	2.45	2.34
ICGV 95290	69.8	4.4	8.2	4.0	7.8	1.0	2.2	27.8	1.52	1.73	1.63
ICGV 95271	86.4	5.4	10.4	9.0	14.8	1.5	3.7	25.1	1.32	1.62	1.47
ICGV 94299	61.4	4.2	5.6	5.0	8.8	1.6	2.2	25.3	1.32	1.64	1.48
ICGV 95299	63.6	4.0	3.0	2.0	3.2	1.6	1.1	30.1	1.66	1.86	1.76
ICGV 95319	70.6	5.0	2.6	2.0	4.0	1.8	1.1	28.3	1.61	1.71	1.66
ICGV 95311	67.2	4.0	5.6	4.0	5.0	1.3	1.3	25.9	1.38	1.66	1.52
ICGV 96356	59.2	4.4	8.0	5.0	7.8	1.3	2.1	26.5	1.41	1.68	1.55
ICGV 96360	56.4	3.6	4.0	3.0	5.0	1.3	1.6	31.9	1.80	1.93	1.87
ICGV 96349	65.2	3.8	5.8	4.0	4.8	1.2	1.3	27.0	1.48	1.67	1.58
ICGV 96359	45.8	4.6	7.6	3.0	8.6	1.2	2.1	24.9	1.34	1.57	1.46
ICGV 95337	42.8	4.6	5.0	3.0	6.8	1.4	2.1	31.4	1.75	1.92	1.84
G 201 (local check)	49.2	6.2	10.4	7.0	13.8	1.3	2.4	22.5	1.12	1.09	1.11
SE±									0.02	0.02	
CD (at 5%)									0.06	0.05	
CV(%)									2.30	3.33	

1. Data are means of two years.

The genotype ICGV 93468 gave higher average pod yield (2.34 $t\ ha^{-1}$) as compared to other test genotypes and local check during summer season in both 1999 and 2000. Number of pods $plant^{-1}$, pod mass $plant^{-1}$, number of seeds $plant^{-1}$, seed mass $plant^{-1}$ and 100-seed mass were also high in ICGV 93468 (Table 1). The incidence of fungal diseases and bud necrosis (viral disease) was low and similar (0-2%) in all the genotypes. Similarly, only slight damage due to the insect pests *Anarsia eppiphias,* jassid, pod borer and termites was recorded in all the genotypes while white grub damage was absent during both the seasons. ICRISAT genotypes that performed well during the summer season were also tested during rainy season of 1999 and 2000. ICGV 93468 gave higher pod yield (2.25 $t\ ha^{-1}$) than the other test genotypes and local check G 201 in the rainy season also (Table 2). These results indicated that ICGV 93468 performed equally well during both summer and rainy seasons.

Table 2. Performance of short-duration groundnut genotypes at the Regional Research Station, Mainpuri, Uttar Pradesh, India, rainy season 1999 and 2000.

Genotype	Pod yield ($t\ ha^{-1}$)		
	1999	2000	Average
ICGV 93468	2.39	2.11	2.25
ICGV 94299	1.46	1.53	1.50
ICGV 96360	1.89	1.94	1.91
ICGV 95337	2.09	2.07	2.08
ICGV 96359	1.29	1.59	1.44
ICGV 95290	2.06	2.06	2.06
ICGV 95299	1.64	1.62	1.63
G 201 (local check)	1.14	1.38	1.26
SE±	0.20	0.16	
CD at 5%	0.61	0.47	
CV(%)	19.96	15.09	

Seven levels of farmyard manure (FYM) (0,2,4,6,8,10 and 12 $t\ ha^{-1}$) were tested with recommended dose of fertilizers (20 kg N ha^{-1} + 30 kg P_2O_s ha^{-1} + 45 kg K_2O ha^{-1} + 200 kg gypsum ha^{-1}) during summer season of 2002 and 2003. Treatment with 10 t FYM ha^{-1} in conjunction with recommended dose of fertilizer produced significantly higher pod yield (2.98 $t\ ha^{-1}$) in comparison to lower doses of FYM. The highest dose of 12 t FYM ha^{-1} in combination with recommended dose of fertilizers did not increase the pod yield further (Table 3).

Due to high yield potential, low incidence of insect pests and diseases, better survival under water stress conditions and thermo-tolerance, ICGV 93468 was considered safe for farmers. The bottom-up planning was done for diffusion of ICGV 93468 among farmers. On-farm trials were initiated in summer season in 2001. ICGV 93468 yielded 2.07 t ha^{-1} pods under maize *(Zea mays)*-potato (*Solatium tuberosum)*-summer groundnut and maize-field pea *(Pisum sativum)*-summer groundnut cropping systems while in the summer season of 2002, farmers harvested 2.49 t ha^{-1} pods under maize-potato-summer groundnut and maize-mustard (*Brassica* sp)-summer groundnut cropping systems.

Under the special extension program, ICGV 93468 was grown in cluster demonstrations during both summer and rainy seasons on farmers' fields. It gave 2.35 t ha^{-1} pods in the summer season of 2002,2.14 t ha^{-1} pods in the rainy season of 2002, 2.52 t ha^{-1} pods in the summer season of 2003 and 2.38 t ha^{-1} pods in the rainy season of 2003. This genotype was also tested on farmers' fields of partially reclaimed sodic soils during summer season of 2003 under maize-mustard-summer groundnut cropping system where farmers harvested 2.34 t ha^{-1} pods. This demonstrated the feasibility of successfully growing groundnut crop in partially reclaimed sodic soils. This was the second success in UP for introducing groundnut cultivation on partially reclaimed sodic soils.

Table 3. Response of groundnut genotype ICGV 93486 to organic manure and recommended dose of fertilizers (RDF) at the Regional Research Station, Mainpuri, Uttar Pradesh, India, summer season 2002 and 2003.

	Pod yield (t ha^{-1})		
Treatment[1]	2002	2003	Average
Control	1.32	1.34	1.33
FYM 0 + RDF	2.13	2.18	2.16
FYM 2 + RDF	2.33	2.35	2.34
FYM 4 + RDF	2.41	2.45	2.43
FYM 6 + RDF	2.55	2.58	2.57
FYM 8 + RDF	2.62	2.66	2.64
FYM 10 + RDF	2.94	3.02	2.98
FYM 12 + RDF	2.95	3.02	2.99
Average	2.40	2.45	2.43
SE±	0.02	0.02	
CD at 5%	0.06	0.06	
CV(%)	1.86	1.09	

1. FYM = Farmyard manure; quantity of FYM applied is in t ha^{-1}. RDF: 20 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 45 kg K_2O ha^{-1} + 200 kg gypsum ha^{-1}.

The economic comparison was made through innovative demonstrations of ICGV 93468 with mung bean *(Vigna radiata)* and black gram (*Vigna mungo).* ICGV 93468 gave maximum net return worth Rs 30,034 ha^{-1} in seed to seed program and Rs 16,201 ha^{-1} under table purpose program while mung bean and black gram gave net return of only Rs 2,818 ha^{-1} and Rs 2,211 ha^{-1} respectively. ICGV 93468 has been named as 'Avtar' and the release proposal has been submitted to the UP State Varietal Release Committee.

New Groundnut Variety Pratap Mungphali 1 Released in Rajasthan

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Groundnut *(Arachis hypogaea)* is an important oilseed crop of Rajasthan, India with an area of 0.27 million ha and production of 0.26 million t of pods. Spanish bunch groundnut varieties currently occupy about 40% of the total groundnut area of the state. The remaining 60% area is covered by Virginia bunch and Virginia runner groundnuts. The Spanish bunch varieties such as JL 24 and GG 2, grown in the state, have low yields and are susceptible to diseases and insect pests.

Pratap Mungphali 1, a Spanish variety, was bred and developed from the cross ICGV 86031 x ICG 2241 at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. After preliminary evaluation at Udaipur, Rajasthan as ICGV 92035, it was proposed in 2001 for evaluation in the All India Coordinated Varietal Trial as ICUG 92035, signifying a joint contribution from the Maharana Pratap University of Agriculture and Technology, Udaipur and ICRISAT. It was released as Pratap Mungphali 1 in 2004 in Rajasthan by the State Seed Sub-Committee for Agricultural Crops. It is erect in growth habit and early in maturity (about 99 days). The leaves are green and elliptical. Pods are two-seeded with moderate reticulation, constriction and beak. Seeds are medium, spheroidal and pink in color. The oil content in Pratap Mungphali 1 (50.5%) is higher than that in JL 24 (48.6%).

Table 1. Dry pod and seed yields (kg ha^{-1}) of groundnut variety ICUG 92035 in on-station and All India Coordinated Varietal trials conducted in Rajasthan, India during rainy season 1999-2002[1].

	Udaipur				Pratapgarh		Durgapura		Hanumangarh		
Variety	1999 (ST-1)	2000 (ST-1)	2001 IVT-I (SB)	2002 IVT-II (SB)	2001 IVT-I (SB)	2002 IVT-II (SB)	2001 IVT-I (SB)	2002 IVT-II (SB)	2001 IVT-I (SB)	2002 IVT-II (SB)	Mean
ICUG 92035											
Pod	2181	4073	2883	3116	2649	3149	1273	1794	1963	1481	2456 (28.7)[2]
Seed	1527	2851	1981	2250	1722	2313	520	897	1207	898	1607 (27.0)
JL 24 (check)											
Pod	1400	2473	2366	2616	2183	2499	984	1273	1771	1500	1907
Seed	1022	1805	1561	1844	1370	1737	424	663	1114	1113	1265
CD (at 5%)											
Pod	66.6	436.4	163.0	248.3	154.5	127.4	NS	396.6	383.3	286.5	
Seed	42.5	312.4	125.8	176.1	110.6	109	NS	197.6	196.8	188.7	
CV(%)											
Pod	2.4	11.1	4.3	6.2	4.4	3.2 '	17.8	17.6	11.5	13.9	
Seed	5.5	12.8	5.0	6.2	5.5	3.9	17.5	17.3	11.4	14.1	

1. ST = Station Trial; IVT = Initial Varietal Trial; SB = Spanish bunch; NS = Not significant.
2. Values in parentheses indicate increase (%) in yield over check.

Table 2. Pod yield (kg ha^{-1}) of groundnut variety ICUG 92035 in adaptive and on-farm trials in Rajasthan, India during rainy season 2003.

		On-farm trials				
Variety	Adaptive trial	Dabok (Udaipur)	Delwara (Rajsamand)	Sarlai (Chittorgarh)	Mandal (Bhilwara)	Mean
ICUG 92035	1389	2350	2000	2600	2450	2158 (14.9)[1]
JL 24 (check)	1333	2050	1750	2200	2050	1877
CD (at 5%)	NS[2]	–	–	–	–	–
CV (%)	10.6	–	–	–	–	–

1. Value in parentheses indicates increase (%) in yield over check.
2. NS = Not significant.

In on-station and All India Coordinated Varietal trials conducted at 10 locations in Udaipur, Pratapgarh, Durgapura (Jaipur) and Hanumangarh districts, Pratap Mungphali 1 produced a mean dry pod yield of 2456 kg ha^{-1} as compared with 1907 kg ha^{-1} of check JL 24, thereby exhibiting 28.7% pod yield superiority over the latter. It showed 27% superiority in seed yield over JL 24 (Table 1). In adaptive and on-farm trials conducted in Udaipur, Rajsamand, Chittorgarh and Bhilwara districts, Pratap Mungphali 1 produced a mean pod yield of 2158 kg ha^{-1} as compared with 1877 kg ha^{-1} of check JL 24, resulting in 14.9% yield increase over the check (Table 2). Pratap Mungphali 1 is moderately resistant to early and late leaf spots and bud necrosis diseases. It is also moderately resistant to the insect pests *Spodoptera,* leaf miner and thrips.

Khon Kaen 6: A New Groundnut Variety in Thailand

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A new groundnut *(Arachis hypogaea)* variety, Khon Kaen 6, was developed from an F_3 segregating population (ICGX 930132-F_3) introduced from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India in 1995. The population (ICGX 930132-F_3), derived from the cross (ICGV 88361 x ICGV 88390) x MACAN, was developed to improve confectionery traits in groundnuts. Khon Kaen 6 was selected following modified single seed descent method at Khon Kaen Field Crops Research Center, Field Crops Research Institute, Khon Kaen, Thailand during 1996-98 and evaluated for yield and adaptation during 1998-2002.

Yield performance

Khon Kaen 6 out-yielded the control Khon Kaen 60-3 on average by 31.7% in 23 varietal yield trials and by 28.8% in 11 on-farm tests (Table 1).

Main characteristics

Khon Kaen 6 is a Virginia bunch (A. *hypogaea* subsp *hypogaea* var *hypogaea)* groundnut variety with large pods. It matures 6 days earlier than Khon Kaen 60-3 (Table 2). Khon Kaen 6 shows resistance to bud necrosis, and moderate resistance to rust *(Puccinia arachidis),* early leaf spot *(Cercospora arachidicola)* and late leaf spot (*Phaeoisariopsis personata)* diseases but is susceptible

Table 1. Performance of Khon Kaen 6 in varietal yield trials and on-farm tests in Thailand, 1998-2002.

Variety	No. of pods hill^{-1}	Pod yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Shelling outturn (%)	100-seed mass (g)
Yield trials (mean of 23 trials)					
Khon Kaen 6	21.3	2,569	1,762	67.4	82.8
Khon Kaen 60-3 (control)	19.7	1,950	1,169	58.6	74.6
Increase (%) over control	8.1	31.7	50.7	15.0	11.0
On-farm tests (mean of 11 locations)					
Khon Kaen 6	24.7	2,206	1,412	66.0	81.0
Khon Kaen 60-3 (control)	22.9	1,712	1,000	59.0	67.0
Increase (%) over control	7.9	28.8	41.3	11.9	21.0

Table 2. Main characteristics of groundnut variety Khon Kaen 6.

Characteristics	Khon Kaen 6	Khon Kaen 60-3 (control)
Growth habit	Erect	Erect
Branching habit	Alternate	Alternate
Days to flowering	21-25	24-28
Days to maturity	119	125
Fresh seed dormancy (wk)	4-6	8-10
Leaf color	Dark green	Dark green
Seed color	Pink	Tan

Figure 1. Groundnut variety Khon Kaen 6 with large pods.

to stem rot *(Aspergillus niger).* It has 2-1-3-seeded pods. Pods have slight constriction and moderate beak and reticulation (Fig. 1).

Recommendation

Khon Kaen 6 has been recommended for cultivation in general groundnut planting area in Thailand. To obtain uniform stand and high yield, the grower should treat seeds with fungicide to control stem rot and with ethrel to eliminate seed dormancy. In soils with low pH, lime at 620 kg ha^{-1} should be added before plowing and 9.4-28.1-18.8 kg N-P-K ha^{-1} should be applied at planting. The plant density should be maintained at 25 plants m^2.

Utilization

Khon Kaen 6 can be used as boiled groundnut for local market, and as shelled groundnut for confectionery use.

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A New Groundnut Variety NSIC Pn 12 Released in the Philippines

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Groundnut *(Arachis hypogaea)* is an important cash crop in the Philippines grown during the dry season (November-April). Cagayan Valley and the Ilocos are the largest growing regions with an area of 30,492 ha and production of 25,474 t of pods (Bureau of Agricultural Statistics 1996). At present, the red-seeded and pink-seeded groundnut varieties are grown in the Philippines. These varieties have small to medium-sized seeds and long pods. They are used as boiled, roasted or fried groundnut and in making peanut butter. The newly released Spanish variety NSIC Pn 12 has large pods and seeds. The seeds have attractive pink seed coat color and shape.

Origin and development

NSIC Pn 12 is a selection from an advanced breeding line ICGS(E) 27, acquired in 1986 from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. This line was evaluated in the preliminary, general and advanced yield trials for six consecutive years. When found consistently a top yielder, it was nominated for inclusion in the National Cooperative Test (NCT). It was accepted in the May 2000 Field Legumes Technical Working Group (FLTVVG) Preseedboard meeting. Thus, line MMPn 89 2040, the code name, was included in the trial during rainy season (May-October) 2000. In 14 valid trials, it ranked first in the dry season and second in the rainy season at different test locations. Because of its good performance, the FLTVVG recommended in November 2001, MMPn 89 2040 for first seed multiplication and for further seed increase in May 2002. In June 2003, the FLTWG endorsed MMPn 89 2040 and nominated it to the National Seed Industry Council (NSIC) Board for approval. Finally, it was approved by the NSIC Executive Committee as national variety for dry and rainy season cultivation in the Philippines in November 2003. The official name of the variety is NSIC Pn 12 and the common name is MMPn 1. Locally, it is also known as Ilocos Pink.

Performance

In 29 valid NCT trials conducted over two years, NSIC Pn 12 produced a mean yield of 1.59 t ha^{-1}, 0.63% more than check variety NSIC Pn 6 (Table 1). The average seed yield of NSIC Pn 12 in 13 valid trials in two rainy seasons (2000 and 2001) was 1.47 t ha^{-1} compared to 1.50 t ha^{-1} in check variety NSIC Pn 6. In the dry season in 2001 (8 valid sites) and 2002 (8 valid sites), NSIC Pn 12 out-yielded NSIC Pn 6 by 3.44% (Table 1).

Plant, pod and seed characters

NSIC Pn 12 has an erect growth habit. It matures in 95-100 days during the rainy season and 96-98 days during the dry season. The majority of the pods are two-seeded with an acceptable shelling outturn of 71-72%. Pods have slight beak, moderate constriction and slight reticulation. The seeds are oblong and large with pink seed coat. The seed contains 26.26% crude protein, 40.18% crude fat, 11.37% carbohydrates and 2.19% ash (minerals) (Bureau of Plant Industry 2002). Chemical composition of seed of the check variety NSIC Pn 6 was 25.34% crude protein, 40.06% crude fat, 27.63% carbohydrates and 2.32%

Reaction to diseases and insect pests

NSIC Pn 12 was evaluated for its reaction to diseases and insect pests over four seasons at 29 valid locations, on a 1-5 rating scale, where 1 = no leaf damage/infection and 5 = >51% leaf damage/infection. On average, it scored 2 for damage by leaf feeding insects, and 3 for late leaf spot incidence during both rainy and dry seasons (Table 2). For rust, the score varied from 1.8 in the rainy season to 2.8 in the dry season. The disease and insect pest reaction of NSIC Pn 12 was similar to check variety NSIC Pn 6.

Table 1. Seed yield (t ha^{-1}) of NSIC Pn 12 in the multilocational NCT trial during 2000 rainy season (RS) to 2002 dry season (DS), Philippines.

Entry	2000 RS[1]	2001 DS[2]	2001 RS[3]	2002 DS[2]	Mean RS	Mean DS	Overall mean"
NSIC Pn 12	1.63	1.70	1.31	1.74	1.47	1.72	1.59
NSIC Pn 6 (check)	1.54	1.70	1.47	1.62	1.50	1.65	1.58
Yield increase over check (%)	5.84	0.0	-10.88	7.41	-0.02	3.44	0.63

1. Mean of 6 valid trials.
2. Mean of 8 valid trials.
3. Mean of 7 valid trials.
4. Mean of 29 valid trials.

Table 2. Plant characters of groundnut varieties NSIC Pn 12 and NSIC Pn 6 during rainy season (RS) and dry season (DS) in the Philippines.

Characters	NSIC Pn 12		NSIC Pn 6 (check)	
	RS	DS	RS	DS
100-seed mass (g)	46.7	57.0	49.1	58.6
Shelling outturn (%)	71.4	72.7	70.8	72.0
No. of pods $plant^{-1}$	15	16	15	16
Plant height at maturity (cm)	65.6	42.0	66.9	41.1
Disease/pest reaction[1]				
Late leaf spot	3.0	3.0	3.0	3.0
Rust	1.8	2.8	2.0	2.7
Leaf feeding insects	2.0	2.0	2.0	2.0

1. Scored on a 1-5 rating scale, where 1 = no leaf damage/infection and 5 = >51% leaf damage/infection.

Seed availability

The Mariano Marcos State University, College of Agriculture and Forestry (MMSU-CAF), Legumes Project at Dingras, Ilocos Norte, Philippines maintains the breeder seed of NSIC Pn 12. Limited quantities of seed for seed increase/multiplication is available on request with FP Sugui, Project Leader, Legumes Project, MMSU-CAF, Dingras 2913, Ilocos Norte.

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A Black Seed Coat Groundnut Cultivar Zhonghua 9 Released in China

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For the first time in China, a black seed coat groundnut *(Arachis hypogaea)* cultivar was released as Zhonghua 9 in March 2004 by Hubei Province. This cultivar was developed by the Oil Crops Research Institute (OCRI) of Chinese Academy of Agricultural Sciences (CAAS). Zhonghua 9 was selected from hybrid progenies of a cross (5001 x NC Ac 17133) x 5001 by pedigree method. In a two-year varietal trial in Hubei Province during 2001-02, Zhonghua 9 produced yields similar to the local control. In replicated quality test, its oil content was 49.3% and protein content was 28.3%. It was regarded as a special edible groundnut cultivar because of its black seed coat, which many consumers liked (Fig. 1). Additionally, it is resistant to late leaf spot and rust and moderately resistant to bacterial wilt.

Figure 1. Groundnut cultivar Zhonghua 9 having black seed coat.

Two Groundnut Varieties Tozi and ElAhmedi for the Irrigated Clays of Central Sudan

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Groundnut *(Arachis hypogaea)* is produced under two different sectors in Sudan: the irrigated sector and the rainfed sector. Irrigated groundnut contributes about 44% to the total groundnut production in Sudan (Mukhtar and Ali 1998). Groundnut productivity is high in the irrigated sector; hence, it can serve as a stabilizing reservoir especially in years of low productivity in the rainfed sector. Late-maturing Virginia *(A. hypogaea* subsp *hypogaea* var *hypogaea)* cultivars with characteristic large seeds are predominantly grown in this sector. Thus, with the objectives of developing high-yielding cultivars varying in seed size, a crossing program was initiated in 1980. Using pedigree method, C69A-25-1 -1 -1 was selected from a cross between Robut 33-4-1 and MH383, while C109A-7-4-B-2 was selected from a cross between two Spanish *(A. hypogaea* subsp *fastigiata* var *vulgaris)* parents UF78-1499 and UF78-1009 obtained from late Prof A Norden, University of Florida, Gainsville, Florida, USA. Due to their excellent performance in the preliminary and advanced on-station trials, these cultivars were incorporated and tested in the national irrigated groundnut variety trial between 1993 and 1998 full irrigated seasons. Based on these tests, the Sudan Variety Release Committee released C69A-25-1-1-1 as Tozi and C109A-7-4-B-2 as ElAhmedi in 2000 for the irrigated clays of Central Sudan.

These two breeding lines were tested together with ten cultivars including three local controls in a randomized

Table 1. Pod yield (kg ha^{-1}) of two groundnut genotypes at three locations in Sudan during 1993-99[1].

	Wad Medani						New Haifa			ElRahad
Genotype	93/94	94/95	95/96	96/97	97/98	98/99	96/97	97/98	98/99	(97/98)
C69A-25-1-1-1	3585	4610	4070	3108	5030	4867	2056	4250	4205	2722
C109A-7-4-B-2	3675	3739	4715	3157	5056	5038	1847	4709	3213	3103
Kiriz (check)	2571	2809	4864	1585	3542	3525	1292	4391	2400	2625
MH383 (check)	3379	3639	3966	2667	4667	3715	1625	4751	3094	2917
Medani (check)	–	-	-	2647	3976	5385	1403	4251	4284	2528
SE±	352*	245*	550	159**	250*	361*	338	530	338*	147
CV(%)	21	13	27	13	11	17	25	25	20	11

1. * = Significant at 5% level; ** = Signi ficant at 1% level.

Table 2. Pod yield, shelling outturn, 100-seed mass, haulm yield and oil content of two groundnut genotypes in different trials (T) in Sudan[1].

	Pod yield (kg ha^{-1})		Shelling outturn (%)	100-seed mass (g)	Haulm yield (kg ha^{-1})	Oil
Genotype	10T	7T	(5T)	(5T)	(3T)	content (%)
C69A-25-1-1-1	3851	3750	66	46	7735	50
C109A-7-4-B-2	3825	3732	62	59	6952	52
Kiriz (check)	2960	2766	65	65	5378	43
MH383 (check)	3378	3257	65	52	6826	51
Medani (check)	-	3239	65	49	5903	-
SE±	107**	121**	2.9**	2.2**	379*	-
CV *(%)*	19	19	6	6.6	21	-

1. * = Significant at 5% level; ** = Significant at 1% level.

complete block design with five replications for six seasons at the Gezira Research Station, Wad Medani, three seasons at New Halfa Research Station and one season at ElRahad Research Station. Out of ten trials, cultivars differed significantly in six trials (Table 1). The combined data analysis over ten trials with two controls and over seven trials with three controls showed that C69A-25-1-1-1 and C109A-7-4-B-2 significantly out-yielded the controls (Table 2). C69A-25-1-1-1 showed increase in pod yield of 30% over Kiriz and 14% over MH383 in ten trials, and increase of 36%, 15% and 16% over Kiriz, MH383 and Medani, respectively in seven trials. C109A-7-4-B-2 also showed increase in pod yield of 29% over Kiriz and 13% over MH383 in ten trials and increase of 35%, 15% and 15% over Kiriz, MH383 and Medani, respectively in seven trials. With regard to seed size, Medani and MH383 belong to the US runner types while Kiriz is characterized as a Virginia marker type (ElAhmedi et al. 1993). C69A-25-1-1-1 with 46 g average 100-seed mass belongs to the Spanish type, which is predominantly grown in the rainfed areas of Western Sudan (ElAhmedi and Osman 1987). C109A-7-4-B-2 with average 100-seed mass of 60 g could be characterized as a Virginia market type. With the incorporation of these cultivars in the production system of the irrigated clays, the irrigated sector will for the first time be truly capable of meeting all groundnut grades and standards required in the international groundnut market. Both cultivars have reasonable high shelling outturn, high haulm yield and high oil content. Botanically they belong to subsp *hypogaea* var *hypogaea.* However, C69A-25-1-1-1 has decumbent-3 growth habit with 35 cm stem height and tertiary branches while C109A-7-4-B-2 has decumbent-1 growth habit with 53 cm stem height and rarely tertiary branches.

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Molecular Diversity for Resistance to Late Leaf Spot and Rust in Parents and Segregating Population of a Cross in Groundnut

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Groundnut (*Arachis hypogaea*) is being cultivated in different agroclimatic conditions in most of the groundnut-growing states of India. As the area under groundnut is predominant in *kharif* (rainy) season (81%), the foliar diseases like late leaf spot (LLS) and rust may cause yield losses of up to 50% in the semi-arid tropics (Subramanyam et al. 1980). Due to the high cost of production, groundnut farmers rarely undertake plant protection measures; in such cases use of resistant genotypes is inevitable. Earlier efforts made to introgress resistance to above foliar diseases by wide hybridization in groundnut have not been quite successful in view of association of disease resistance with undesirable pod traits like poor shelling outturn and prominent reticulation on the pods (Dwivedi et al. 2003). However, use of advanced breeding lines with desirable characters and adapted varieties in the hybridization program made it possible to overcome the above deficiencies. The work initiated at the University of Agricultural Sciences (UAS), Dharwad, Karnataka, India in this direction enabled to identify a very promising genotype GPBD 4 that has multiple resistance to foliar diseases.

In groundnut, although extensive variation occurs for morphological and physiological characters in cultivated as well as wild species (Halward et al. 1991), many studies indicate limited variation at the DNA level (Kochert et al. 1991, Halward et al. 1993). Evaluation of genotypes for existence of genetic diversity based on morphological features may not be efficient as they are highly influenced by environment. On the other hand, the molecular techniques employed earlier in groundnut suggests the utility of random amplified polymorphic DNA (RAPD) markers in identifying polymorphism at the DNA level (Halward et al. 1991, He and Prakash 1997, Dwivedi et al. 2001). Therefore, this study was carried out to identify DNA profiles for tagging disease resistance in the segregating population of a selected cross and to determine molecular diversity among the genotypes for the levels of resistance to LLS and rust.

Ten RAPD assays (Williams et al. 1990) using oligo-nuleotide primers OPF-02, OPF-09, OPF-10, OPAG-03, OPAG-06, OPAG-18, OPA-07, OPA-09, OPA-15 and OPA-18 were used to study diversity among three parents (two rust and LLS tolerant parents GPBD-4 and Dh-22 and one susceptible parent Dh-40). Ten recombinant progenies from a three-way cross of Dh-40 x (GPBD-4 x Dh-22) were also studied along with the parents after the preliminary evaluation of genotypes in F_2 for the incidence of diseases. Of the ten recombinant lines used, RL1, RL2, RL3, RL4, RL5 and RL7 were resistant while RL8, RL9, RL10 and RL11 were susceptible to rust and LLS. Young leaves from two-week-old plants grown in pots were bulk harvested and DNA was extracted adopting the cetyltrimethylammonium bromide (CTAB) method as suggested by Saghai-Maroof et al. (1984). The polymerase chain reaction (PCR) was performed following the procedure suggested by Subramanian et al. (2000). Amplified products were scored for presence and absence of a band by assigning the values 1 and 0 from higher to lower molecular weight, respectively. Polymorphism (%) for each primer was computed as:

$$P = (N_P,/N_A)\ 100$$

where N_A is the total number of amplified fragments and N_P, is the number of amplified fragments. Similarity

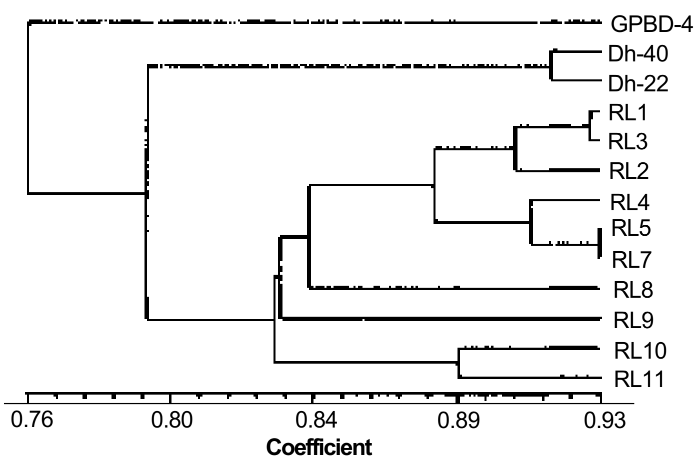

Figure 1. UPGMA-based dendrogram obtained from pooled data of RAPD profiles of groundnut parents and selected progenies of the cross Dh-40 x (GPBD-4 x Dh-22).

Table 1. Analysis of RAPD patterns generated using ten primers comparing groundnut parents and progenies of the cross Dfa-40 X (GPBD-4 x Dh-22).

Primer code	Primer sequence	No. of bands	Polymorphic bands	Polymorphism (%)
OPF-02	5'GAGGATCCCT3'	6	1	16.6
OPF-09	5' CCA AGC TTC C 3'	12	7	58.8
OPF-10	5' GCA AGC TTG G3'	9	6	66.6
OPAG-03	5'TGC GGG AGT G3'	14	7	50.0
OPAG-06	5' GCT GGC ATA C 3'	10	4	40.0
OPAG-18	5' GTG GGC ATA C 3'	9	4	44.4
OPA-07	5GAA ACG GGT T3'	17	17	100.0
OPA-09	5' AGG TGA CCG T 3'	14	10	71.4
OPA-15	5' TGC CGA GCT G 3'	9	9	100.0
OPA-18	5' GGG TAA CGC C 3'	14	10	71.4
Total		114	75	
Mean			7.5	61.92

coefficients (Sij) were used to determine pair-wise comparisons and Sij values (Nei and Li 1979). A dendrogram was constructed based on the Sij values using clustering technique of unweighted pair-group method of arithmetic average (UPGMA) using NTSYS PC software (Rohlf 1993).

The results indicated that ten primers produced polymorphic bands ranging from 16.6% to 100% with an average of 62% per primer (Table 1). Among the primers OPA-07 and OPA-15 revealed 100% polymorphism followed by OPA-09 and OPA-18, which revealed 71.4% polymorphism. The results obtained are in conformity with the earlier reports of Bhagwat et al. (1997), Subramanian et al. (2000), Dwivedi et al. (2001) and Nalini Mallikarjuna et al. (2003). Thus, it is opined that RAPD assays can be efficient in identifying DNA polymorphism provided suitable primers are used.

Seventy-eight comparisons were made using dice similarity coefficients generated from pooled data of all the ten primers. The results revealed that genetic similarity coefficients of the genotypes ranged from 0.76 to 0.93 with an average of 0.86. This suggested that molecular diversity among the parents as well as in their segregating populations is low when compared to overall parental diversity (0.71 to 0.90) (Nagarajareddy 2003). This is probably due to limited number of parents used for such studies and also genetic constitution of parents involved in the cross. Further, analysis of parents and progenies revealed that the parent GPBD-4 identified itself in a distinct cluster at 0.73 Sij (Fig. 1). The individual progenies sharing genes of GPBD-4, viz, RL1, RL2, RL3, RL4, RL5 and RL7, all resistant formed one cluster but separately from their susceptible counterparts. The resistant progenies RL7 and RL5 showed clustering at 0.93 and the progenies RL1 and RL2 clustered at 0.92 Sij suggesting existence of DNA level variation even within the resistant progenies. Among the susceptible lines, RL10 and RL11 clustered distinctly away from the resistant group. However, the parents Dh-22 (resistant) and Dh-40 (susceptible) belong to the same botanical group, ie, Spanish bunch and clustered together at 0.92 Sij. This is also confirmed from the study of Halward et al. (1991) which indicated less variation in Spanish groundnut compared to wild species. The lack of variation in cultivated type may be attributed to recent origin and genome complexity of the crop.

Clustering of resistant genotypes in one group based on phenotyping of LLS and rust is being confirmed in this study. Therefore, it can serve as a basis for future work for tagging resistant genes. However, more primers need to be screened for better understanding and confirmation of the above results.

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Evaluation of Transgenic Groundnut Lines Under Water Limited Conditions

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Groundnut *(Arachis hypogaea),* an annual legume crop, is the third major oilseed of the world, and is produced in tropical and sub-tropical regions. Asia accounts for 66.5% of the world groundnut production while Africa produces only 24.7%. Poor yields of the groundnut crop are often due to abiotic constraints like drought or low soil fertility. Annual estimated losses in groundnut production, equivalent to over US$520 million, are caused by drought (Sharma and Lavanya 2002). Yield losses due to drought are highly variable in nature and depend mainly on the timing, intensity and duration of drought.

Genetic improvement for drought tolerance is crucial in many regions where agriculture depends on scarce water resources. The finding of the genes involved in the tolerance to drought and their insertion in the genetic background of agronomically preferred varieties could enhance and/or stabilize the yields under drought-prone situations. Therefore, a holistic approach integrating physiological dissection and molecular marking of the tolerance traits is needed (Subbarao et al. 1995) to understand the mechanisms underlying tolerance, and to insert these traits into agronomically desirable material. Plant survival under severe drought is an important aspect of the tolerance to drought as it contributes to ensure a minimum yield in subsistence farming.

Research in transgenic crops may offer new means to improve agriculture, particularly in dry areas, as genes specifically involved in the response to drought have been identified (Liu et al. 2000). However, a major challenge of transgenic research, besides obtaining transgenic material, is to understand the physiological expression at the plant level of the inserted genes. Transgenic groundnut lines from the parent JL 24, with enhanced survival under moisture deficit conditions, have been developed. The process included transformation of drought-responsive elements and transcription factors.

like DREB1A cDNA driven by drought-responsive promoter rd29A, which specifically interacts with the DRE inducing the expression of stress tolerance genes (Shinozaki and Yamaguchi-Shinozaki 1997). Fourteen transgenic lines of T-2 generation along with the untransformed JL 24 were evaluated. This study was conducted to: (i) assess the transpiration response of transgenic groundnut to water deficit in comparison to the control JL 24; and (ii) select a few lines with contrasting responses for further detailed studies (leaf gas exchange characteristics of transgenic material).

Methods

The dry-down experiment was conducted according to previous work using FTSW (fraction of transpirable soil water) as a covariate (Sinclair and Ludlow 1986, Ray and Sinclair 1997) and included exposure of plants to progressive drought by withholding water. The dry-down plants typically go through three stages. Stage I occurs when there is non-limiting soil water to fully supply transpiration demand. Stage II occurs when the roots no longer fully supply transpiration demand and stomatal conductance decreases to adjust transpiration to available water. Stage III occurs when stomatal conductance is at a minimum and can no longer decrease.

Twelve plants per transgenic line were grown under well-watered conditions until 19 days after sowing in glasshouse conditions with 20/12°C day/night temperatures. Single plants were grown in 20-cm diameter pots, filled with 4.5 kg Alfisol taken from a field with low nitrogen content (8.5 mg kg^{-1}) and mixed with 4 g of single super phosphate. Seeds were inoculated with *Bradyrhizobium* NC 92 (IC 7001) (1 g L^{-1}) to ensure adequate nodulation of groundnut and 2 g of carbofuran. At 19 days after sowing, pots were saturated with water prior to exposure to water stress. The pots were sealed with polythene bags to prevent any water loss directly from the pots. The pattern of the transpiration response to soil drying and FTSW was examined on the basis of recorded daily weights of the pots. The water loss by transpiration in irrigated control pots was added back daily. No water was added to drought stressed plants. Normalized transpiration rate (NTR) was calculated to compare the transpiration of drought stressed plants to that of control and to minimize the effect of plant-to-plant variation (Ray and Sinclair 1997). Drought stressed plants were considered to have extracted all the extractable water from the pot when NTR was less than 10% of the transpiration of controls, defined as the end point of the dry-down (beginning of stage III). A plateau regression procedure using SAS (SAS Institute 1989) and NTR as a function of FTSW was applied to calculate the threshold at which the stomatal closure initially occured, ie, when transpiration began to decline. This allowed the calculation for the number of days between initial decline of transpiration and the end of the dry-down for each transgenic line (stage II).

Results

Control JL 24 started to show wilting symptoms (loss of turgor) after 21 days of stress and thereafter, severe symptoms were evident in this line. It took 27 days for control JL 24 to reach stage III (NTR<0.1). The transgenic lines showed no wilting symptom even after 21 days. Thereafter, transgenic lines started to vary in their wilting symptoms, with a few transgenic lines showing no symptoms, while lines RD 14, RD 22 and RD 25 showed reduced level of symptoms (compared to JL 24). The transgenic lines differed largely in the time (number of days) to reach the end point (Table 1). RD 14 reached the end point in 29 days, about the same time as control JL 24, while RD 4 reached the end point at 52 days. All the lines had similar growth at the time when

Table 1. Average number of days to end point of the drying cycle for groundnut transgenic lines along with control JL 24.

Line number	Number of days to end point[1]
JL 24 (control)	27 e
RD 14	29 de
RD 13	32 d
RD 25	32 d
RD 19	33 d
RD 22	34 cd
RD 12	36 c
RD 28	36 c
RD 30	39 bc
RD 20	44b
RD 23	44b
RD 21	45 b
RD2	47 ab
RD11	49 ab
RD 4	52 a

1. Means followed by the same letter have overlapping 95% confidence intervals using Duncan's multiple range tests.

drought stress was applied, so the differences in plant responses reported here are not related to plant size.

The data of NTR, FTSW and number of days to end point were subjected to average linkage cluster analysis for preparing dendrogram using Euclidean distance of NTSYSPC (Version 2.10 d). The dendrogram (Fig. 1) showed that the lines could be broadly classified into four groups at 0.6 SI (similarity index), which clearly distinguished the water-use pattern among these lines, and suggested that the transgenic lines differed in their stomatal response to water deficit.

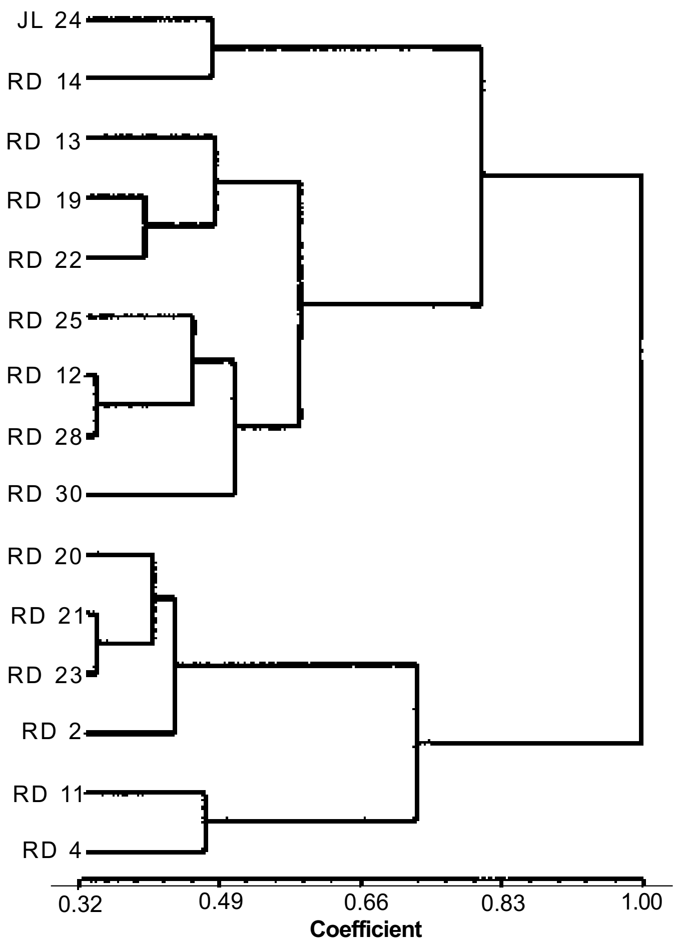

Figure 1. Dendrogram showing relative similarities in 15 transformed groundnut lines (including control JL 24) based on FTSW threshold values and the number of days to end point under water deficit conditions.

The results confirmed that drought-responsive elements inserted in the transgenic groundnut plants are linked to stomatal regulation. The fact that certain transgenic genotypes withstand drought for longer periods, and how this relates to stomatal closure needs further investigation, as there might be a scope to use transgenic plants for inducing drought tolerance. Here, we identified contrasting transgenic material to assess the physiological response of stomata under drought, with RD 4 withstanding drought for long while RD 14 was similar to control JL 24. A selection of contrasting transgenic lines from this study is being used in detailed experiments to confirm present results, and further investigate the link between the differences in stomatal closure and the transpiration efficiency.

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Pathology

Sources of Resistance to Bud Necrosis Disease in Groundnut

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Bud necrosis is an economically important viral disease of groundnut *(Arachis hypogaea)* caused by peanut bud necrosis virus (PBNV), vectored by *Thrips palmi.* It occurs in all major groundnut-growing areas of India and other parts of Southeast Asia (Ghanekar et al. 1979, Gopal and Upadhyaya 1991, Reddy et al. 1991, Dwivedi et aL 1995). The disease incidence on groundnut genotypes differs considerably in the fields (5 to 80%). Low disease incidence observed in certain genotypes is due to the vector non-preference (Buiel 1993). Yield losses due to bud necrosis mainly depend on the time of infection. Infection in <50-day-old plants results in no pod yield and >70-day-old plants are less susceptible to the disease and such plants will have near normal pod setting (Gopal and Upadhyaya 1991). Host plant resistance to PBNV is scarce in the germplasm. Identification of genotypes that can tolerate the disease during early stages of crop growth are useful in mitigating yield loss due to the disease. Therefore in this study, 242 groundnut accessions were evaluated to identify genotypes with field resistance to bud necrosis in three cropping seasons during 1996-97 under epiphytotic conditions at the Regional Agricultural Research Station (RARS), Jagtial, Andhra Pradesh, India. Of the 242 genotypes, 190 were from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh; 15 from the National Research Centre for Groundnut (NRCG), Junagadh, Gujarat; 10 from the University of Agricultural Sciences (UAS), Dharwad, Karnataka; and 27 from RARS, Jagtial. Bud necrosis resistance in various genotypes was assessed based on the percentage of disease incidence and area under disease pressure curves (AUDPC) (Southern and Wilcoxson 1984).

The three trials were sown on 17 July 1996, 20 November 1996 and 15 July 1997 at 45 cm x 20 cm spacing. in 2 rows of 5 m length and replicated twice. One row of cv JL 24, highly susceptible to PBNV was sown after every four rows of test genotypes. Buffer crop of JL 24 was sown around the experimental field to maintain PBNV inoculum. Field operations followed were as per the package of practices of Acharya NG Ranga Agricultural University (ANGRAU), Hyderabad, Andhra Pradesh (Anonymous 1985). No plant protection measures against diseases or pests were used. Bud necrosis incidence was recorded at 10-day intervals, with first observation from 30 days after sowing (DAS) till a week before crop harvest. The infected plants were marked with colored bamboo pegs to facilitate easy recognition of infected plants and to avoid miscounting in case of premature death of early infected plants. After final observation disease incidence (%) was calculated for each observation and AUDPC (A-value) was calculated by multiplying disease incidence (%) with days (duration between DAS and date of observation) (Nagarajan and Muralidharan 1995).

But necrosis was first recorded in JL 24 at 20, 39 and 22 DAS in rainy *(kharif)* season 1996, postrainy *(rabi)* season 1996/97 and rainy season 1997, respectively (Table 1). However, disease incidence in JL 24 was variable and was 98% in rainy season 1996, 66% in postrainy season 1996/97 and 69% in rainy season 1997. But highest disease incidence was always in JL 24 during the three seasons tested (Table 1). Only 89/94-3-2 remained free from PBNV infection during all the 3 rainy seasons (Table 1).

Disease incidence (%) and A-values were considered for evaluating the resistance. Based on this, 10 of the 242 genotypes tested were promising resistant sources (Table 1). The genotypes 89/94-3-2, ICGV 92269, 83/151-7 and 85/203-6 consistently recorded low disease incidence and A-value.

The disease incidence accounts the number of plants infected at a given time whereas the A-values account the disease incidence and age of the crop recorded several times during the cropping season to arrive at a single point scoring and measure the disease progress. Thus, A-value represents multipoint scoring of disease incidence reduced to single statistics and offers distinctive advantage in selecting genotypes possessing field resistance and is very useful in identifying field resistant sources (Southern and Wilcoxson 1984). For instance, bud necrosis incidence in 85/203-6,89/94-7-3 and ICGV 86031 was 2.7, 7 and 8%, respectively and the A-values were 49.7,255.6 and 102.7, respectively. Although disease incidence in ICGV 86031 was 8% it had a low A-value

Table 1. A-value and bud necrosis disease incidence of some promising groundnut genotypes at Jagtial, Andhra Pradesh, India[1].

	Kharif 1996		*Rabi* 1996/97		*Kharif* 1997		Mean	
Genotype[2]	A	DI	A	DI	A	DI	A	DI
ICGV 92269	48	5	NT[3]	NT	0	0	24	2.5
89/94-3-2	0	0	0	0	0	0	0	0
ICGV 91229	286	26	100	11	0	0	128.7	12.3
ICGV 91193	249	22	NT	NT	180	5	214.5	13.5
89/94-7-3	256	7	0	0	255	7	255.6	7
83/151-7	192	14	85	6	0	0	92.3	6.7
85/203-6	149	8	0	0	0	0	49.7	2.7
ICGV 91248	406	28	266	6	0	0	224	11.3
ICGV 91117	194	19	0	0	478	6	224	8.3
ICGV 86031	129	9	143	5	36	10	102.7	8
JL 24 (susceptible check)	2581	98	1820	66	1665	69	2021.9	77.7

1. A = AUDPC value; DI = Disease incidence (%).
Disease incidence was recorded 5-8 times during the crop growth period starting from 30 days after sowing.
2. All test genotypes were obtained from ICRISAT.
3. NT = Not tested.

(102.67) compared to 89/94-7-3 (256.6 A-value) suggesting that 7% incidence recorded in 89/94-7-3 occurred at early stage of crop growth and probably would result in greater yield loss. In ICGV 86031 the disease effect on yield would be low because most of the infection would occur with age of the crop. Data in Table 1 clearly indicate the usefulness of A-values over disease incidence (%) in differentiating the promising genotypes.

Three conclusions are drawn from this study: (1) Of the 242 genotypes tested, the genotypes 89/94-3-2, ICGV 92269, 83/151-7 and 85/203-6 were found to be most promising sources of resistance to bud necrosis; (2) There is a great variability in the reaction of groundnut genotypes to PBNV infection; and (3) The evaluation based on A-values was found to be more useful in identification of promising groundnut genotypes with field resistance to bud necrosis.

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Role of In Vitro Resistance *to* Aflatoxin Contamination in Reducing Pre-harvest Aflatoxin Contamination Under Drought Stress in Groundnut

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Aflatoxin contamination caused by *Aspergillus flavus* and *A. parasiticus* has been an important constraint to groundnut *(Arachis hypogaea)* industry worldwide. Genetic resistance to aflatoxin in groundnut is the most effective solution to this problem. Resistance to fungal infection as well as to aflatoxin contamination have been reported, but breeding for resistance has been slow due to various reasons. In most cases the resistance has been found unstable across locations or seasons and poorly related to pre-harvest contamination. During the past decade, we have been continuously screening for resistance to aflatoxin contamination by using artificial inoculation and toxin test under laboratory conditions and several resistant genotypes have been identified. In this study, the role of in vitro resistance to aflatoxin contamination in reducing pre-harvest contamination under natural conditions was studied by testing four resistant genotypes in potted trials with end-of-season drought stress treatment.

Four resistant lines, H 2030, H 2060, H 2063 and H 2095, and a susceptible line, 88-1202, were planted in 30-cm diameter plastic pots containing sandy loam soil. In each pot, four plants were grown. Potted plants of all the genotypes were normally managed during the first 80 days after sowing (DAS). For the end-of-season drought stress treatment, the potted plants were transferred to water shelter plot and protected from 80 DAS. Irrigation was controlled and the plants showed slight wilting symptom due to water deficit in the later growth stage. The control plants were normally irrigated and did not show wilting symptom. For each treatment, four replications were tested. The plants were harvested at 120 DAS. The seeds were tested for aflatoxin contamination within 30 days after harvest by using the fluoremeter method.

The results of aflatoxin determination are given in Table 1. Based on statistical analysis, the variances of both genotypes and treatment (drought) were significant. For the susceptible control genotype, 88-1202, drought stress treatment significantly increased the aflatoxin content. Under drought stress, the aflatoxin content of 88-1202 was also significantly higher than that of the four test genotypes which were previously identified with resistance to aflatoxin contamination under laboratory

Table 1. Aflatoxin concentration in different samples of groundnut under end-of-season drought stress.

		Aflatoxin content (μg g^{-1})				
Genotype	Treatment	I	II	III	IV	Mean
H 2030	Drought	0.035	0.152	0.034	0.071	0.073
	Irrigated	0.063	0.047	0.319	0.088	0.129
H 2060	Drought	0.560	0.369	0.662	0.341	0.483
	Irrigated	0.107	0.824	0.657	0.749	0.584
H 2063	Drought	0.081	0.242	0.168	0.329	0.205
	Irrigated	0.664	0.017	0.200	0.292	0.293
H 2095	Drought	0.412	0.529	0.074	0.425	0.360
	Irrigated	0.688	0.563	0.434	0.011	0.424
88-1202	Drought	2.254	2.842	1.220	3.143	2.365
	Irrigated	0.725	0.558	0.796	0.644	0.681

conditions. Drought treatment did not significantly increase the aflatoxin content in these resistant lines. The aflatoxin content of H 2030 was significantly lower than that of the remaining three test genotypes regardless of drought stress treatment. In previous experiments, H 2030 was relatively more resistant to aflatoxin contamination under artificial inoculation.

Several reports indicate that resistance to aflatoxin contamination is unstable and less useful. But our investigation verified that the aflatoxin resistant genotypes screened under laboratory conditions could also reduce pre-harvest contamination under drought stress. These germplasm lines could be valuable for further development in the breeding program.

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Agronomy/Physiology

Effect of Sowing Time and Rainfall Distribution on Groundnut Yield

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Groundnut *(Arachis hypogaea)* is the predominant crop under the current farming system in Saurashtra region of Gujarat, India. The crop is generally sown between 15 June and 1 July, depending on the normal onset of monsoon. However, the erratic onset of monsoon and commencement of sowing rains, sometimes, force the farmers to sow the crop late in the season. The farmers know that late sowing reduces the yield of groundnut crop. Hence, the purpose of this study was to investigate the advantages and disadvantages of normal and late sowing on yields and recommend farmers appropriate time for groundnut sowing.

The effectiveness of rainfall in crop production depends mainly on commencement of sowing rains and amount and distribution of rainfall during the season. The rainfall in Junagadh district in Gujarat is erratic with high variability from season to season and within the season (Sahu et al. 1994).

Materials and methods

A long-term fertilizer experiment was conducted for 29 years (1975-2003) at the research farm of Junagadh Agricultural University, Junagadh (21°31' N and 70°30' E, 61 m amsl). The trial was conducted on medium black and calcareous soil with 39% and 19% field capacity and permanent wilting point at 30 and 50 cm depth, respectively. The spreading groundnut variety GG 11 was used. Sowing was not taken up for two years (1992 and 1993) due to ban on groundnut cultivation at the research farm because of peanut stripe virus incidence; therefore yield data for these two years were not available. The data for 1987 is not included in the study because of severe drought. The yields of control plots (recommended fertilizers) were used as dependent variables to study the effect of sowing time, total rainfall, phenophasic rainfall and weekly rainfall pattern. The 17-week crop period was divided into six periods: (1) Emergence and vegetative (P1 = 3 weeks); (2) Flowering (P2 = 3 weeks); (3) Pegging (P3 = 3 weeks); (4) Pod formation (P4 = 3 weeks); (5) Pod filling (P5 = 3 weeks); and (6) Pod maturity (P6 = 2 weeks). Correlation and regression methods were adopted to assess the association between yield and rain-related parameters in the season. Daily rainfall data for the corresponding crop seasons were collected from the Agrometeorological Observatory located adjacent to the experimental field.

In each year, sowing was done after sufficient amount of rainfall was received during or after the 25th standard meteorological week (SMW). Hence the sowing time was divided into two periods, timely sowing (25* and 26* SMW) and late sowing (after 27* SMW), to study the effect of sowing time on yield.

On the basis of total growing period rainfall (sowing to maturity), each year of experimentation was classified as low rainfall year (<590 mm), moderate rainfall year (590 to 740 mm) or high rainfall year (>940 mm). According to yields, the years were grouped into three categories: below average (<575 kg ha^{-1}), average yield (575 to 1115 kg ha^{-1}) and above average yield (>1115 kg ha^{-1}). The delineation of years on the basis of total rainfall as well as yields was done in relation to long range mean and standard deviation (SD) values (mean ±0.5 SD).

Table 1. Sowing time, rainfall and yield of groundnut at Junagadh, Gujarat, India during 1975-2003[1].

Year	Sowing week	Harvesting week	Monsoon rainfall (mm)	Growing period rainfall (mm)	Rainy days	Yield (kg ha^{-1})
1975	25	45	694	662	52	1784
1976	25	41	815	775	44	582
1977	25	42	835	789	45	612
1978	25	41	694	635	33	1736
1979	26	44	1157	1120	37	1370
1980	25	45	1668	1427	38	1074
1981	28	45	1134	617	46	872
1982	28	44	892	852	45	364
1983	26	43	2791	1358	61	743
1984	27	45	1031	1010	33	458
1985	29	45	315	274	45	133
1986	26	41	696	284	39	466
1988	27	45	1382	1271	51	1655
1989	24	43	586	519	47	519
1990	28	45	852	789	47	539
1991	29	45	509	350	41	228
1994	24	43	1176	1176	61	634
1995	28	45	856	841	46	627
1996	25	44	731	632	32	1233
1997	25	44	837	796	39	1310
1998	27	44	968	902	39	317
1999	28	44	395	394	32	209
2000	28	44	595	353	29	698
2001	25	42	848	794	51	1286
2002	26	43	537	506	22	1597
2003	25	42	1281	1269	43	1690
Mean	26	44	934	784	42	874
SD	1.5	1.4	489.2	336	9.2	530
CV(%)	6.0	3.0	52	48	22.0	61
r	-0.512**	-0.158	0.180	0.337	-0.084	-

1. r = Correlation coefficient; ** = Significant at 1% level.

Results and discussion

Effect of sowing time. Out of 27 years, timely sowing was done in 13 years, late sowing in 12 years and sowing before 25* SMW in 2 years (Table 1). A closer look at the statistics reveals that there is a wide difference between total rainfall (934 mm) and actual rainfall during growth period (784 mm) of the crop. The yield of groundnut varied from 100 kg ha^{-1} in a disastrous drought year (1987) to 1784 kg ha^{-1} in a moderate rainfall year (1975), with an average of 846 kg ha^{-1} and variability of 61 %.

A critical examination of the relation between sowing time and yield revealed that timely sowing resulted in high yields while late sowing resulted in low yields. Commencement of sowing time has a relation with total rainfall in a season (Ramana Rao 1988). Timely onset of monsoon is mostly associated with moderate rainfall and late onset with low rainfall and short growing period, causing reduction in yield, irrespective of any amount of rainfall. The effect of total growing period rainfall and rainy days on yield revealed that high and moderate rainfall gave higher yields whereas low rainfall gave lower yields.

Effect of phenophasic rainfall. A good rainfall pattern between vegetative to pegging stages (32%, 28% and 18% of 849 mm average rainfall) coincides with timely-sown condition and a drought-like condition (9%, 8% and 7% of 678 mm of average rainfall) coincides with the critical periods of groundnut under late-sown condition in a season (Table 2). The correlation coefficient (r) between the rainfall during vegetative period (P1) and pod formation period (P4) was negative indicating that moderate rainfall had synergetic effect on the yield under timely-sown condition.

Under late-sown condition the rainfall during vegetative stage (P1) and flowering stage (P2) had positive and significant effect on yield. The effect of rainfall was greater on vegetative development than on reproductive organ development under late-sown condition (Mayeux 1992). Rainfall during subsequent periods was insufficient to meet the requirement of the crop resulting in lower yields. Krishnamurthy et al. (2002) have also observed that the occurrence of water stress during pegging to maturity resulted in drastic reduction of dry matter accumulation at maturity.

Conclusion

The following conclusions can be drawn from this study:

- Timely onset of monsoon and commencement of sowing rain in 25^{th} SMW led to moderate as well as high rainfall during the season whereas the late commencement of sowing rain led to low rainfall and resulted in low yields.
- Timely sowing resulted in good and moderate yields whereas late sowing resulted in low yields.
- With the advancement of sowing week, water stress during late stages of crop growth resulted in low yields.

Table 2. Statistics of rain-related parameters and groundnut yield in Junagadh, Gujarat, India, 1975-2003.

	Average (26 years)				Timely sowing				Late sowing			
Parameters	Mean	SD	CV (%)	r[1]	Mean	SD	CV (%)	r[1]	Mean	SD	CV(%)	r'
Sowing week (SMW)	26	1.5	6	-0.512**	25	0.5	2	-0.221	28	0.7	3	-0.503
Harvesting week (SMW)	44	t.4	3	-0.158	43	1.5	3	0.352	45	0.5	1	0.291
Rainy days	42	9.2	22	-0.084	41	10	24	-0.294	41	7.1	17	0.425
TotaJ monsoon rainfall (mm)	934	489	52	0.180	1056	609	58	-0.218	769	316	41	0.792**
Total crop period rainfall (mm)	784	336	43	0.337	849	365	43	0.092	678	338	50	0.825**
Phenophasic rainfall (mm)												
Vegetative (P1)	296	230	78	0.146	272	271	100	0.034	331	204	62	0.674*
Flowering (P2)	225	160	71	0.212	240	154	64	-0.167	183	147	80	0.694*
Pegging (P3)	113	106	94	0.368	156	130	84	0.191	62	43	70	0.141
Pod development (P4)	69	71	103	0.132	70	51	73	-0.028	60	88	146	0.309
Pod filling (P5)	66	64	96	0.249	84	73	86	0.045	39	49	125	0.200
Pod maturity (P6)	20	39	196	0.335	28	49	173	0.480	9	25	282	-0.174
Yield (kg ha^{-1})	874	530	61		1191	462	39		555	429	77	

1. r = Correlation coefficient; * = Significant at 5% level; ** Significant at 1% level.

- The rainfall during vegetative to pegging stages played a determining role under timely-sown condition and contributed to high yields.

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Variation in Transpiration Efficiency and Related Traits in a Groundnut Mapping Population

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Previous research to enhance *the* drought tolerance of groundnut *(Arachis hypogaea)* has led to the selection of transpiration efficiency (TE) as an important component trait of water-use efficiency (WUE) and a major source of yield variation under drought stress (Nageswara Rao and Wright 1994). The need to find non-destructive methods of selection for drought tolerant progenies and to breed for improved TE has subsequently led to the identification of surrogate traits that are closely related to TE such as carbon discrimination ($\Delta^{13}C$), specific leaf area (SLA), SPAD Chlorophyll Meter Readings (SCMR) and leaf nitrogen status (Nageswara Rao et al 2001). Low SLA has been incorporated into genotypes with high transpiration and/or harvest index through subsequent trait-based breeding approaches, with a parallel development of progenies through empirical breeding approach. Comparison of the progenies developed through trait-based and empirical breeding approaches, for enhanced drought tolerance and WUE across environments, have shown that the trait-based groundnut selections failed to demonstrate any clear superiority over the empirical selections for yield under drought (Nigam et al. 2003). This failure has necessitated reexamining the adequacy of the physiological model for fully explaining the yield and WUE variations, the reliability of the surrogate traits as a proxy for TE and the perfection of selection indices and genotype x environment analysis. These recent findings have also prompted the need for the development of a component-trait approach using molecular markers to characterize the parents precisely for the WUE related physiological traits and to identify relevant quantitative trait loci (QTLs) for subsequent marker-assisted selections (Nigam et al. 2003).

The dry-down experimental method, which consists *of* exposing plants to progressive and controlled drought stress, offers an adequate way to quantify the response of transpiration and TE traits to drought (Sinclair and Ludlow 1986). The first objective of this work was to characterize a set of genotypes including the two extensively used parents, ICGV 86031 and TAG 24, using the dry-down methodology for confirming the extent of contrast in their TE. The second objective was to characterize a set of mapping populations derived from a cross between these two parents for assessing the extent of TE variation among progenies and its suitability for further genotyping and phenotyping.

Seven genotypes (JUG 26, ICGS 76, CSMG 84-1, ICGS 44, ICGV 86031, TAG 24 and ICG 2773), known from previous studies to possess various combinations of transpiration, TE and harvest index, were subjected to a dry-down experiment following the methodology described by several authors (Sinclair and Ludlow 1986, Serraj et al. 1999). Single plants were grown in 20-cm diameter pots with 4.5 kg of Alfisol mixed with 4 g of single super phosphate. Rhizobial inoculation was carried out immediately after sowing. The design of the experiment was randomized complete block design (RCBD) with 8 replications per treatment and the treatments included well-watered control and gradual stress imposition. Five plants (replications) per genotype were grown separately and harvested at 28 days after sowing (DAS) to estimate the pre-stress leaf area and dry matter accumulation of the plant components. The pots

Table 1. Trial means, range of best linear unbiased predicted (BLUP) means and analysis of variance of transpiration efficiency (on the basis of total biomass) and its related characteristics at stages related to stress imposition and harvest of 318 groundnut RILs and their parents TAG 24 and ICGV 86031 during March-April 2004.

Trait[1]	Trial mean	Range of predicted means	SEd(±)	σ^2_g	CV (%)	Heritability[2] (h^2)
Transpiration (kg)	1.42	1.31-1.48	0.053	0.002 (0.0005)[3]	9.0	0.105
Transpiration efficiency (g kg^{-1})	3.08	2.63-3.52	0.276	0.06(0.011)	18.9	0.150
Specific leaf area at the start of stress (cm^2 g^{-1})	151.5	137.3-169.7	7.61	52.1 (8.0)	7.2	0.303
Specific leaf area at harvest (cm^2 g^{-1})	147.6	117.1-171.3	9.44	103.8(12.7)	10.7	0.293
SCMR at the start of stress	45.7	40.7-50.1	2.18	5.0 (0.66)	8.3	0.258
SCMR at 1 week after stress	49.8	43.1-55.2	2.61	6.7 (0.93)	9.4	0.232
SCMR at harvest	49.7	42.9-55.8	2.30	5.1 (0.72)	8.4	0.227

1. SCMR = SPAD Chlorophyll Meier Readings.
2. Heritability was estimated as $h^2 = \sigma^2_g/(\sigma^2_g + \sigma^2_e)$.
3. Standard error values are given in parentheses.

were irrigated to 90% field capacity until subjecting them to drought stress. Drought stress was imposed at 28 DAS by irrigating stress treatment pots, with 70% of the water lost during the previous day, as a measure to impose gradual stress while similar number of control pots received all the water lost. Drought stress treatment was considered to be completed when the normalized transpiration of stressed plants was lower than 0.1 of the transpiration of controls. Plants were then harvested and TE calculated as the biomass increase during the drought treatment, divided by the total water transpired during that period.

There were significant differences among the genotypes for TE, with TAG 24 showing the lowest TE values and ICGV 86031 the highest. The important finding in this study was that the soil water content where transpiration begins to decline relative to control, proxied by the fraction of transpirable soil water (FTSW) threshold, varied from one genotype to the other and these threshold values were negatively related to TE (Fig. 1). Although mesophyll efficiency, rather than stomatal factors, has been concluded to mainly contribute to TE in groundnut (Udayakumar et al. 1998), our results indicate the likelihood of involvement of stomatal control also in regulating the TE.

In another set of dry-down experiment, 318 F_8 recombinant inbred lines (RILs) derived from a cross between ICGV 86031 and TAG 24 were characterized for TE along with their parents. Large pots containing 8 kg of Alfisol mixed with 165 g of Multiplex® (vermicompost) and 2 g of diammonium phosphate (DAP) were planted with a single seed of each RIL in an alpha lattice (16 x 20) design with 8 replications and regularly irrigated to 90% field capacity until 33 DAS. At 33 DAS, three pots (replications) were harvested to assess the SLA and shoot and root biomass accumulated before the initiation of stress treatment. Soils of the remaining five pots for each RIL were saturated with repeated watering on the day before initiation of drought stress, allowed to drain overnight, and the pots were wrapped with polythene bags to prevent soil evaporation. The pots were weighed after overnight draining and then exposed to progressive drought stress. The SCMR were also recorded on all leaflets of the second fully expanded leaf from the top. Prior to drought imposition the weights of the pots and the SCMR of the parents were recorded everyday while that of the RILs were recorded on seventh day and on tenth day after drought imposition. Plants were harvested when 80% of plants were showing symptoms of permanent wilting. Plants were separated into leaf, stem and roots and SLA was recorded using the leaflets and the weights were recorded after drying the samples in hot air ovens.

Substantial variation among the RILs for transpiration, TE and SLA before and after imposition of drought stress and the SCMR before, during and at the end of imposition of drought stress was observed (Table 1). The parent ICGV 86031 had higher TE than TAG 24 (Fig. 2),

Table 2. Correlation coefficients among various transpiration efficiency (TE)-related traits of 318 groundnut RILs and their parents[1].

Trait	Transpiration (kg)	TE ($g\ kg^{-1}$)	SLA ($cm^2\ g^{-1}$) (pre-treatment)	SLA ($cm^2\ g^{-1}$) (at harvest)	SCMR at the start of stress	SCMR after 7 days of stress
TE ($g\ kg^{-1}$)	0.343***					
SLA ($cm^2\ g^{-1}$) (pre-treatment)	-0.031	-0.030				
SLA ($cm^2\ g^{-1}$) (at harvest)	-0.416***	-0.387***	0.425***			
SCMR at the start of stress	-0.009	0.102	-0.307***	-0.135*		
SCMR after 7 days of stress	0.374***	0.406***	-0.281***	-0.474***	0.515***	
SCMR at harvest	0.076	0.159**	-0.347***	-0.257***	0.644***	0.596***

1. SLA = Specific leaf area; SCMR = SPAD Chlorophyll Meter Readings.
* = Significant at 5% level; ** = Significant at 1% level; *** = Significant at 0.1% level.

lower SLA and higher SCMR (data not shown). The distribution of TE was normal and there were also RILs with values lower than the lowest parent and values higher than the highest parent indicating that the trait segregates transgressively and is governed by polygenes. Already well-documented relationships such as the negative relationship between TE and SLA, the positive relationship between TE and SCMR and the negative relationship between SLA and SCMR (Bindu Madhava et al. 2003) were exhibited clearly at 7 days after stress imposition (Table 2). However, such relationships of TE could not be seen with SLA or SCMR under well watered conditions before stress imposition (Table 2). Therefore, SLA and SCMR measured under well watered conditions are of little use since surrogate characters (SLA or SCMR) measured are mostly linked to TE after imposition of stress, and particularly at mid-way through stress. The heritability value for SLA was the highest (0.3), followed by that for SCMR (0.23). However, these values were low for TE or transpiration (Table 1) because these values are the plant biomass based estimates and therefore would have the reflections of polygenic control as seen for shoot biomass in chickpea *(Cicer arietinum)* under terminal drought (Serraj et al. 2004). Also TE was estimated from a pre- and post-treatment harvest, then with a different set of plants, and low number of replications, increasing the measurement of TE.

The FTSW threshold value estimated for ICGV 86031 was 0.43 and that of TAG 24 was 0.55. These values were about the same observed in the first experiment confirming

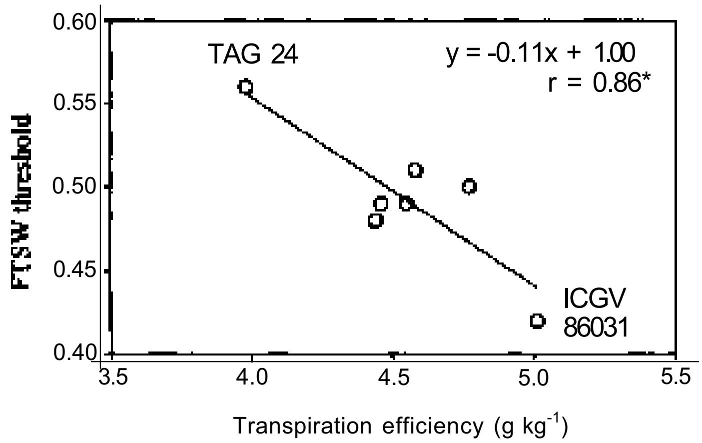

Figure 1. Relationship between transpiration efficiency ($g\ kg^{-1}$) and the fraction of available soil water (FTSW) threshold (at which the stomatal control starts limiting transpiration) in seven groundnut varieties with contrasting transpiration, transpiration efficiency and harvest index characteristics.

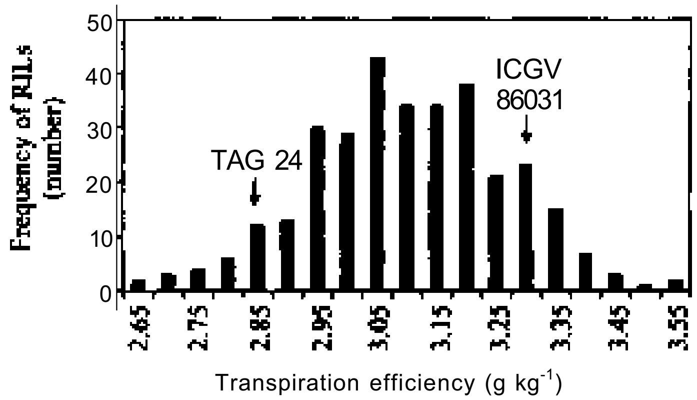

Figure 2. Frequency distribution of transpiration efficiency of 318 groundnut RILs along with their parents, ICGV 86031 and TAG 24, grown in a pot culture and exposed to progressively increasing drought stress till about permanent wilting point during 2004 season.

the varietal differences in the level of drought stress at which the stomatal control starts regulating the water loss.

In conclusion, adequate variation for TE is available among the parents as well as the RILs and considering the poor heritability of TE it is necessary to identify molecular markers for this trait. Although the relationship of SLA and SCMR with TE was significant, R^2 values remained fairly low (0.15-0.17). Therefore, SLA and SCMR can be useful surrogates as a proxy for TE, only when direct biomass-based evaluation of TE is not possible, like in field experiments. However, direct measurement of TE remains the best option when the need to estimate TE precisely is required, for example, for a precise physiological characterization of that trait, or to phenotype for TE for further genotyping and identification of molecular markers.

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Effect of Irrigation Regimes, Weed Management and Growth Regulators on Protein and Dry Pod Yields of Groundnut Grown Under Polythene Mulch

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India is the second largest producer of groundnut *(Arachis hypogaea)* accounting for 38% area (7.7 million ha) and 31% production (6.7 million t) of the world. However, the productivity in India is only 1046 kg ha^{-1} (2001-02) as compared to the world's average of 1662 kg ha^{-1} . Use of transparent polythene mulch in groundnut cultivation augments its yield by 20 to 50% (Wenguang et al. 1995). Amongst different inputs, water is of great significance to plants for their physiological and biochemical processes like transpiration, respiration, nutrient absorption, photosynthesis and translocation. Efficient and economical use of water is essential for higher productivity as it is a scarce and expensive input. There is a need to find out optimum water use and irrigation schedule for groundnut crop as high soil moisture results in pod rot, low yield and poor seed quality. Similarly, water stress reduces photosynthesis mainly due to the reduction in photosynthetic area. Application of growth regulators under optimal water supply increases the protein and dry pod yields of groundnut (Patil and More 1991). Hence, this investigation was conducted to study the effect of irrigation regimes, weed management and growth regulators on the protein and dry pod yields of groundnut grown under polythene mulch.

Field study

Field trials grown under polythene mulch were conducted during *rabi* (postrainy) season of 2000/01 and 2001/02 at the College of Agriculture, Dapoli, Maharashtra, India. The experiment was conducted in a split plot design with three replications. The treatments included three irrigation levels based on IW/CPE (irrigation water/cumulative pan evaporation) ratio, ie, 0.6,0.75 and 1.0 in main plots. The subplots consisted of combinations of three weed management levels: unweeded control, fluchloralin at 1.0 kg ai ha^{-1} and oxadiargyl at 0.12 kg ai ha^{-1}; and two levels of growth regulators: control and application of growth regulators (tricontanol at 50 ppm at 15 days after emergence and paclobutrazol at 75 ppm at 25 and 35 days after flower initiation). The gross and net plot sizes were 4.0 m x 3.6 m and 3.8 m x 3.0 m, respectively. The quantity of water applied per irrigation was 60 mm. The soil of the experimental plot was lateritic, clay loam in texture and acidic in reaction (pH 6.2). During 2000/01 and 2001/02 field capacity was 27.78% and 27.99% and wilting point was 16.13% and 16.22%, respectively. The water table during the experimental period was below 2 m. During 2000/01 and 2001/02 available nitrogen, phosphorus and potassium contents of the soil were 187.5 and 198.3, 16.9 and 20.3, and 285 and 310 kg ha^{-1}, respectively. Broadbeds of 60 cm width were prepared and well decomposed farmyard manure at 10 t ha^{-1} was mixed well in the soil at the time of broadbed formation. Full dose of fertilizers at 50 kg N ha^{-1}, 100 kg P_2O_5, ha^{-1} and 50 kg K_2O ha^{-1} was applied in a band opened at a distance of 20 cm on broadbeds at the time of sowing. Fluchloralin and oxadiargyl were applied pre-emergence as per the treatments on the beds. Then white transparent polythene film strips of 0.007 mm thickness and 90 cm width with holes at 20 cm x 10 cm were laid to cover the beds. The edges of each strip were buried on either side of the bed. Seeds of cultivar TG 26 were sown on 15 December 2000 and 30 December 2001 through the holes of polythene mulch. Two common irrigations, ie, at sowing and 8 days after sowing were given and then the irrigation schedule was followed as per the treatments. Tricontanol in the form of Vipul (0.1 %) and paclobutrazol 25 EC were sprayed as per the treatment. Need-based plant protection

Table 1. Effect of irrigation regimes, weed management and growth regulators on weed growth and protein and dry pod yields of groundnut at Dapoli, Maharashtra, India.

	Protein yield (t ha^{-1})			Dry pod yield (t ha^{-1})			Pooled dry mass of weeds at	Weed control efficiency
Treatment	2000/01	2001/02	Mean	2000/01	2001/02	Mean	harvest (t ha^{-1})	(%)
Irrigation regimes (IVY/CPE ratio)								
0.6 (360, 6)[1]	0.8	0.6	0.7	3.9	2.8	3.3	1.1	48.5
0.75 (420, 7)	0.9	0.7	0.8	4.4	3.6	4.0	1.3	39.9
1.0(540, 1)	0.9	0.7	0.8	4.6	3.7	4.1	1.4	35.5
SEm±	0.02	0.02	0.01	0.01	0.11	0.06	0.07	
CD (at 5%)	0.07	0.10	0.02	0.36	0.43	0.19	0.19	
Weedicide[2]								
Control	0.4	0.3	0.3	2.2	1.3	1.8	2.2	
Fluchloralin	1.0	0.7	0.8	4.8	3.7	4.3	1.2	43.2
Oxadiargyl	1.2	1.0	1.1	5.9	5.0	5.4	0.4	80.6
SEm±	0.02	0.01	0.01	0.10	0.05	0.05	0.10	
CD (at 5%)	0.06	0.03	0.02	0.29	0.15	0.13	0.27	
Growth regulators[3]								
Control	0.8	0.6	0.7	4.2	3.2	3.7	1.3	44.1
TRIA + PBZ	0.9	0.7	0.8	4.4	3.4	3.9	1.3	38.2
SEm±	0.02	0.01	0.01	0.08	0.04	0.04	-	
CD (at 5%)	0.05	0.02	0.02	0.24	0.12	0.10	NS[4]	

1. Total quantity of water supplied (mm), total number of irrigations given.
2. Fluchloralin at 1.0 kg ai ha^{-1} ; oxadiargyl at 0.12 kg ai ha^{-1}.
3. TRIA = Tricontanol (at 50 ppm); PBZ = Paclobutrazol (at 75 ppm).
4. NS = Not significant.

measures were followed. The nitrogen content in seeds was analyzed by modified micro Kjeldahl's method (Piper 1956) and was estimated for each plot. Then the protein content was calculated by multiplying the nitrogen content (%) in seeds by 6.25. The weed control efficiency (WCE) was calculated as:

$$WCE\ (\%) = \frac{W_0 - W_1}{W_0} \times 100$$

where W_0 = Dry weight of weeds from unweeded control; and W_1 = Dry weight of weeds from treated plot.

Effect of irrigation

The quantity of water applied at 0.6, 0.75 and 1.0 IW/CPE was 360, 420 and 540 mm in 6, 7 and 9 irrigations, respectively. In both the years, protein and dry pod yields were significantly higher with irrigation scheduling at 0.75 and 1.0 IW/CPE than at 0.6 IW/CPE. However, the protein yield differences at 0.75 and 1.0 rW/CPE were not significant (Table 1). Gajera and Patel (1984) also reported similar results on the effect of irrigation on pod yield under non-mulch condition. Dry matter of weeds was significantly higher with irrigation scheduling at 1.0 IW/CPE than at 0.6 IW/CPE. The maximum weed control efficiency (WCE) was observed at 0.6 IW/CPE (Table 1).

Effect of weed management

The following weeds were observed in the experimental fields.

Grasses: *Echinocloa colonum, Digitaria sangularis, Eleusine indica, Oryza sativa* and *Panicum miliaceum;* sedges: *Cyperus rotundus;* Broad-leaved weeds: *Physalis minima, Amaranthus viridis, Portulaca oleracea, Alternanthera triandra, Mimosa pudica* and *Eclipta alba.*

Among these *Digitaria sangularis* and *Physalis minima* were the dominant weed species.

Protein yield was significantly higher in plots with herbicides than unweeded control during both the years. Oxadiargyl spray resulted in significantly higher yield of protein than fluchloralin (Table 1).

During both the years, application of herbicides significantly increased the dry pod yield of groundnut over weedy control. Dry pod yield was significantly higher in plots with oxadiargyl at 0.12 kg ai ha^{-1} than in plots with fluchloralin and in unweeded control. Pawar (1999) also reported increased dry pod yield of groundnut due to application of herbicides. Dry matter of weeds was significantly reduced due to the use of herbicides in the pooled data. Among the herbicides, oxadiargyl spray recorded significantly less dry matter of weeds as compared to fluchloralin. The mean WCE values in treatment with oxadiargyl and fluchloralin were 80.6 and 43.2%, respectively.

Effect of growth regulators

Application of growth regulators significantly increased the mean protein and dry pod yields of groundnut (Table 1). Tilak (1991) also reported increased dry pod yield of groundnut due to application of growth regulator. Application of growth regulators did not influence the dry matter of weeds to a significant level.

Based on data of two years, we conclude that for obtaining higher yield from groundnut crop grown under polythene mulch, it should be irrigated at 1.0 IW/CPE with pre-emergence application of oxadiargyl at 0.12 kg ai ha^{-1}. If water is limited, irrigation may be scheduled at 0.75 IW/CPE ratio.

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Evaluation of Efficacy of Source and Levels of Sulfur for Groundnut in Lateritic Soil

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Groundnut *(Arachis hypogaea)* is an important oilseed crop in Orissa, India and occupies about 0.234 million ha. Although Orissa ranks third in productivity (1058 kg ha^{-1}) in India, there is a great scope for increasing the yield to 1750 kg ha^{-1}. Low yields of groundnut are due to the use of sulfur (S)-free chemical fertilizers in the state (Sahu et al. 1991). On an average 35% soils in Orissa are deficient in S; the lateritic soils show the maximum deficiency of 50-60% S. Response of groundnut to S through phosphogypsum in Orissa have been studied by Sahu et al. (1991) and Sahu and Dash (1997). They reported increase in yields ranging from 10 to 30%. Farmers are advised to use phosphogypsum as source of S at 40 kg ha^{-1} for groundnut. Sulphur-95®, a granular source containing 95% S, was compared with phosphogypsum (16% S) to evaluate the efficacy of these two sources at 20,40 and 60 kg S ha^{-1} in groundnut variety AK-12-24 on a lateritic loamy sand (Aeric Haplaquept) at the Regional Research Station, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, Orissa. An elemental S at 40 kg ha^{-1} was also tested. Eight treatments including one control were tested in a randomized block design during *rabi* (postrainy) seasons in 2001 and 2002. The crop received a common dose of 20 kg N ha^{-1},40 kg P_2O_5, ha^{-1} and 40 kg K_2O ha^{-1} through urea, diammonium phosphate and MOP, respectively. The soil had 0.428% organic carbon, 0.15% $CaCl_2$ and 9.6 ppm extractable S and the pH was 5.8.

The data (Table 1) showed that application of S to groundnut increased the yields of pod and haulm, shelling outturn and uptake of S by the crop. Application of S at 40 kg ha^{-1} either through Sulphur-95® or phosphogypsum showed almost equal yields and shelling outturn but produced higher yield than the elemental S of the same dose. The yields obtained with 20 kg S ha^{-1} from Sulphur-95® and phosphogyspum were similar to those with 40 kg S ha^{-1} through elemental S. Raising the S level from 40 to 60 kg ha^{-1} from either source produced an increase in pod yield of 12.6% with Sulphur-95® and 20.7% with

Table 1. Effect of source and levels of sulfur (S) in pod yield, haulm yield, shelling outturn and S uptake.

	Pod yield (t (ha^{-1})			Haulm yield (t ha^{-1})			Shelling outturn (%)			Suptalke (kg ha^{-1})		
Treatment	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
Control (no S)	1.05	1.03	1.04	1.86	2.00	1.93	57.3	59.5	58.4	6.08	5.93	6.01
S-95 (20 kg S ha^{-1})	1.24	1.04	1.14	2.35	2.01	2.18	68.8	65.5	67.2	9.01	8.31	8.66
S-95 (40 kg S ha^{-1})	1.50	1.46	1.48	2.59	2.40	2.49	73.7	66.7	70.2	11.36	11.73	11.55
S-95 (60 kg S ha^{-1})	1.76	1.58	1.67	3.08	2.95	3.01	69.4	71.7	70.5	12.70	14.41	13.56
Phosphogypsum (20 kg ha^{-1})	1.16	1.24	1.20	2.50	2.05	2.28	69.1	64.8	67.0	9.34	9.37	9.36
Phosphogypsum (40 kg ha^{-1})	1.46	1.44	1.45	2.74	2.61	2.68	75.6	71.4	73.5	10.47	13.60	12.04
Phosphogypsum (60 kg ha^{-1})	1.84	1.66	1.75	2.75	2.68	2.73	72.3	68.5	70.4	11.76	15.47	13.62
Elemental S (40 kg ha^{-1})	1.24	1.16	1.20	2.26	2.28	2.27	68.7	68.9	68.8	7.31	8.72	8.02
CD (at 5%)	0.346	0.382	0.276	0.604	0.618	0.515	5.63	8.89	5.48	2.89	3.04	2.22

phosphogypsum. Maximum shelling outturn of 73.5% was recorded due to application of 40 kg S ha^{-1}. The uptake of S was dependent on the concentration of S in plant and seed and was maximum at 60 kg S ha^{-1} from either source. Sulfur through elemental S proved to be a poor source.

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Effects of Fly Ash on Rice-Groundnut Cropping System in Lateritic Soil

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Groundnut *(Arachis hypogaea)* is a major oilseed crop of Orissa, India mostly cultivated in rice *(Oryza sativa)* fallows with residual moisture. The soils of these lands are moderately acidic having low nutrient status (Sahu 1999). Farmers normally use recommended dose of NPK fertilizer for both the crops. There is a reduction in yield due to depletion of secondary nutrients and micronutrients. Fly ash, a byproduct of the thermal power plants, is produced at 6.51 million t yr^{-1} in Orissa. It contains 80 ppm N, 30 ppm P, 43 ppm K, 800 ppm Ca, 54 ppm Mg, 21 ppm S, 18 ppm DTPA extractable Fe, 0.35 ppm Zn, 11 ppm Mn, 25 ppm Cu and 0.75 ppm B and the pH is 7.6. It corrects the soil acidity and improves the physical properties. An investigation was carried out to study the direct and residual effects of fly ash on rice-groundnut system in a lateritic sandy loam (Haplustalf) soil with pH 5.8 at the Regional Research and Technology Transfer Station, Mahisapat, Dhenkanal, Orissa during 1999/2000. The treatments included application of fly ash at 20 and 40 t ha^{-1}, 10 t ha^{-1} farmyard manure (FYM) and recommended NPK (80-17-33 kg ha^{-1}) alone and combination of fly ash with NPK and FYM (Table 1). Altogether nine treatments including one absolute control were replicated thrice in a randomized block design. All the treatments were imposed to rice in medium land and their residual effects were studied on groundnut variety AK 12-24 during *rabi* (postrainy) season 1999/2000.

The data indicated that application of fly ash, FYM or recommended dose of NPK alone increased the yields of both the crops as compared to control (Table 1). Integration of fly ash with 50% recommended dose of NPK increased the yields of both the crops significantly compared to

Table 1. Integrated effects of fly ash on rice-groundnut cropping system on lateritic soils in Orissa, India during postrainy season 1999/2000.

	Direct effect on rice		Residual effect on groundnut						
Treatment[1]	Grain (t ha^{-1})	Straw (t ha^{-1})	No. of nodules $plant^{-1}$	No. of pods $plant^{-1}$	Pod yield (t ha^{-1})	Haulm yield (t ha^{-1})	Shelling' outturn *(%)*	Seed yield (t ha^{-1})	Oil content (%)
T_1	2.0	2.2	38.0	9.6	0.9	1.8	66.3	0.6	40.8
T_2	3.7	4.2	36.3	13.3	1.3	2.4	68.3	0.9	41.4
T_3	2.5	2.8	37.7	13.3	1.1	2.2	67.0	0.8	40.6
T_4	2.5	2.9	42.0	13.3	1.2	2.2	67.0	0.8	41.3
T_5	2.8	3.1	46.3	15.3	1.3	2.3	68.0	0.9	41.2
T_6	3.6	4.1	45.0	15.0	1.2	2.2	67.0	0.8	42.0
T_7	3.6	4.1	46.7	16.3	1.3	2.4	67.3	0.9	42.0
T_8	3.7	4.2	45.7	16.6	1.3	2.5	67.7	0.9	42.1
T_9	3.8	4.3	45.3	17.0	1.4	2.6	70.0	1.0	42.3
SEm	0.1	0.1	0.1	0.7	0.04	0.1	0.9	0.02	0.2
CD (at 5%)	0.3	0.2	0.3	2.2	0.1	0.2	2.8	0.08	0.8

1. T_1 = Control (Absolute); T_2 = NPK (80 N:40 P_2O_5:40 K_2O kg ha^{-1}); T, = Farmyard manure (FYM) at 10 t ha^{-1}; T_4 = Fly ash at 20 t ha^{-1}; T_5 = Fly ash at 40 t ha^{-1}; T_6 = Fly ash at 20 t ha^{-1} + 50% NPK; T_7 = Fly ash at 40 t ha^{-1} + 50% NPK; T_8 = Fly ash at 20 t ha^{-1} + 50% NPK + FYM at 5 t ha^{-1}; T_9 = Fly ash at 40 t ha^{-1} + 50% NPK + FYM at 5 t ha^{-1}.

application of fly ash and FYM alone. These yields were similar to that obtained with application of 100% recommended dose of NPK. Maximum yields of rice (3.8 t ha^{-1}) and groundnut (1.4 t ha^{-1}) with high shelling outturn (70%) and oil content (42.3%) were obtained with integration of 40 t ha^{-1} fly ash, 5 t ha^{-1} FYM and 50% recommended dose of NPK. Perhaps increase in yields of crops due to application of fly ash may be due to increase in water-holding capacity and pH of acid soil (5.66 to 6.0) and decrease in the bulk density of lateritic soil. Also, supplementation of B to the deficient soil also contributed to the yields.

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Socioeconomics

Improved Production Technology in Raiiifed Groundnut Helps Reap Rich Benefits by Resource-poor Farmers of Andhra Pradesh

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The drought-prone districts (Kurnool, Mahbubnagar, Nalgonda, Anantpur and Prakasam) of Andhra Pradesh state of India are characterized by low soil fertility, inappropriate soil and water management practices causing land degradation, lack of improved varieties, pest and disease attack, declining land:man ratio, resource-poor farmers and rural poverty. In Andhra Pradesh 42% of total land area is degraded. The problem of land degradation is particularly serious where local food production cannot adequately provide survival options for the rural poor. Low agricultural yields and high population pressure have forced small and marginal farmers to cultivate fragile marginal lands and clear forests thus causing soil erosion and further land degradation. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Government of Andhra Pradesh have initiated a collaborative project with the Andhra Pradesh Rural Livelihoods Programme (APRLP) to help reduce poverty through increased agricultural productivity and improved livelihood opportunities through technical backstopping and convergence through a consortium of institutions.

Nucleus watersheds for undertaking on-farm research were selected in Karivemula and Devanakonda villages of Kurnool district, based on representative typology of the watershed, extent of rainfed areas, current crop productivity and willingness of community to participate in the on-farm research activities. The strategy adopted is knowledge-based bottom-up and participatory approach, which involved close interactions with the project implementation agencies (PIAs) and the farmers from the beginning. The detailed participatory rural appraisal (PRA) in each nucleus watershed helped us to understand the constraints for increasing the productivity from the farmer's perspective. Systematically collected soil samples from thirty farmers' fields in Karivemula and Devanakonda villages on a toposequence were analyzed for physical and biological parameters and various nutrients. The results indicated that all the fields are low in nitrogen (N) (599 mg kg^{-1} soil), low to medium in available phosphorus (P) (9.8 mg kg^{-1} soil) (Olsen's P), high in exchangeable potassium (K) (133 mg kg^{-1} soil), and low in available zinc (Zn) (0.4 mg kg^{-1} soil), sulfur (S) (3.2 mg kg^{-1} soil) and boron (B) (0.3 mg kg^{-1} soil). Information on soils along with historical rainfall and minimum and maximum temperature data enabled us to calculate the length of growing period (LGP). This critical information assisted us in identifying best-bet options to improve the productivities and managing natural resources sustainably.

Thirty on-farm trials were conducted during the rainy season in 2002 and 2003 with the objective to demonstrate the beneficial effects of improved production technologies on groundnut *(Arachis hypogaea):* improved cultivar (ICGS 11), seed rate of 125 kg ha^{-1}, seed treatment with a mixture of captan and benlate (3 g kg^{-1} seed) and inoculation with *Rhizobium,* a fertilizer dose of 20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}, basal application of micronutrient mixture (0.5 kg B ha^{-1}, 10 kg Zn ha^{-1}), split application of gypsum at 500 kg ha^{-1} (200 kg ha^{-1} as basal and 300 kg ha^{-1} as top dressing at pegging stage), and appropriate need-based pest and disease control measures. Improved production technology was compared with the farmers' method in an area of 1000 m^2 each. The farmers' method included a seed rate of 90 kg ha^{-1} and a fertilizer dose of 12 kg N ha^{-1} and 30 kg P_2O_5 ha^{-1} at planting. All other practices were the same. The crop experienced a long dry spell of 28 days from the beginning of pod initiation to pod maturity in 2002 and of 16 days from the beginning of peg initiation to the beginning of pod development in 2003. However, the season was more congenial for crop growth in 2003 as rainfall distribution was more uniform. The rainfall in both the years (480 mm) was below the mean long-term annual rainfall (572 mm).

The improved production technologies gave higher yield at all the locations. The pod yield was 1.22 t ha^{-1} in 2002 and 1.64 t ha^{-1} in 2003 compared to 0.77 t ha^{-1} and 1.02 t ha^{-1}, respectively with farmers' practice (Table 1). The increase in pod yield was 58% in 2002 and 61% in 2003. The increased pod yields with improved practice were mainly because of significant increase in number of filled pods $plant^{-1}$, shelling outturn (%), 100-seed mass and harvest index. Pod yield increases in response to balanced fertilization were also reported by Balasubramanian et al. (1988). The additional mean cost incurred in the improved package was US$25 ha^{-1} (1 US$ = Rs 45) as compared to increased mean income of US$158 with a benefit-cost ratio of 1.6. The improved production practices gave higher pod yields in both the years and evidently demonstrated the potential of improved technology.

In on-farm trials conducted by Prabhakaran et al. (1996), 24% higher pod yields and higher benefit-cost ratio of 1.72 were recorded with improved practices compared to a ratio of 1.48 with farmers' practice. Nguyen Thi Lien Hoa et al. (1996) reported 25% higher pod yields and 29% reduction in production cost with improved package (usage of locally available coconut ash instead of costly inorganic fertilizers, need-based chemical sprays for insect and pest control) in on-farm trials conducted in southern Vietnam. The results from this study clearly indicate the potential benefits of improved production technology in enhancing groundnut

Table 1. Economics of groundnut production in on-farm trials in Kurivemula and Devanakonda nucleus watersheds, Kurnool district, Andhra Pradesh, India, rainy season 2002 and 2003[1].

	Yield (t ha^{-1})			Cost of cultivation (Rs ha^{-1})			Net return (Rs ha^{-1})			Benefit-cost ratio		
Cultivation method	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean
Improved production technology	1.22	1.64	1.43	8770	9505	9138	11934	16694	14314	1.4	1.8	1.6
Farmers' practice	0.77	1.02	0.89	7967	8026	7997	6144	8275	7210	0.8	1.0	0.9
SE±	0.05	0.10		140.00	164.30		726.00	1434.00				
CV(%)	27	29		8.40	7.7							
LSD (5%)	0.14	0.27		398.16	473.40		2064.40	4130.80				

1. Data are means of 30 trials in each year.

yield and net returns in the dry ecoregions of Andhra Pradesh.

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On-farm Evaluation of Groundnut and Pigeonpea Intercropping System Using Participatory Rural Appraisal Techniques in the Saurashtra Region of India

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The advances in agricultural technology have contributed to increased productivity at research stations. However, it appears from the socioeconomic surveys that this is not reflected in raising the income and prosperity of the farmers in general and farmers belonging to the small production system in particular. The non-adoption of modern technologies by small and resource-poor farmers was attributed to the inadequate support system, such as extension, credit and input supplies, etc.

Saurashtra region of Gujarat state in India is characterized by typical semi-arid climate. Junagadh district, which lies between 71 ° 13' E longitude and 21 ° 1' N latitude was selected for the study. Based on the preliminary survey of 24 villages, four villages, viz., Vadhavi, Zanjarda, Nandarkhi and Umatwada were selected depending on area under groundnut (*Arachis hypogaea)* and transportation facilities. A detailed survey using different participatory rural appraisal (PRA) techniques was conducted by the core team scientists of the National Research Centre for Groundnut (NRCG) and participating scientists from Gujarat Agricultural University (GAU), Junagadh during 1995. Different PRA methods (Chambers 1992) like transect walk, mapping (resource, agroecology and household), seasonality analysis, livelihood analysis, venn diagrams (use of circles of paper or card to represent real linkages and distance between people, groups and institutions), matrix ranking and wealth ranking were used.

Monocropping of groundnut in set furrows 90 cm apart was a general practice in all the four villages. The PRA exercise with farmers indicated low yields of groundnut due to wide row spacing of 90 cm, high plant density ha^{-1} (2-5 cm plant to plant spacing within a row) and high seed rate (120-140 kg ha^{-1}), which resulted in interplant competition for light, nutrients and moisture. Mid-season drought, which affects the groundnut yield adversely, occurs frequently in the project area. To avoid risk of such crop failure and to increase the yield per unit area and resource-use efficiency, groundnut + pigeonpea *(Cajanus cajan)* intercropping was tried in the four villages. One hundred and twenty-five on-farm trials (OFTs) were conducted over a period of two years (1996-97). Each farmer was guided to lay out 1000 m^2 area under groundnut + pigeonpea intercropping system in rows of 1:1, 2:1 and 3:1. The rest of the field was cultivated according to the farmers' conventional practice (sole crop of groundnut). The idea was to provide an opportunity for the farmers to assess and compare the intercropping system with that of their own practice. Different methods were used to facilitate evaluation of the trials by the farmers themselves and elicit constructive feedback. The varieties tested were GAUG 10 [124 days to maturity (DTM)], GG 2 (104 DTM) and GG 20 (122 DTM) of groundnut and BDN 2 of pigeonpea. The staff of NRCG visited the villages and conducted farm walks several times during each season to promote discussions amongst fanners about the advantages of groundnut + pigeonpea intercropping system. All farmers agreed that groundnut + pigeonpea intercropping increased the gross monetary returns per

Table 1. Mean yield and gross monetary returns (GMR) of groundnut + pigeonpea intercropping trials during rainy season 1996-97 in Junagadh, Gujarat, India[1].

GN:PP row ratio (Varieties)	On-farm trials 1996				On-farm trials 1997				Mean GMR (Rs ha^{-1})
	No.	Yield (kg ha^{-1}) GN	Yield (kg ha^{-1}) PP	GMR (Rs ha^{-1})	No.	Yield (kg ha^{-1}) GN	Yield (kg ha^{-1}) PP	GMR (Rs ha^{-1})	
1:1 (GG 2 + BDN 2)	34	2031	1371	44,942	21	1700	1312	48,435	46,688
2:1 (GG 20 + BDN 2)	16	1635	1021	34,932	19	1505	1488	48,595	41,763
3:1(GAUG10 + BDN 2)	19	1443	1072	33,396	16	1585	1406	47,552	40.774
Farmers' practice Sole groundnut (GG 2, GG 20, GAUG 10)	-	1558	-	18,696	-	1461	-	21.915	20,305

1. GN = Groundnut; PP = Pigeonpea.

unit area per season. Of different row ratios tested, 1:1 plot recorded the maximum monetary returns of Rs 46,688 (Table 1).

A survey was conducted during 2001 rainy season with participating farmers and non-participating farmers to know the level of adoption. About 75% of participating farmers in an area of 65 ha and 30% of non-participating farmers in an area of 80 ha were adopting the groundnut + pigoenpea intercropping system (Satish Kumar and Devi Dayal 2002).

Farmers experienced that fodder from pigeonpea is highly relished by their cattle, which is an important component of the farming system. As observed from the PRA survey, the milk yield in these villages was low to medium due to non-availability of green fodder during lean period and also inadequate groundnut fodder. Therefore additional fodder of pigeonpea would help in reducing the fodder deficit to a certain extent. Also, stalks of pigeonpea could be utilized for different purposes as firewood and for making thatched houses and storage bins.

Based on this study it can be concluded that groundnut + pigeonpea intercropping was not at all being followed by the farmers in this region although it was being practiced in other parts of the country. By adopting PRA techniques it was possible for us to introduce this simple, low-cost, operationally feasible, economically viable and risk covering technology for the first time in the region, which gave security for food and fodder. Participatory OFTs comparing the farmers' practice allowed them to evaluate the potential benefits of the intercropping system for themselves. The technology was adopted on 10% of total groundnut area in 2001 and it is hoped that it would spread in the entire region of Saurashtra in the near future.

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Pande S and Parthasarathy Rao P. 2003. Evaluation of the effects of plant diseases on yield and nutritive value of crop residues used for peri-urban dairy production on the Deccan Plateau of India. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 56 pp. ISBN 92-9066-465-7. Order code CPE149. HDC US$15.00, LDC US$5.00, India Rs 257.00.

Traditional sorghum is susceptible to foliar and stalk diseases. Similarly, groundnut cultivars are also prone to complex fungal foliar diseases. The quantity and nutritive value of their residues are likely to be affected by these diseases besides grain and pod yields. The present study has addressed these issues. The project provided a unique framework to bring together social, plant and animal scientists to address the effects of plant diseases on nutritive value of crop residues on the institutional, village and the peri-urban dairy production level. Information has been collected from on-farm surveys of disease incidence on the Deccan Plateau in Andhra Pradesh, India. Perceptions of farmers and fodder traders regarding the effects of diseases have been solicited. On-station trials have been conducted to quantify disease efffects and their mitigation through management practices. Short-term animal feeding trials were undertaken to measure the effects of diseases on digestibility and voluntary intake in buffalo and cattle. The project not only documented and quantified the impact of plant disease on crop residue nutritive value but also identified possible approaches and solutions to the problems. The study found that disease management in these crops would benefit quality of crop residues used in dairy production, increase income and quality of milk.

Prasada Rao RDVJ, Reddy DVR, Nigam SN, Reddy AS, Waliyar F, Yellamanda Reddy T, Subramanyam K, John Sudheer M, Naik KSS, Bandyopadhyay A, Desai S, Ghewande MP, Basu MS and Somasekhar. 2003. Peanut stem necrosis: a new disease of groundnut in India. Information Bulletin no. 67. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 16 pp. ISBN 92-9066-466-5. Order code IBE067. HDC US$12.00; LDC US$4.00; India Rs 207.00.

The first known instance of tobacco streak virus (TSV) in groundnut (*Arachis hypogaea)* was recorded when it caused a disease epidemic in 2000 in Anantapur, Andhra Pradesh, India. The disease was named as peanut stem necrosis. It is difficult to distinguish between stem necrosis and bud necrosis, another economically important viral disease of groundnut based on symptoms alone. Techniques have been developed for precise diagnosis of the disease by ELISA and by the reaction of indicator hosts. TSV infects several economically important crop plants and survives on many weed hosts under field conditions. *Parthenium,* a widely distributed and symptomless carrier of TSV, plays a major role in the perpetuation and spread of the disease. While the role of infective pollen and flower-inhabiting thrips in the transmission of TSV has been established, seed transmission of TSV in groundnut and other crop plants as well as in weed hosts requires further investigation. However, based on field observations and laboratory tests, this bulletin suggests several interim measures for the management of the disease.

Nigam SN, Giri DY and Reddy AGS. 2004. Groundnut seed production manual. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 32 pp.

In spite of the involvement of public sector seed producing agencies in groundnut seed production, the varietal seed replacement rate in the crop in developing countries remains low. This restricts the full benefit of varietal improvement research reaching farmers. Thus, the productivity of the crop remains low in most of the developing countries. Low seed multiplication ratio, bulky nature of the produce, quick loss of seed viability, self-pollinated nature of the crop and low profitability of the seed production systems discourage private sector's involvement in commercial seed multiplication of this crop. This situation can improve only when farmers, non-governmental organizations, and public sector agencies participate more vigorously in seed production of this crop. This manual provides basic information about the crop, formal and informal seed production systems and processes, and crop husbandry to enable farmers and others to take up formal or informal seed production of improved varieties of groundnut.

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The International *Arachis* Newsletter (IAN) is published annually by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Peanut Collaborative Research Support Program (Peanut CRSP), USA. It is intended as a worldwide communication link for all those who are interested in the research and development of groundnut or peanut (*Arachis hypogaea* L.) and its wild relatives. Though the contributions that appear in IAN are peer-reviewed and edited, it is expected that the work reported will be developed further and formally published later in refereed journals. It is assumed that contributions in IAN will not be cited unless no alternative reference is available.

IAN welcomes short contributions (not exceeding 1000 words) about matters of interest to its readers.

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- Keep the items brief - remember, IAN is a newsletter and not a primary journal. About 1000 words is the upper limit (no more than four double-spaced pages). In exceptional cases, longer articles may be accepted.
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About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political, international organization for science-based agricultural development. ICRISAT conducts research on sorghum, pearl millet, chickpea, pigeonpea and groundnut - crops that support the livelihoods of the poorest of the poor in the semi-arid tropics encompassing 48 countries. ICRISAT also shares information and knowledge through capacity building, publications and ICTs. Established in 1972, it is one of 15 Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

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