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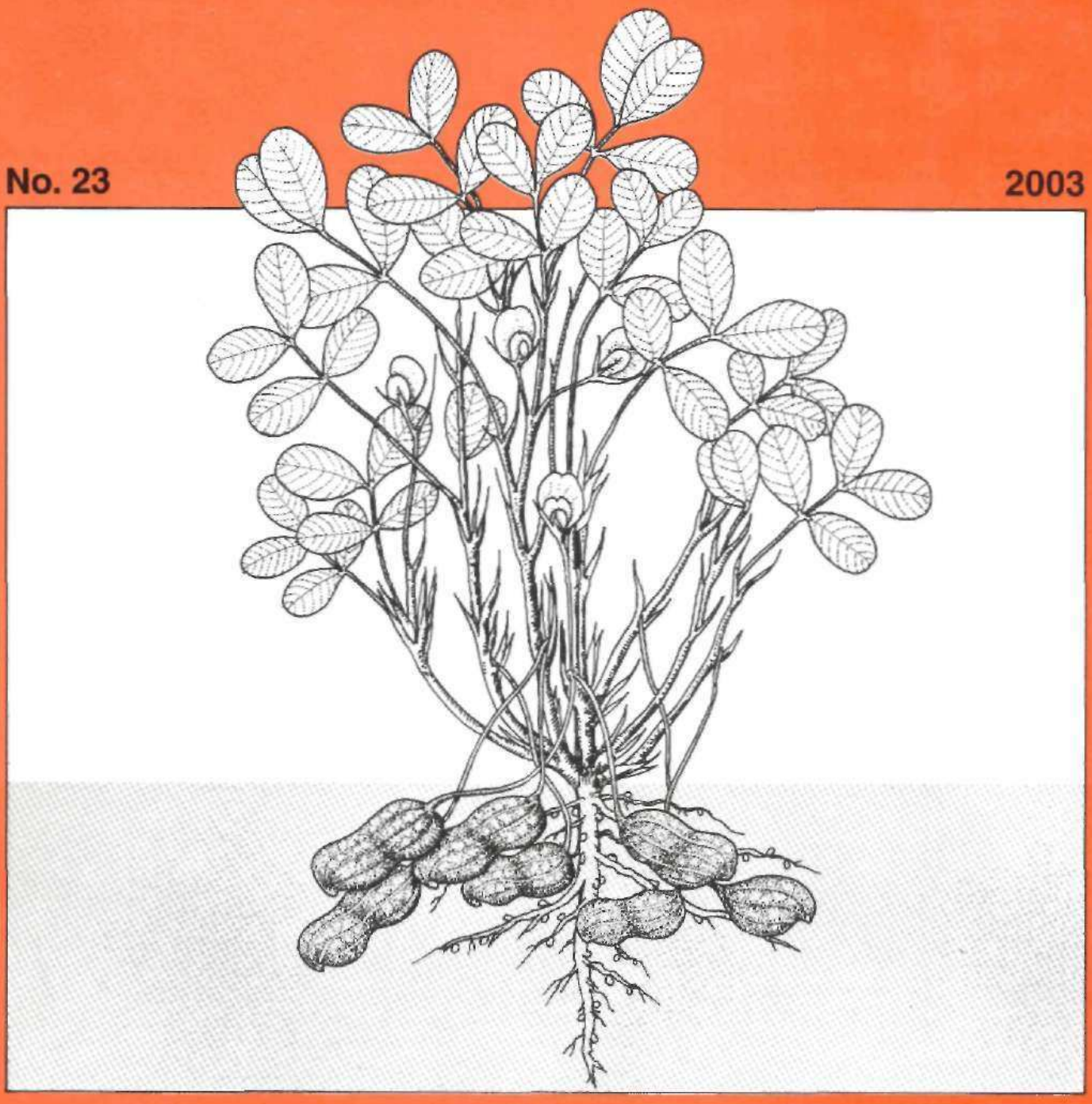
No. 23 2003



International *Arachis* Newsletter (IAN)

Co-publishers

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

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
(http://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 semi-arid tropics (SAT) encompass parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, chickpea, pigeonpea, and groundnut - five crops vital to life for the ever-increasing populations of the SAT. ICRISAT's mission is to conduct research that can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library-' services and publishing.

ICRISAT was established in 1972. It is supported by the Consultative Group on International Agricultural Research (CGIAR), an informal association of approximately 50 public and private sector donors. It is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank. ICRISAT is one of 16 nonprofit CGIAR-supported Future Harvest Centers.

IAN Scientific Editor

SN Nigam

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News and Views

From the Editor

We are pleased to note that IAN is distributed to more than 1100 individuals and 600 libraries globally. This wide circulation is indicative of the usefulness of IAN to those who are involved in groundnut research and development, production and trade all over the world. IAN provides a strong medium for sharing your results, news and views with fellow members of the global groundnut community. This issue of IAN has fewer articles than the previous issues. We all would like to have more articles and news and views on groundnut, particularly related to new releases, production technologies, food quality and trade. We encourage the private sector and farmers to share their experiences with this commodity through the medium of IAN. However, I would urge contributors to follow the guidelines for publication in IAN so that the manuscript processing is smooth and less time consuming.

I would like to acknowledge M Ferguson, P Lavakumar, N Mallikarjuna, BR Ntare, S Pande, P Parthasarathy Rao, GV Ranga Rao, TJ Rego, KK Sharma, P Singh, HD Upadhyaya and F Waliyar who reviewed IAN manuscripts and the Library at 1CRISAT for compiling SATCR1S listing.

The IAN team wishes its readers a very happy Christmas and a healthy and productive 2004.

SN Nigam

Peanut CRSP Perspectives: Priorities for Peanuts - Aflatoxin and World Health

Aflatoxin is not a problem for peanuts (groundnuts) alone; contamination may occur in many crops and high toxin content is usually present in other dietary staples such as maize, rice and cassava. Peanut is just one of many commodities that can be contaminated, but it is widely associated with the problem. The risk of aflatoxin contamination should be something considered in defining priorities for peanut research. The Peanut CRSP program has consistently accorded aflatoxin the highest priority for our efforts. This position has been justified by the importance of protecting consumers from the consequences of contamination, and the need to satisfy quality standards for trade with the profitable markets in the developed world. It is not sufficient to increase peanut production; peanut needs to be safe to consume and market for the best prices. The importance of aflatoxin in our commodity is just about to increase significantly because of emerging information relating aflatoxin to a much wider health concern.

Medical doctors generally identify aflatoxin as a carcinogen responsible for liver cancer. However, a veterinary doctor will consider the immune system suppression and nutritional interference associated with aflatoxin exposure. Our literature review confirms that the focus on aflatoxin toxicity differs between the two scientific domains: human medicine is preoccupied with cancer risks while veterinary medicine is focused on immunity. The difference is because of the contamination allowed in the different industries within places like USA. Animal exposure may be an order of magnitude higher than that allowed in human foods. We all also have to recognize that the levels of human exposure differ between developed countries and developing countries. Reports of contamination in market samples, trade rejections, and studies of human exposure using tissue samples all indicate that chronic aflatoxin exposure is a feature of life in developing countries. Our studies and published reports in other locations measuring aflatoxin derivatives in blood show that most people are chronically exposed.

Recent publications show that the nutritional interferences that are observed in the livestock industry when aflatoxicosis occurs are also contributing to poor nutrition and the 'underweight' condition in children in West Africa (Gong et al. 2002). Peanut CRSP studies in Ghana show that the immune suppression and nutritional interference (vitamin A) by aflatoxin observed in livestock is occurring at least for the most exposed one-third of the human population. How serious is this? The World Health Organization (WHO) estimates that about 40% of the burden of disease is associated with infectious diseases or nutritional deficiencies promoted (in animals) by aflatoxin exposure (WHO 2002). Credible connections between aflatoxin and factors in the HIV/AIDS epidemic-exist in at least 6 areas. Indeed one paper indicates that aflatoxin is a potential factor in the rapid progression of HIV (Hendrickse et al. 1989). Heroin addicts in Europe (exposed to aflatoxin from contaminated drugs) and Africans both experience relatively rapid HIV progression.

Can we influence the HIV epidemic through our efforts to prevent aflatoxin?

While peanuts are not the only source of aflatoxin in diets around the world we need to recognize that our commodity does contribute to the burden and that we need to increase our efforts to ensure that both the available technologies that can decrease contamination are used by producers and processors of peanuts, and that our research to develop new ways to control contamination is accelerated. The potential benefits to health, wealth and happiness suggest that we need to accept the wider importance of what we are already doing and work to achieve those goals sooner.

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Dr Kazumi Maeda Honored

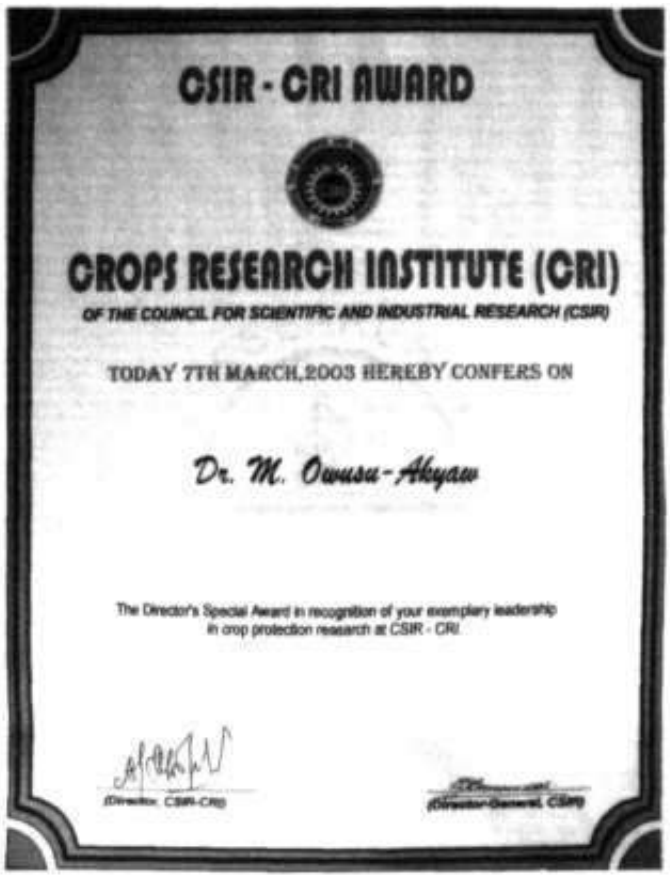
Dr Kazumi Maeda, Prof Emeritus, Kochi University, Japan received awards in April 2002 from the Agricultural Academy of Japan and The YOMIURI SHINBUN (one of the major newspaper publishers in Japan) for his contributions in groundnut research, particularly in promoting the concept of 'Ideotype' for high yield in groundnut. This work was presented at the international workshop entitled "Groundnut - A Global Perspective" held at ICRISAT Center, Patancheru, India in November 1991. Dr Maeda was a Visiting Scientist in 1978-80 with the then Groundnut Improvement Program at ICRISAT Center when a beginning in groundnut physiology research was made.

Dr Maeda is currently assisting the Japanese importers to improve the yield and processing quality of large-seeded groundnut produced in Shandong Province of China. He is now 72 years old (as on 1 January 2003) and

we wish him a very healthy and long productive life. His present address is: 781-5202, Higashi 2-55 Midorino. Noichi-cho, Koch-ken, Japan.

Award for Peanut CRSP Collaborator in Ghana

Dr Mike Owusu-Akyaw, the groundnut research coordinator for the Peanut CRSP project at the Crops Research Institute in Kumasi, Ghana was recently awarded a Council for Scientific and Industrial Research - Crops Research Institute (CSIR - CRI) Award citation in March 2003. The citation was the Director's Special Award in recognition of exemplary leadership in crop protection research at CSIR-CRI. This award was a result of his outstanding team approach to the Peanut CRSP project in Ghana. Mike has worked tirelessly to develop a strong mullidisciplinary team to help solve pest problems



CSIR - CRI AWARD

CROPS RESEARCH INSTITUTE (CRI)

OF THE COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR)

TODAY 7TH MARCH,2003 HEREBY CONFERS ON

Dr. M. Owusu-Akyaw

The Director's Special Award in recognition of your exemplary leadership in crop protection research at CSIR - CRI

(Director, CSIR-CRI)

(Director-General, CSIR)

associated with groundnut production throughout southern Ghana. He successfully coordinates activities of a research team that includes entomologists, plant pathologists, soil scientists, nematologists, virologists and weed scientists. These efforts of the team are providing an integrated approach to pest management in groundnut and making significant progress toward improving yield potential and consistency of crop performance. Currently, the team Mike leads is evaluating their findings on farm with farmers at several locations. Congratulations Mike!

Contributed by: Rick Brandenburg
Department of Entomology, NC State University
Raleigh, NC 27695-7613, USA

Standard Reference Material (SRM) 2387 Peanut Butter Now Available from the National Institute of Standards and Technology

The Nutrition Labeling and Education Act of 1990 requires that information for selected nutrients is provided on labels for processed foods. In response, the National Institute of Standards and Technology (NIST), USA has been working to provide food-matrix Standard Reference Materials (SRMs) with values assigned for the required nutrients. SRM 2387 Peanut Butter is one in this series. It is intended for use as a primary control material for assigning values to in-house control materials and to validate analytical methods for measuring nutrients such as fat, protein, vitamins and minerals. SRM 2387 is the first food-matrix reference material available from NIST with values assigned for amino acids, making the material potentially useful as a quality assurance tool in USDA's nutrient databases.

To study the robustness of analytical methods, AOAC International developed a nine-sector triangle in which foods are positioned based on their fat, protein and carbohydrate contents. The idea was that one or two foods within each sector should be representative of other foods within that sector when validating an analytical method. Similarly, one or two food-matrix reference materials in each sector can be used as control materials for other foods within that sector. NIST currently has food-matrix reference materials available within or along boundaries of all sectors except for the one in which peanut butter lies. Other foods in this sector include pasteurized processed cheese spread and beef bologna.

SRM 2387 also addresses a need for a reference material with values assigned for aflatoxins. Aflatoxins are highly carcinogenic metabolites of molds that may contaminate peanuts (groundnuts) and other crops. This is the first reference material available from NIST for which values are assigned for aflatoxins.

NIST analysts provided data for certification of fat and individual fatty acids, vitamin E and elements of

nutritional interest (eg, calcium, sodium, iron, zinc, etc.) in SRM 2387. NIST data were combined with data provided by collaborating laboratories to assign certified values. Reference values for additional vitamins, protein, calories, aflatoxins, amino acids, etc were generated from data provided by collaborating laboratories.

To see the Certificate of Analysis, or for sales or ordering information, visit http://www.nist.gov/srm. For technical information, contact (Catherine Sharpless at katherine.sharpless@nist.gov.

(News posted on Peanut CRSP website http:// 168.29.148.65)

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Plans to Expand the Mandate of CLAN

The Cereals and Legumes Asia Network (CLAN) was established in April 1992. The aim of this network is to achieve sustainable increase in production of sorghum, pearl millet, chickpea, pigeonpea and groundnut in member countries through an upgraded and intensified network for research and development. The network facilitates collaborative research exchange of germplasm, information and technology among cereals and legumes scientists in Asian countries. The overall goal is to improve the well-being of the farmers and consumers by improving the sustainable production and productivity of crops. The member countries include Bangladesh, China, India. Indonesia, Iran, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand. Vietnam and Yemen.

CLAN mandate crops include sorghum, pearl millet, chickpea, pigeonpea and groundnut. During the early period of CLAN, the network has provided germplasm and breeding material, and improved production technologies and capacity building of member NARS. Several member countries have been able to develop and release many high-yielding and disease and pest resistant varieties, and have developed improved production technologies through on-farm adaptive trials. Network activities also include crop management technologies that can be adapted and adopted by farmers on a large scale. The need for continuing the activities of CLAN has been requested by the member countries during the Steering Committee meeting in December 1999.

Over the last few years, member countries of the Asia-Pacific Association of Agricultural Research Institutions (APAARI) have been emphasizing the importance of legumes. Considering the important role that legumes play in human and animal health, efforts are in place to enhance inclusion of legumes in the cropping systems in many Asian countries. At the APAARI General Assembly Meeting held during 2-4 Dec 2002 at Penang, Malaysia, the members recommended that CLAN should be expanded to include facilitation of mung bean and lentil research and development in Asia, in collaboration with AVRDC (mung bean) and ICARDA (lentil).

A joint ICRISAT-ICARDA-AVRDC-APAARIspon-sored Steering Committee meeting of CLAN is planned during 10-12 November 2003 to ratify the APAARI recommendation and to amend the constitution of CLAN to include lentil and mung bean among the mandate crops.

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Development of Sustainable Groundnut Seed Systems in West Africa Project Launched

The ICRISAT-executed Groundnut Seed Project (GSP) in West Africa was launched at a 2.5-day project inception workshop held at the International Conference Center in Bamako. Mali from 26 to 28 May 2003. Thirty-two participants from Nigeria, Niger, Mali, Senegal, Kenya, Malawi. USA, the Netherlands and Italy attended the inception workshop. The project will be conducted in partnership with the NARS of Mali, Niger. Nigeria and Senegal. The project is financed by a grant from the Common Fund for Commodities (CFC) and the Inter-Governmental Group on Oilseeds, Oils and Fats (IGOOF) of FAO acts as the Supervisory Body (SB). The duration of the project is four years (2003-06). This is a follow-up project to the Groundnut Germplasm Project (GGP), executed by ICRISAT from 1996-2002 and funded by CFC.

The goal of the project is to improve productivity and quality of groundnuts through the development of sustainable seed supply and delivery systems in West Africa. The project seeks to promote utilization and uptake of improved varieties responding to market requirements; improve the skills of the farmers and other entrepreneurs in seed production, delivery, processing and marketing; and small seed enterprise management including measures to minimize aflatoxin contamination.

F Waliyar, Principal Scientist (Pathology), lCRlSAT, Pataneheru. India is the Project Executing Agency representative. BR Ntare, Principal Scientist (Breeding), 1CRISAT, Bamako, Mali is the project manager assisted by a National Project Coordinator (NPC) in each of the participating countries.

Contributed by: BR Ntare
ICRlSAT, Bamako, Mali

lCRISAT Groundnut Varieties Released in Mali

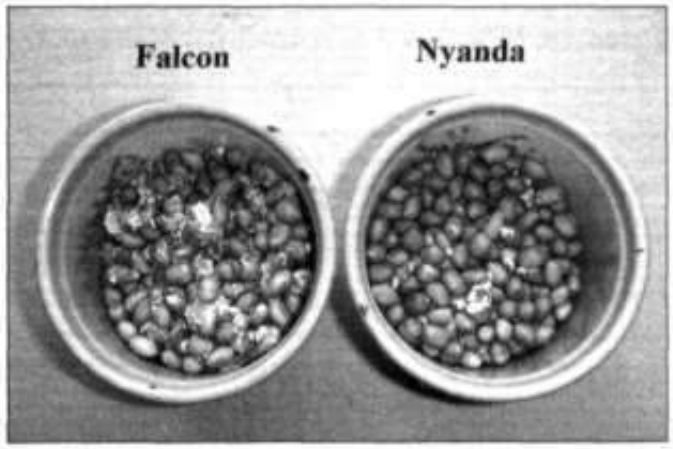
Three groundnut varieties resistant to foliar diseases [lCG 7878 (Waliyatiga), ICG (FDRS) 4 and ICG (FDRS) 10] and an early-maturing variety 1CGS (E) 34 were registered in the official Malian National Variety Catalog for wide-scale production. These varieties are very popular in the Kolokani region of Mali and produce 15-50% higher yields than the local varieties.

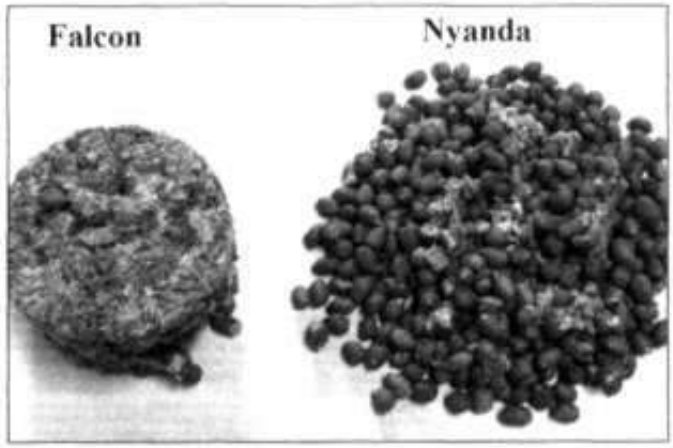
Contributed by: BR Ntare
ICRlSAT, Bamako. Mali

Tropical Warehouse Moth Resistance in Groundnut Cultivar Nyanda

Geoff Hildebrand, Seed Co Ltd., Harare, Zimbabwe wrote (vide his emails of 22 January and 4 February 2003) to share the following information on tropical warehouse moth *(Ephestia cautella)* resistance in groundnut cultivar Nyanda (ICGV 93437), which was released in 1999 in Zimbabwe.

Geoff and his technician kept similar amounts of Falcon and Nyanda seed in containers and added 10 moth-infested seeds (which were marked) to each sample.





Sometime later, they found a large difference between the two varieties in severity of seed damage (see figure). Nyanda is already reported to be tolerant to aphids and *Hilda patruelis* (Source: Minja et al. 2002, IAN 22:49-51). This additional resistance in Nyanda makes it a useful parent in breeding programs in southern Africa. Geoff intends to repeat this experiment and would also include 1CGV-SM 99537, a potential candidate for release, in the study as it has Nyanda as one of its parents.

Current ICRISAT Groundnut Research-related Special Projects

Investor	Project title	Project coordinator	Grant (in US$)	Duration
Asian Development Bank	Rapid crop improvement for poor farmers in the semi-arid tropics of Asia	JH Crouch	1200 000	Jan 2001-Dec 2003
Australia/ACIAR	Selection for peanut varieties with low aflatoxin risk	SN Nigam	204 000	Jul 2001-Jun 2004
Australia/ACIAR	Seeds of Life - East Timor	SN Nigam	58 000	2000-03
Australia/ACIAR	Improving yield and economic viability of peanut production in Papua New Guinea and Australia using integrated management and modeling approaches	HD Upadhyaya	12 193	1 Jul 2002-30 Jun 2005
Belgium	Towards sustainability of groundnut and cereal production in West Africa: management of peanut clump virus	FWaliyar	810 000	2000-04
CFC	Development of sustainable groundnut seed systems in West Africa	F Waliyar, BR Ntare	2102 946	1 Apr 2003-30 Jun 2008
CGIAR/ICARDA/CAC	Research activities on groundnut and on management of drought in chickpea, targeted to the Central Asia and the Caucasus (CAC) region	SN Nigam	24 000	2001-03
FAO	Empowerment through technology - Synthesis of lessons learned about gender dimensions in adoption of groundnut production technology, poverty reduction and build-up of social capital	MCS Bantilan	26 000	2003
Germany/BMZ/GTZ	Promotion of legume cultivation in Malawi, Mozambique. Zimbabwe and Zambia - Phase V	M Siambi	521 000	2000-03
IFAD	Farmer-participatory improvement of grain legumes in rainfed Asia	SN Nigam	1300 000	1 Sep 2001-20 Sep 2005
India/ICAR/NATP	Aflatoxin contamination in groundnut: mapping and management in Gujarat and Andhra Pradesh	SN Nigam	28 000	2000-03
India/ICAR/NATP	An integrated approach to control stern necrosis disease of groundnut	SN Nigam	35000	2001-04
India/MAHYCO Research Foundation	Management of tospoviruses in selected crops and strategies for management of tobacco streak virus	FWaliyar	10 500	2001-03
India/UK APRLP/DFID	Convergence of agricultural, livestock improvement initiatives in watersheds - support to APRLP	SP Wani	485 000	2002-04
OPEC Fund for International Development	Harnessing technology for sustainable development: Economic empowerment of poor groundnut farmers in Asia	SN Nigam	100 000	1 Jul 2003-30 Jun 2004
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, SN Silim, AH Freeman	630 000	1 Oct 2002-30 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	172 000	1 Apr 03-31 Mar 05
USA/University of Georgia (Peanut CRSP)	Support for: International Arachis Newsletter; International Peanut Congress 2004; groundnut rosette in Southeast Africa; aflatoxin model	F Waliyar	20 000	2002-03
USAID/TARGET	More bang for the research buck: Raising farmers' incomes through use of profitable grain legume technologies and better linkages to markets	RB Jones. SN Silim	600 000	2002-04
USAID/US University Linkages	Quantifying yield gaps and abiotic stresses in soybean- and groundnut-based production systems	P Pathak	90 000	2001-03
USAID/SMIP	Promoting growth in Malawi's groundnut and pigeonpea trade through technology and market improvement	J Estrada-Valle	380 700	2002 03

Research Reports

Genetic Resources and Enhancement

Groundnut Germplasm Seed Viability after Ten Years of Storage as Base Collection

DVSSR Sastry[1], N Kameswara Rao[2] and HD Upadhyaya[1]
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2. IPGRI-SSA, C/o ICRAF, PO Box 30677, Nairobi, Kenya)

Long-term storage strategies for seed germplasm are needed to assure preservation of diminishing plant genetic resources. Monitoring the main factors causing genetic-erosion in ex situ collections is strongly recommended to minimize the loss of genetic integrity. Seed deterioration is a continuous process, but for orthodox seeds such as groundnut *(Arachis hypogaea)* a combination of 3-7% seed moisture content and storage temperature below 0°C would permit long-term seed preservation (FAO and IPGRl1994). The Rajendra S Paroda Genebank at ICRISAT, Patancheru, India conserves the global collection of groundnut germplasm consisting of 15,419 accessions assembled from 93 countries as active collection at +4°C and 30% relative humidity and as base collection at -18°C. Active collection is immediately available for multiplication and distribution while base collection at preferred seed moisture content and other storage facilities is for long-term storage for future use.

Different species and accessions within species may respond differently to storage conditions, resulting in a wide variance in the storability of individual accessions (Sikdar 1988). The determination of the maximum storage period for each accession in particular conditions of the genebank is of importance in designing management guidelines that minimize viability controls and seed multiplication of the samples. Genebank managers are responsible for providing conditions that will maintain the viability of each accession held within the genebank above a minimum value. Periodic testing of viability is crucial to operation of genebanks because it permits the control of genetic erosion during storage. The objectives of this study were to determine the changes in the viability of groundnut germplasm accessions stored at -18°C for 10 years and to determine the risk of viability decreasing below acceptable levels after 10 years of storage and to analyze the possible factors involved in the viability losses. In this work, seed viability of base collection of 990 groundnut accessions stored for 10 years was analyzed following a methodology recommended for germplasm conservation (FAO and IPGRI 1994).

Seed samples of 990 groundnut germplasm accessions regenerated at ICRISAT, Patancheru were dried to about 4% moisture content and maintained at -18°C in hermitically-sealed, laminated aluminum foil pouches to serve as base collection. For long-term storage, the seed is desiccated to a low level of moisture content in a seed drying cabinet at 15°C and 15% relative humidity. The seed moisture content was estimated using oven-drying method (ISTA 1985) on 30 randomly selected accessions before initial storage and during monitoring seed viability. The same seed samples of all accessions were used for monitoring viability after 10 years of storage. Seed viability was assessed by standard germination tests. Initial germination (GO) was determined before placing the samples in storage. Germination was monitored after 10 years of storage (G10). Germination tests were conducted in 1990 and 2001 following "between paper" method using standard towels (ISTA 1985). Two replications of 25 seeds were used for both initial and final germination testing to save the valuable seed material. Germination results are reported as percentage normal seedlings.

Changes in Seed Viability

The results revealed that groundnut germplasm accessions stored at -18°C with moisture content below 4% can also lose viability (Table 1). The minimum viability standard for conserving seeds as base collection was 85%. Viability was unaffected in 36.4% (360 accessions), improved (G10 over GO) in 20.2%> (200 accessions), and decreased in 43.4%. (430 accessions) of total collection monitored. The increase in germination during storage could be due to fresh seed dormancy, a common feature with groundnut germplasm, which was broken after a time of storage period (Ellis et al. 1993). This effect is more pronounced in *A. hypogaea* var *hypogaea* accessions (28%) compared to other botanical types. For reporting the potential viability in some of the accessions before storage, dormancy-breaking treatments are recommended.

The average initial viability of 990 accessions was 98.2%. Considerable variation occurred in the average viability for different botanical varieties of groundnut. The highest viability (99.2%) was recorded in *A. hypogaea* var *fastigiata* followed by 98.3% in *A. hypogaea* var *vulgaris* and 97.7% in *A. hypogaea* var *hypogaea.* The average initial viability was lowest (97.6%) for *A. hypogaea* var *peruviana* accessions. After 10 years of storage, the average viability of the total collection was 96.5%, a decrease of 1.7%. The reduction was lowest (1.0%) in *hypogaea* followed by 1.3% in *fastigiata,* and 2.1% in *vulgaris* accessions. The highest reduction in average viability (7.5%) was recorded in *peruviana* accessions. A germination level less than 85%, after 10 years of storage was observed in 46 accessions while it was less than 75% in 12 accessions. A deviation of 5% germination level between initial and final was considered as normal. Thus, over a period of 10 years as base collection, 787 accessions (79.5%) remained neutral, 35 accessions (3.5%) had improved viability and 168 accessions (17%) had viability losses. The highest gain was in 25 accessions (5.4%) of *hypogaea,* while the loss in viability was highest in 27 accessions (54.0%) belonging to *peruviana.*

It is necessary to investigate why some accessions possess low germinability after storage. One reason might be that they are sensitive with respect to the environment during reproduction as described in the genebank standards (FAO and IPGRI 1994). During storage, accessions with low viability lose their germinability much faster than accessions with high initial viability (Ellis 1982) and all accessions with low initial germinability need more frequent germination control. Passport data and taxonomical background of the accessions could be a possible source of information for ascertaining the possible losses in germination in addition to the regeneration and pre-storage conditions. No relationship was found between the passport traits and the loss in germination relating to donor, year of multiplication and the geographical distribution. However, significant ($P < 0.001$) differences in germination were related to the botanical variety. More significant losses were observed in *peruviana* group followed by *vulgaris.* This shows *hypogaea* and *fastigiata* accessions were more stable during storage compared to *peruviana* and *vulgaris,* which require frequent regeneration even when conserved under preferred conditions as base collection.

Table 1. Changes in germination in groundnut *(Arachis hypogaea)* accessions of different botanical varieties in the base collection at ICRISAT, Patancheru, India after 10 years of storage.

	No. of accessions											
Change in viability[1] (Range)	Entire collection		*hypogaea*		*fastigiata*		*aequatoriana*		*peruviana*		*vulgaris*	
16 to 20	1	(0.1)[2]	0	(0.0)	0	(0.0)	0	(0)	0	(0.0)	1	(0.3)
11 to 15	5	(0.5)	4	(0.9)	1	(0.6)	0	(0)	0	(0.0)	0	(0.0)
6 to 10	29	(2.9)	21	(4.6)	4	(2.3)	0	(0)	0	(0.0)	4	(1.3)
1 to 5	165	(16.7)	104	(22.6)	11	(6.3)	0	(0)	1	(2.0)	49	(16.2)
0	360	(36.4)	136	(29.5)	76	(43.2)	1	(100)	13	(26.0)	134	(44.4)
(-) 1 to (-) 5	262	(26.5)	131	(28.4)	65	(36.9)	0	(0)	9	(18.0)	57	(18.9)
(-) 6 to (-) 10	114	(11.5)	52	(11.3)	17	(9.7)	0	(0)	12	(24.0)	33	(10.9)
(-) 11 to (-) 15	31	(3.1)	10	(2.2)	2	(1.1)	0	(0)	7	(14.0)	12	(4.0)
(-) 16 to (-) 20	12	(1.2)	2	(0.4)	0	(0.0)	0	(0)	3	(6.0)	7	(2.3)
(-) 21 to (-) 25	6	(0.6)	0	(0.0)	0	(0.0)	0	(0)	3	(6.0)	3	(1.0)
(-) 26 to (-) 30	4	(0.4)	1	(0.2)	0	(0.0)	0	(0)	1	(2.0)	2	(0.7)
(-) 31 to (-) 35	1	(0.1)	0	(0.0)	0	(0.0)	0	(0)	1	(2.0)	0	(0.0)
Total	990	(100.0)	461	(46.6)	176	(17.8)	1	(0)	50	(5.1)	302	(30.5)
Gain in viability	35	3.5	25	5.4	5	2.8	0	0	0	0	5	1.7
Viability neutral	787	79.5	371	80.5	152	86.4	1	100	23	46	240	79.5
Loss in viability	168	17	65	14.1	19	10.8	0	0	27	54	57	18.8
Total	990	100	461	100	176	100	1	100	50	100	302	100

1. Each value refers to change in germination (GO minus G10). GO = Initial germination (%); and G10 = Germination (%) after 10 years.
2. Percentage of accessions is given in parentheses.

Regeneration Requirements

A level of viability less than 85% of initial viability was recommended for regeneration of base collection, as these standards are useful to ensure that the genetic integrity of the accessions is maintained (FAO and lPGRI 1994). The results obtained from the monitoring tests revealed that more than 97% of the accessions did not have significant decrease in germination after 10 years of storage and only 2.4% (24 accessions) would need regeneration. During storage, dormancy could be a common phenomenon in some accessions requiring special treatments at the time of germination testing.

This study revealed that taxonomical variation in groundnut had an impact on storage longevity suggesting suitable precautions during regeneration and pre-storage to secure high quality seeds for conservation of accessions belonging to *peruviana* group. Though the germplasm seeds are conserved under preferred conditions of international standards for present and future use, periodic monitoring of viability is vital for developing protocols for cost-effective regeneration intervals.

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Yield Potential of Some Spreading Type Local Groundnut Cultivars Under Late Rainy Conditions at Bijapur, India

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The area (0.43 million ha) and production (0.35 million t) of groundnut *(Arachis hypogaea)* is slowly declining in the northern dry zone of Karnataka, India and the groundnut farmers are switching to alternative oilseed crops. Under the prevailing circumstances such as erratic rains in the early rainy season and the lack of suitable groundnut genotypes, the crop is not bringing expected returns. Although most of the farmers have been growing many local spreading types continuously for a long time in this region, all these are not high yielding. There is a need to evaluate these genotypes during early rainy and late rainy seasons to assess the yield potentiality after preliminary screening. Thus, the performance of the cultivars can be evaluated in different climatic situations in different years.

The suitability of genetic architecture of some varieties to perform well in different seasons needs to be accounted statistically by assigning appropriate ranks, which might provide an opportunity to farmers to reconsider the best varieties available with them. Studies on water relations of groundnut by Sivakumar and Sarma (1986) have shown that the selection of appropriate-varieties is feasible with a growing cycle that would match the probable stress periods and dependable rainfall periods. Moisture stress during early phase of the growth is favorable for optimum yield in groundnut (Anonymous 1995). Ramesh and Durgaprasad (1996) who screened many groundnut genotypes to identify good yielders despite mid (peg initiation to pod development) and late season drought (pod development to seed development) indicated that TG 26, ICGV 86347 and K-13G gave higher yield. Hence, there may be a possibility to isolate some of the groundnut genotypes that perform well under drought during both vegetative and reproductive phases. Analysis of long-term rainfall for Bijapur, Karnataka has indicated that water availability is relatively undependable during early part of the rainy season and more assured during later part of the rainy season (Kavi 1996). This may provide opportunities for some of the spreading groundnut genotypes to make better use of the season.

Preliminary investigations were carried out at the Regional Research Station, Bijapur during 1997 rainy season to evaluate 90 local spreading groundnut cultivars collected around Bijapur along with S 230 as check. Eight promising cultivars were selected. These were further evaluated during 1998 and 1999 early rainy seasons (June sowing) and 2000 and 2001 late rainy seasons (August sowing). The design of the experiment was randomized block design with four replications. The plot size was 5 m x 2.70 m with 45 cm inter-row and 15 cm intra-row spacing. Recommended agronomic practices for the region were followed. The pod yield was recorded plot-wise in each replication. Disease incidence of late leaf spot and rust was recorded as per modified 1-9 scale

(Subrahmanyam et al. 1995), where 1 = no incidence and 9 = >80% incidence. Bud necrosis disease incidence was recorded as percentage of infected plants and cultivars were categorized as susceptible (51-100%), moderately susceptible (40-50%), moderately resistant (11-39%) and resistant (1-10%). To select the best performing cultivars for early and late rainy situations at Bijapur and for more meaningful interpretation, the values of increased yield percentage over check in both the seasons were added across each cultivar to have Accumulated Advantage Values (AAV). Finally, ranking for each of the 9 cultivars was given based on AAV with 1 as highest rank.

Table 1. Performance of spreading type local groundnut cultivars in early rainy season 1998 and 1999 and late rainy seasons at Bijapur, Karnataka, India.

Cultivar	Pod yield (kg ha^{-1}) in early rainy season			Yield increase (%) over control (a)	Pod yield (kg ha^{-1}) in late rainy season				Yield increase (%) over control (b)	AAV (a+b) (%)	Ranking[2]
	1998	1999	Mean		2000	2001	2002	Mean			
BG 6	736	622	679	-2.1	995	831	598	sos	+ 10.6	+8.5	5
BG 7	860	685	772	+ 10.2	943	876	675	831	+ 13.1	+23.3	2
BG 27	768	714	741	+6.5	886	788	502	725	+ 0.4	+6.9	6
BG 28	641	608	624	-11.1	715	655	475	615	-17.4	-28.5	9
BG 29	988	772	880	+21.3	1074	1012	784	957	+ 24.5	+45.8	1
BG 31	823	639	731	+ 5.2	892	857	566	772	+ 6.5	+ 11.7	4
BG 85	794	667	730	+5.3	914	936	632	S27	+ 12.7	+ 18.0	3
BG 86	729	531	630	-10.0	835	740	487	687	5.1	-15.1	8
S 230 (check)	756	630	693	0.0	797	766	602	722	0.0	0.0	7
Mean	788.3	652.0			894.6	829.0	591.2				
SEm±	63 5	49.8			47.0	69.1	53.4				
CV (%)	14.4	12.2			9.7	16.2	18.6				

1. AAV = Accumulated Advantage Value.
2. From 1 to 9 based on AAV with 1 as top rank.

Table 2. Field screening of spreading groundnut cultivars for disease resistance during early rainy season 1999 and late rainy season 2001, Bijapur, Karnataka, India.

Cultivar	Early rainy season 1999			Late rainy season 2001	
	Bud necrosis[1] (%)	Late leaf spot[2]	Rust[2]	Late leaf spot[2]	Rust[2]
BG 6	23.3	7.0	6.0	6.5	5.5
BG 7	20.5	5.0	3.5	7.0	5.5
BG 27	18.7	6.5	4.0	6.0	4.5
BG 28	33.6	5.5	5.0	5.5	7.0
BG 29	4.5	4.0	3.5	3.5	3.5
BG 31	16.6	6.0	4.5	5.5	4.0
BG 85	26.9	4.0	4.5	4.5	4.0
BG 86	24.1	5.5	4.5	6.0	4.0
S 230 (check)	42.3	7.0	5.5	5.5	5.5
Mean	-	-	-	-	-
SEm ±	-	1.45	1.21	1.98	0.93
CV(%)	-	3.97	1.76	4.36	2.34

1. Cultivars were scored as susceptible (51-100%), moderately susceptible (40-50%), moderately resistant (11-39%) and resistant (1-10%).
2. Disease incidence scored on a 1-9 scale, where 1 = no incidence and 9 = >80% incidence.

During early rainy season of 1998 and 1999, all the cultivars except BG 28 and BG 86 produced higher mean yield than the check S 230 (693 kg ha^{-1}) (Table 1). BG 29 produced maximum yield (880 kg ha^{-1}) followed by BG 7 (772 kg ha^{-1}). BG 29 was also resistant to bud necrosis and moderately resistant to late leaf spot and rust (Table 2). Under late rainy season of 2000, 2001 and 2002, all the cultivars produced higher yield over the check S 230 (722 kg ha^{-1}) except BG 28 and BG 86. The variety BG 29 again produced higher yield (957 kg ha^{-1}) and its moderate resistance to late leaf spot and rust was confirmed. In general, pod yields of varieties were higher in the late rainy season than in the early rainy season, except during 2002 when acute drought was observed. The cultivars BG 29 (24.5%), BG 7 (13.1%) and BG 85 (12.7%) produced relatively higher pod yields than the check S 230 during late rainy season. BG 29 was the best cultivar as it consistently produced highest pod yield in all the seasons over check S 230.

The late rainy season groundnut crop in Bijapur generally produces high pod yield as perhaps it is better suited to the weather pattern for realization of optimum pod yield (Anonymous 1995). Hence, the normal agroclimatic situations in Bijapur were not congenial for good growth of the local spreading groundnut cultivars sown in June [potential evapotranspiration (PET) =. 183.2 mm, moisture adequacy index (MAI) = 0.25 to 0.50 and total day length = 392.7 h] and July (PET = 131.3 mm, MAI = 0.25 to 0.50) compared to the crop sown in August (PET = 137.3 mm, MAI = 0.50 to 1.00) and September (PET = 115.8 mm, MAI = 1.00). The individual performance of promising cultivars in both the seasons was reflected in AAV (Table 1). The top ranking groundnut cultivars were BG 29, BG 7 and BG 85 with AAV of 45.8, 23.3 and 18, respectively. Since most of the local farmers arc accustomed to late sowing, these cultivars are most suitable for late-sown situations.

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Development of Groundnut Cultivars with High Oil Content

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In China, the market demand for edible oil and protein has sharply increased since the early 1990s, and the current domestic production of these products is still not enough despite significant production increases in all the major oilseed crops. This has made China the largest importer of oilseed products especially soybean (*Glycine max)* in recent years in the world. While changing the traditional unbalanced cropping pattern, the harvested area and production of groundnut *(Arachis hypogaea)* in China expanded greatly during the past decade. As the largest groundnut producer in the world, China is also the largest consumer of groundnut oil, with about 56% of the nuts crushed for oil and over two million ton oil consumed. The production of groundnut is expected to increase further due to its relatively higher benefit-cost ratio compared to many other crops, and more groundnut would be crushed for oil. However, the groundnut oil, in both domestic and international markets, has been less competitive in price to rapeseed *(Brassice napus)* and soybean oils. The development of new cultivars with improved yield potential and high oil content would be crucial for enhancing the market competitiveness of groundnut oil.

At the Oil Crops Research Institute (OCRI) of the Chinese Academy of Agricultural Sciences (CAAS), Wuhan, China one of the important objectives in groundnut

breeding has been high oil content with high seed yield. From our germplasm evaluation, groundnut genotypes with lowest (40%) and highest (58%) oil content have been identified. In general, the landraces belonging to the Spanish group possess higher oil content than those of the other groups, while the large-seeded genotypes with high yield potential normally possess lower oil content. Traditionally, much attention was paid to pod uniformity and yield components in selecting breeding lines in the field, and the chemical traits received little attention. The integration of large seed size (high yield potential) and desirable pod uniformity with high oil content proved complex and difficult. As the groundnuts for oil and those for direct consumption normally with low oil content would be separated from planting to marketing in the future, we tried to integrate high yield and high oil content without a concern for pod uniformity especially on the clay soil in Wuhan. Since 1998 we have released three cultivars, Zhonghua 5, Zhonghua 7 and Zhonghua 8, with oil content more than 55%.

Zhonghua 5, with 55.4% oil content was released in 1998 in Hubei and Sichuan provinces. It out-yielded the control cultivar by 10.5% and was the highest yielder among the varieties in the regional varietal trial for central China during 1992/93. It matures in about 123 days in spring (mid-April - August) in central China. Its average 100-pod mass is about 190 g with a shelling outturn of 75%. It was rewarded by the Central Government in 2000 and by Hubei Province in 2001 for its special traits and application. The oil content of Zhonghua 5 is most stable across locations and seasons.

Zhonghua 7 with 55.8% oil content was released in 2000 in Hubei province. It out-yielded the control cultivar by 13.6% in the provincial varietal trial in Hubei during 1996/97 and had the highest yield among the varieties tested. Its average 100-pod mass is about 180 g with a shelling outturn of 74%. It matures in about 126 days in spring (mid-April - August) in central China. In 2002, it was supported by the Central Government for extension among the farmers.

Zhonghua 8 with an oil content of 55.4% was released in 2002 by the Central Government. It out-yielded the control cultivar by 18.3% and had the highest yield among the varieties tested in regional varietal trial for central China during 1999/2000. It matures in about 125 days in spring (mid-April-August). Its average 100-pod mass is about 190 g with a shelling outturn of 75%. It was supported by the Central Government in 2002 for development of complementary production techniques and extension. It has better resistance to late leaf spot compared to Zhonghua 5.

The above new cultivars are now in extensive cultivation in central China. Besides their high yield, these cultivars have attracted much attention of groundnut oil processors due to their high oil content. The net benefit of using groundnut cultivars with oil content of 55% in oil crushing is believed to be 20% higher than that from the edible groundnuts with oil content of about 50%. However, all the three high oil content cultivars are susceptible to bacterial wilt. Breeding efforts are in progress at OCRI to combine high oil content with resistance to bacterial wilt and aflatoxin contamination.

Revitalization of Groundnut Production in West and Central Africa: Partnership between ICRISAT, the CFC, FAO, NARS and CIRAD

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The West African Groundnut Germplasm Project, commonly known as GGP, was initiated in 1996 to revitalize groundnut *(Ararhis hypogaea)* production in West Africa. The main objectives of the project were to enhance the productivity and sustainability of groundnut production systems in West Africa, and to produce and distribute necessary foundation seeds that can be multiplied by the national research centers for introduction into the seed production and distribution system.

The project comprised six components: (1) germplasm assembly, maintenance and conservation; (2) germplasm characterization, evaluation and screening for genetic traits; (3) enhanced availability of germplasm for utilization in crop improvement; (4) training; (5) technology dissemination; and (6) project management, coordination and monitoring.

The Common Fund for Commodities (CFC) funded the project. ICRISAT was the project-executing agency (PFA) responsible for the overall implementation of the project, including coordination of activities, financial control (including audits), procurement and reporting of progress. Two sub-centers were selected to play a key role in project implementation: ICRISAT Sahelian Center (ISC) and L'lnstitut Senegalais de Recherches Agricoles (lSRA). The Centre de Cooperation Internationale

en Recherche Agronomique pour le Developement (CIRAD) based at Montpellier, France provided the project manager to assist the PEA in coordinating project activities. The Inter-Governmental Group on Oilseeds, Oils and Fats (JGG/OOF) of the Food and Agriculture Organization of the United Nations (FAO) acted as the Supervisory Body.

Key national agricultural research systems (NARS) played a leading role in some of the project activities where they had comparative advantage. For example, ISRA in Senegal was responsible for the identification of agronomically suitable varieties and foundation seed multiplication and distribution. ISRA also conducted research on drought, integrated management of aflatoxin contamination and confectionery groundnuts.

L'Institut National de I'Environement et de Recherches Agricoles (lNERA), Burkina Faso was responsible for screening and evaluation of germplasm for resistance to foliar diseases: rust and early and late leaf spots. The Institute for Agricultural Research (IAR), Nigeria, with backstopping from ICRISAT, was responsible for screening germplasm and breeding lines for resistance to groundnut rosette. L'Institut d'Economic Rurale (1ER), Mali carried out research in integrated management of aflatoxin contamination and variety evaluation. L'Institut National de Rccherches Agronomiques du Niger (INRAN) provided the project with facilities for screening, rejuvenation, and multiplication of germplasm at its research station at Bengou in Niger. The project empowered these NARS to take a lead on specific regional constraints and has encouraged horizontal exchange of technology.

Other NARS such as Institut National de Recherche Agricole du Benin (INRAB), Benin, Savannah Agricultural Research Institute (SARI), Ghana, Institut Togolais de Recherche Agricole (ITRA), Togo, Institut de Recherche Agronomique pour le Developpement (IRAD), Cameroon, Institut de Recherches Agronomiques du Guinee (IRAG). Guinee, and Institut Tchadien de Recherche Agronomique pour le Developpement (ITRAD), Tchad conducted regional variety trials and have greatly benefited from research spillovers.

Germplasm Assembly, Maintenance and Conservation

The project addressed biodiversity in a broad sense and focused on upstream activities. The germplasm was characterized for botanic and agronomic characteristics, screened, and evaluated for genetic traits of economic importance. Other activities included germplasm documentation and distribution, variety identification, production and distribution of foundation seed of released varieties and training of professionals and technical staff involved in germplasm conservation and seed production.

Germpalsm assembly and conservation. Six thousand diverse groundnut germplasm accessions from the global genebank at ICRISAT, Patancheru were duplicated in a regional genebank at ICRISAT, Niamey, Niger. The regional genebank is maintained to international standards. Additional collections of unique groundnut germplasm were collected in Mali (23 samples) and Tchad (14 samples).

Germplasm documentation. The assembled germplasm has been documented in various forms such as printed catalogs, a computer-based catalog and CD-ROMs, and has been posted on the Web (www.icrisat.org). The printed catalogs and CD-ROMs have been widely distributed in the sub-region.

Germplasm distribution and exchange. The project ensured that useful germplasm and improved varieties were available to NARS and other beneficiaries in a timely manner. A total of 6370 samples were distributed during the project period. To ease germplasm exchange, technical aspects of quarantine procedures were documented in consultation with NARS partners. Most of the accessions held in the genebank are designated to the FAO. To protect this material as International Public-Goods (IPGs), a Material Transfer Agreement (MTA) setting out general principles and procedures in germplasm transfer and exchange was established. This is routinely used.

Evaluation and Diffusion of Selected Germplasm and Improved Groundnut Varieties

Variety evaluation. A network of regional variety trials was established in 1998 in 11 countries of West Africa. A total of 92 improved breeding and germplasm lines were evaluated in these trials. The varieties were grouped according to various economic traits such as resistance to foliar diseases, resistance to groundnut rosette, tolerance to aflatoxin contamination, tolerance to drought, confectionery types and high yield potential. They were compared with standard controls of appropriate maturity. The best varieties across the region yield 15 - 40% more than the standard varieties and are listed in Table 1.

Variety releases. Four short-duration rosette resistant varieties (ICGV-IS 96894, ICGV-IS 96891, ICGV-1S 96808 and ICGV-IS 96855) and three medium-duration varieties (UGA 2, UGA 5 and M572.801) were proposed to the National Variety Release Committee of Nigeria for registration and release. In May 2001, ICGV-IS 96894, UGA 2 and M572.801 were approved for wide-scale production. These varieties offer prospects for eliminating 30-100% yield losses due to rosette, thus improving productivity of the crop in Nigeria. This will also restore farmers' confidence that they can grow the crop without losing their harvest to a devastating disease.

In Senegal, six high-yielding confectionery varieties (ICGV 97041, ICGV 97047, ICGV 97049, ICGV 97052, ICGV 9765 and H75-0) were identified and are candidates for release. These varieties will be available to farmers for cultivation under irrigation to provide protection from aflatoxin contamination and promote the groundnut trade. Other varieties are in advanced stages of on-farm testing in national variety trials in other countries.

A regional variety catalog, which brings together the best varieties currently available, has been published.

Foundation Seed Multiplication

Before the project, less than 20 varieties were multiplied in the region. Some of these are no longer adapted to environmental conditions such as drought, pest pressure and viral diseases or do not meet the quality standards of the market (free from aflatoxin contamination, and grades and standards for edible groundnut). The project assisted NARS to produce limited quantities of breeder and foundation seed of new verities at the national level. A total of 37 new high-yielding varieties is available. About 30,000 t of high quality breeder and foundation seed was produced during the project period.

Table 1. The best varieties from the regional testing program.

Variety group	Variety	Variety group	Variety
Resistant to early leaf spot	ICGV 91225 ICGV 92099 ICGV 92087 #3-94 ICGMS 42 (CG 7)	Tolerant to drought	ICGV 86024 ICGV 86124 ICGV-SM 86024 OC 8-35 11908-13 55-21
Resistant to late leaf spot	ICG 7756 ICG 8298 ICGV 88274 ICGV 92082 ICG (FDRS) 4	Tolerant to aflatoxin contamination	ICGV 88274 ICGV 89063 ICGV 89112
Resistant to groundnut rosette (short-duration)	ICGV-SM 93525 ICGV-IS 96802 ICGV-IS 96808 ICGV-IS 96855 ICGV-IS 96891 ICGV-IS 96894 ICIAR 19BT	Resistant to rust	ICG 10933 ICG 10963 ICG 10014 ICC. 10918
Resistant to groundnut rosette (medium-duration)	ICGV-IS 96812 ICGV-IS 96814 ICGV-SM 88761 M343-81 A MDR 8-15 M516.791 M572.801 UGA 2	Confectionery groundnut	ICGV 88434 ICGV 93057 ICGV 93104 ICGV 94222 ICGV 97041 ICGV 97052 ICGV 97065 H 75-0

Strengthening National R & D Capacity

Training was an integral part of all research and development (R&D) activities to upgrade the skills of professional and technical staff in priority areas. Research capability in collaborating NARS was enhanced through the provision of funds for labor, supplies and equipment. Three major training workshops were organized. Sixteen national scientists from 11 countries in West Africa received training in genetic-resources and genebank management, 15 scientists from 12 countries were trained in methods for diagnosis and detection of virus diseases and aflatoxin contamination; and 27 participants from 13 countries attended a training workshop on groundnut seed production, handling, storage, distribution and marketing. Two hundred farmers (100 each in Mali and Niger) received training in participatory variety selection, on-farm seed production, and conservation. Fellowships were also offered to visiting scientist and research scholars.

Technology Dissemination

Paramount among the project's goals was the imparting of information of value to beneficiaries. The project promoted the sharing of information, research databases, methodologies and outputs among all its participants and stakeholders. This was achieved by conventional means such as hosting workshops and conferences, annual planning sessions, publishing reports and newsletters, and on-farm pilot programs. Other means of information dissemination was through e-mail and web-based approaches. Seven scientific articles written by project scientists in collaboration with NARS scientists were published in refereed international journals and 16 conference papers were also published in workshop proceedings. These articles covered a variety of aspects including genetic resources, material exchange, seed systems, conservation and distribution. The publications provide both a permanent record of project achievements and an enhanced understanding of technology. Other important publications included five project newsletters, 3 training manuals and 4 technical manuals.

Lessons Learned

Development lessons

- A broad range of germplasm has been assembled in the region to support future development. Breeders and other users now have a ready access to a diverse gene pool for development of new varieties to meet farmers' and market requirements. It is imperative that this resource be maintained at a sustainable level.
- To increase the returns on research investment the promotion of technologies (improved varieties) arising from the project has to be extended to the ultimate beneficiaries (eg, farmers, small-, medium- and large-scale processors).
- There are inherent transaction costs of centralized seed production because of the bulkiness and fragility of groundnut seed. The development of sustainable systems to produce high quality seed in close proximity to those in dire need is essential.
- National programs in West Africa are highly heterogeneous, with different capacities and needs, and many face extremely difficult resource allocation choices. Those NARS that lack the required financial, scientific and infrastructure resources may use resources more efficiently by improving their capacity to be efficient spillover recipients.

Operational lessons

- Partnership and networking are essential in tackling regionally important constraints. Individual NARS possess considerable expertise in particular research areas. Tapping this potential and assuring collaboration and coordination between NARS should contribute to sustainable groundnut production in the sub-region.
- Accessibility to information is crucial. Databases developed on groundnut germplasm make ready access to this resource a practical reality. Knowing what is available in the collections, and the trails and characteristics of the material, saves users' precious time and energy.
- Farmers are eager to experiment with new varieties. This is increasing the adoption of new varieties selected by farmers themselves.

Perspectives

In the past, germplasm exchange in West and Central Africa was rare, fortuitous and not usually monitored, and the development and distribution of improved groundnut varieties faced serious constraints. Under the project, a regional network for sustainable conservation of germplasm and for the development and free distribution and exchange of improved seed material has

been established. In particular, a broad range of germplasm has been assembled in the region to support future development, the capacity of NARS to handle and improve germplasm has been enhanced and an important number of improved groundnut varieties has been tested and is now available in the region. This represents the first, essential step towards increased productivity and sustainable production of groundnut in West Africa. In an environment where public agencies have progressively withdrawn from germplasm research and seed production and distribution activities, the project has raised the awareness of stakeholders at the public, private, non-governmental organization and farmer groups of the need for long-term, coordinated efforts in the production of improved seed. To build on this solid foundation CFC approved a four-year (2003-06) follow-up project to focus on the development of sustainable seed production and delivery systems:

The main objectives of the follow-up project are:

- Promote utilization and uptake of improved groundnut varieties responding to market requirements, through the development of sustainable community-based seed systems
- Promote measures to minimize *Aspergillus flavus* and aflatoxin contamination
- Improve skills of farmers and other entrepreneurs in seed production, delivery, processing marketing and small seed enterprise management
- Improve the How of information between various stakeholders
- Project management and monitoring

Outputs

- Groundnut varieties meeting domestic, regional and international markets available
- Sustainable breeder and foundation seed supply developed to cover at least 20% of the cultivated areas in the target areas
- Alternative seed supply strategies implemented
- Linkages between producers, processors and other stakeholders enhanced
- Impact of improved varieties and seed delivery systems documented
- Agronomic practices to reduce aflatoxin contamination demonstrated
- Diagnostic tool kits extended and safety standards system ready for implementation
- Better harvesting and storage technologies extended
- Relevant stakeholders trained
- Relevant information widely disseminated
- Project management, coordination and monitoring

Groundnut Releases

Groundnut Variety Narayani Suitable for Cultivation in Andhra Pradesh, India

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Groundnut *(Arachis hypogaea)* is an important oilseed crop in Andhra Pradesh, India. It is grown on about 2.2 million ha with 85% of the area sown to the rainy season crop. Due to wide variations in rainfall distribution across years, the rainy season groundnut yields fluctuate from 550 to 1100 kg ha^{-1}. The crop is subjected to moisture stress at different stages of crop growth in different years. Varieties that would overcome or avoid moisture stress would greatly stabilize the groundnut yields in the rainy season. The existing variety JL 24 is highly susceptible to moisture stress at the pod-filling stage. Thus, with the objective of evolving an early-maturing variety that would circumvent the moisture stress at the pod formation and the pod development stages, a crossing program was initiated during 1981/82 between Ah 316/S and EC 21137-1 (as donors for earliness) and JL 24 (as the female parent). TCGS 29 was developed from JL 24 x Ah 316/S cross following the mass pedigree method of breeding and was found promising for the required attributes, ie, earliness, and high pod and kernel yields. It was tested in different yield trials at the research station from 1988 to 1992 as well as on farmers' holdings during 1995 and 1996 rainy seasons and 1998/99 postrainy season. Based on these tests, the Andhra Pradesh State Varietal Release Committee released TCGS 29 as 'Narayani' in July 2002. TCGS 29 is an early-maturing (100 days), Spanish bunch

Table 1. Pod yield (kg ha^{-1}) of TCGS 29 in different trials during rainy and postrainy seasons at Tirupati, Andhra Pradesh, India.

	Station trials (rainy season)						Station trials (postrainy season)					Rainy season minikits[1]		
Variety	1988	1989	1990	1991	1992	Mean	1988/89	1989/90	1990/91	1991/92	Mean	1995	1996	Mean
TCGS 29	2378	1165	1561	1634	1638	1675	2921	2459	3185	1984	2637	1367	1137	1252
JL 24	2302	868	1425	1305	1472	1470	2379	1938	2693	1561	2143	917	1024	971
CD (*P* = 0.05)	195	186	168	239	195	–	282	344	481	563	–	–	–	–
CV (%)	6	14	9	13	15	–	6	9	18	15	–	–	–	–
Yield increase (%) over control	3	34	10	25	11	13	23	27	18	27	23	49	11	29

1. Trials organized on farmers' holdings in collaboration with officials of the Department of Agriculture, Andhra Pradesh.

(A. *hypogaea subsp fastigiata* var *vulgaris)* variety. It is recommended for cultivation in both rainy (June/July to October/November) and postrainy (November/December to March/April) seasons.

At the Regional Agricultural Research Station, Tirupati, Andhra Pradesh, TCGS 29 was evaluated in both rainy and postrainy seasons. During the rainy season, it produced an average pod yield (mean of 5 rainy seasons. 1988, 1989, 1990, 1991 and 1992) of 1675 kg ha^{-1}, which was 13% higher than that of JL 24 (Table 1). During the postrainy season, it produced an average pod yield of 2637 kg ha^{-1} (mean of 4 seasons. 1988/89. 1989/90,1990/91, 1991/92). which was 23% higher than that of JL 24. In the multilocational trial conducted during 1994 rainy season at three locations, Tirupati, Kadiri and Anantapur in Andhra Pradesh, it gave an average pod yield of 1086 kg ha^{-1}, which was 20% higher than JL 24. In minikits organized on farmers' holdings in Chittoor, Anantapur, and Kurnool districts of Andhra Pradesh during 1995 and 1996 rainy seasons, the overall average pod yield of TCGS 29 was 1236 kg ha^{1}. which was 43% higher than that of JL 24 or local Spanish bunch cultivar. TCGS 29 was also evaluated during postrainy season in an on-farm demonstration trial during 1998/99 postrainy season. It produced 3883 kg ha^{-1} pod yield, an increase of 16% over the red-seeded variety locally known as 'Pollachi'.

The leaflets of TCGS 29 are long, elliptical and green. The stem is angular with light greenish purple pigmentation. It is tolerant to mid-season drought. There is no resistance to major pests and diseases. Its growth habit is determinate and erect. It possesses four primary branches (very rarely five) and the secondary branches are more. TCGS 29 has medium-sized pods (100-pod mass of 90-99 g and 100-seed mass of 42-45 g) with moderate reticulation and moderate constriction. Seeds have light red testa with oil content of 47-49% and shelling outturn of 74-76%. The other important desirable attribute of TCGS 29 is synchronous maturity of all pods in a plant. However, it is not suitable for high rainfall areas as it produces excessive vegetative growth under such conditions.

A Kalahasti Malady Resistant Groundnut Variety Suitable for Postrainy Season Cultivation in Andhra Pradesh, India

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Groundnut *(Arachis hypogaea)* is a major oilseed crop grown in Andhra Pradesh. India during rainy (June/July to October/November) and postrainy (November/December to March/April) seasons. During postrainy season, it is cultivated in about 0.4 million ha under irrigated conditions and the yield is almost double that of the rainy season crop due to congenial climatic factors and assured irrigation. In the eastern parts of Chittoor and adjoining areas of Nellore and Prakasam districts, groundnut is grown in about 50.000 ha during postrainy season. In these areas, the soilborne nematode *Tylenchorhynchus brevilineatus* associated with the problem called 'Kalahasti malady' is responsible lor considerable yield losses in groundnut. The disease starts appearing as small, brown or black spots on the pegs and on developing pods. The spots enlarge and coalesce covering the entire pod surface. Consequently, the pod

Table 1. Pod yield (t ha^{-1}) of the groundnut variety TCGS 320 in different yield trials during the postrainy season in Andhra Pradesh, India.

Variety	RARS, Tirupati[1]							APSSDC Farm, Srikalahasti[2]					Minikits on farmers' holdings[3]			
	Advanced varietial trial			Multilocational Varietial Trial												
	1996/97	1997/98	Mean	1997/98	1998/99	1999/2000	Mean	1993/94	1994/95	1996/97	Mean		1996/97	1997/98	1998/99	Mean
TCGS 320	4.3	3.0	3.6	3.5	3.2	2.1	2.9	3.9	2.8	3.1	3.3		3.6	3.6	4.1	3.7
JL 24	3.2	2.6	2.9	2.9	2.3	1.5	2.2	2.8	2.0	2.0	2.3		2.7	3.0	3.6	3.1
CD ($P = 0.05$)	0.329	0.530	–	0.326	0.343	0.494	–	–	–	–	–		–	–	–	–
CV (%)	7	13	–	12	15	14	–	–	–	–	–		–	–	–	–
Yield increase (%) over control	35	15	30	21	37	44	31	42	38	55	45		33	19	13	21

1. RARS = Regional Agricultural Research Station.
2. APSSDC = Andhra Pradesh State Seed Development Corporation.
3. In Kalahasti malady endemic areas of Chittoor, Nellore and Prakasam districts.

surface becomes black. The pod size gets reduced. However, the seeds inside the pods look normal but are small. Thus, it spoils the quality and appearance of the produce. The varieties that are currently grown are highly susceptible and in severe cases of infestation, yield reduction can be up to 50%. Disease control measures such as application of carbofuran granules are costly and affect other soil microflora and fauna. Thus the development of resistant varieties is the best solution to this problem.

Kalahasti malady became a serious problem in Andhra Pradesh from early 1980s. During 1983, about 1600 groundnut genotypes obtained from lCRISAT and the Andhra Pradesh Agricultural University [now Acharya NG Ranga Agricultural University (ANGRAU)] were screened for resistance to Kalahasti malady in hot spot areas. Of these, only three were resistant to Kalahasti malady. Among the three genotypes, only one, TCGS 1518 had desirable agronomic attributes. It was released as Tirupati 3 in 1991 as a short-term control measure. But it was a Virginia bunch *(A. hypogaea* subsp *hypogaea* var *hypogaea)* variety and matured in 125-130 days with 2-3 additional irrigations in the hot months of March and April. Farmers preferred a shorter duration variety. Thus, a breeding program was initiated during 1988-89 utilizing TCGS 1518 as donor of Kalahasti malady resistance and male parent and Spanish bunch *(A. hypogaea* subsp *fastigiata* var *vulgaris)* breeding lines, TCGS 1709, TCG 1716, TCG 1717 and TCG 273 as female parents to develop a high-yielding, short-duration (105-110 days) Kalahasti malady resistant variety. Following mass pedigree method of breeding, TCGS 320 was developed from the cross TCGS 1709 x TCGS 1518. TCGS 320 was released as 'Kalahasti' by the Andhra Pradesh State Varietal Release Committee in July 2002.

The performance of Kalahasti was impressive in various yield trials at the Regional Agricultural Research Station (RARS), Tirupati, Andhra Pradesh State Seed Development Corporation (APSSDC) Farm in Srikalahasti (a hot spot location of Kalahasti malady) and in farmers' holdings in endemic areas of Chittoor, Nellore and Prakasam districts. In an advanced varietal trial at RARS, Tiruapti it produced 3.6 t ha^{-1} pods (mean of 2 seasons, 1996/97 and 1997/98), 28% higher yield than that of JL 24 (Table 1). At the APSSDC Farm, it surpassed JL 24 by producing 3.3 t ha^{-1} pods (mean of 3 seasons, 1996/97, 1997/98 and 1998/99) 44% higher yield than that of JL 24. In a multilocational varietal trial of groundnut in Tirupati, TCGS 320 produced an average pod yield of 2.9 t ha^{-1} with 31 % increase over JL 24. The pod yields of TCGS 320 in adaptive minikits in farmers'

holdings in Kalahasti malady endemic areas of Chittoor, Nellore and Prakasam districts varied from 3.6 to 4.1 t ha^{-1}, with a mean of 3.7 t ha^{-1}, an increase of 22% over JL 24. The mean pod yield in JL 24 was 3.1 t ha^{-1}. In north-coastal and northern Telangana districts where excess vegetative growth due to high rainfall is a problem in the rainy season, the performance of Kalahasti was encouraging. It produced a pod yield of 1.4 t ha^{-1} which was 28% higher than that of JL 24 or the local variety.

Kalahasti is a short-duration (105-110 days), high-yielding, Kalahasti malady resistant, Spanish bunch variety. Its distinguishing morphological features are: plant height 22-25 cm, sequential branching pattern, short internodes, and short, broad obovate dark green leaflets. Pods are medium in size (100-pod mass ranges between 108 and 142 g, 100-seed mass ranges between 42 and 46 g) with shallow constriction, slight reticulation, and moderate beak. Shelling outturn is 74 to 76%. Seeds have red testa and contain 52% oil.

Kalahasti is recommended for postrainy season cultivation especially in Kalahasti malady endemic areas. It is suitable for rainy season cultivation in high rainfall areas of north-coastal and northern Telangana districts of Andhra Pradesh. For better pod-filling in this variety, gypsum application is essential at full bloom stage. A post-sowing irrigation is also needed to ensure uniform germination because of the high moisture requirement of this variety for germination.

Biotechnology

Genetic Relationship Among Arachis Species Based on Molecular Data

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The origins of modem *Arachis* can be traced to the valleys of South America, in the Brazil-Paraguay region (Simpson et al. 2001) where it is distributed even today. Cultivated groundnut *(Arachis hypogaea)* shows great morphological variability but limited molecular polymorphism (Dwivedi et al. 2001). Based on morphological characters and cross compatibility relationships, Krapovickas and Gregory (1994) classified the genus *Arachis* into nine sections.

Traditionally morphological and agronomic traits have been used to measure genetic diversity but most of the vegetative characteristics are influenced by environmental factors, show continuous variation and have high degree of plasticity. In an attempt to overcome these problems, biochemical and molecular techniques have been used to assess genetic and taxonomic relationships. For such studies a flexible and reliable marker system to detect high levels of polymorphism is required. Galgaro et al. (1998) based on restricted fragment length polymorphism (RFLP) data have shown that sections *Arachis* and *Extranervosae* form two clearly defined groups and sections *Heteranthae, Caulorrhizae* and *Triseminatae* form the third group. Gimenes et al. (2002) used amplified fragment length polymorphism (AFLP) to study genetic relationships among *Arachis* species. Their study grouped section *Arachis* species together with *A. glandulifera* showing distant relationship between *A. hypogaea* and the A and B genome species. Species from section *Erectoides* grouped with *A. glabrata* (section *Rhizomatosae)* and *A. rigoni* (section *Procumhentes)* showed close relationship with *A. dardani* (section *Heteranthae).*

Amongst the different types of markers, randomly amplified polymorphic DNA (RAPD) markers are easy to use and do not need sequence data. These are also economical and do not need expensive kits or equipment. The RAPDs can produce multiple bands using a single primer; thus a relatively small number of primers can be used to generate a very large number of fragments. These fragments are usually generated from different regions of the genome and hence multiple loci may be examined very quickly. The sequence changes in genomic DNA may result in a change in the pattern of amplification products following agarose gel electrophoresis. This makes RAPD a very powerful technique for screening populations for sequence diversity as well as plant diversity analysis. RAPD markers have been used in evolutionary studies of wild species from section *Arachis* (Halward et al. 1992) and in the creation of genetic linkage map (Halward et al. 1993). These have also been used to distinguish seventeen wild species from five sections of *Arachis* and cultivated groundnut *A. hypogaea* and introgression of alien genes in wide crosses (Fennell 1994, Mallikarjuna 2002).

Thirty-two accessions of wild species of *Arachis,* belonging to twenty-five species and grouped under six sections, including *A. hypogaea* were used to study their genetic relationship using RAPDs. Twenty-nine primers belonging to OPH 1-20 and OPM 1-9 were used in this study. All the primers showed polymorphic bands, with

the number of bands per locus varying from 5 to 33. Pair-wise similarities (S_{ij}) between accessions (i and j) were estimated using Jaccard similarity coefficient (Jaccard 1908). A dendrogram was constructed (Fig. 1) based on the S_{ij} values using clustering technique of unweighted pair group method of arithmetic means (UPGMA) (Sneath and Sokal 1973). Similarity values (S_{ij}) for 464 pair-wise comparisons among 32 accessions ranged from 0 to 49%, with an average of 15%.

Arachis hypogaea grouped with *A. monticola,* a tetraploid wild species from section *Arachis.* The A genome was represented by many diploid species including *A. stenosperma,* B genome by *A. batizocoi* (Singh and Moss 1982), *A. ipaensis, A. hoehnei, A. valida* and *A. magna* (Milla 2003), and D genome by *A. glandulifera* (Stalker and Moss 1987). *Arachis stenosperma* accessions grouped together. Wild species from section *Arachis* with the B genome formed two clusters, with one cluster having *A. batizocoi* showing distant relationship and the other cluster with *A. hoehnei* showing close relationship. The D genome accession *A. glandulifera* remained apart. Most of the wild species grouped according to their expected relationship with each other, based on crossability (Nalini Mallikarjuna and Bramel 2001) and morphological characters (Krapovickas and Gregory 1994). But accessions of *A. cardenasii* (ICGs 11558 and 11559) from section *Arachis* did not group with any of the A, B or D genome species from section *Arachis* and with each other.

The RAPDs were used to distinguish species belonging to different sections of *Arachis.* Although more than 200 simple sequence repeat (SSR) markers have been developed for *Arachis* (ME Ferguson, lCRlSAT, Kenya, personal communication), there is no information that they would identify different species belonging to different sections.

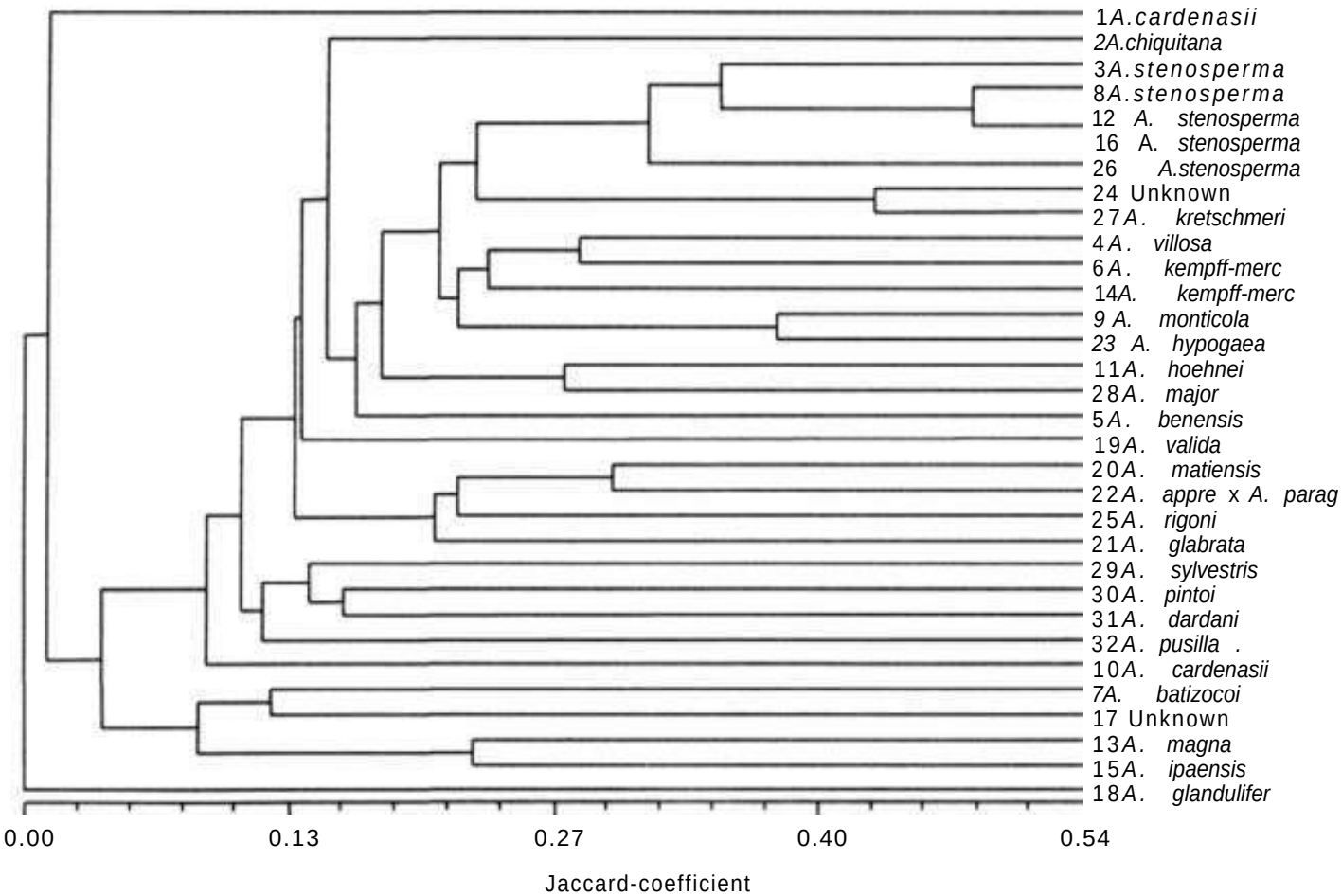

Figure 1. UPGMA-based dendogram of *Arachis* species prepared from RAPD data. (Note: 22 refers to *A. appressipila* x *A. paraguariensis.)*

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AFLP Diversity Among Selected Rosette Resistant Groundnut Germplasm

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Groundnut rosette is the most destructive disease of groundnut *(Arachis hypogaea)* in Africa. It is sporadic and unpredictable but causes significant loss in groundnut in years of epidemics (Naidu et al. 1999). Three synergistic agents cause rosette disease: groundnut rosette virus (GRV), a satellite RNA of GRV and groundnut rosette assistor virus (GRAV) (Bock et al. 1990). All three agents need to be present in the plants for aphid *(Aphis craccivora)* transmission. Resistance to groundnut rosette has been detected in 116 accessions of *A. hypogaea.* These accessions possess resistance to GRV but are susceptible to GRAV (Subrahmanyam et al. 1998). A few rosette resistant accessions are also resistant to *Aphis craccivora* (Padagham et al. 1990, Minja et al. 1999). These represent a wide range of biotypes and landraces from Latin America, Africa, and Asia, but their genetic-relationships are not known.

Molecular marker-based diversity estimates are useful to select diverse lines for developing populations that may be used for mapping studies to identify DNA markers linked with resistance to rosette in groundnut. Nine amplified fragment length polymorphism (AFLP) assays (Vos et al. 1995), using primer pairs E-ACA + M-CAA, E-ACA + M-CAG, E-AGC + M-CTG, E-AGC + M-CTA. E-ACT + M-CAG, E-ACC + M-CAG, E-ACC + M-CAA, E-AAC + M-CTG and E-AAC + M-CAG, were performed on nine rosette resistant (ICGs 3436, 6323, 6466, 9558, 9723, 10347, 11044, 11968 and 12876) and one susceptible (ICG 7827) groundnut accessions. Young leaves from 2-week old plants were bulk harvested for each accession and immediately placed in liquid nitrogen for DNA extraction. DNA was extracted using the CTAB method (Saghai-Maroof et al. 1984). The concentration of DNA was assessed by spectrophotometer analyses, and the quality by gel electrophoresis using 0.8% agarose with a known concentration of uncut lambda DNA. 500 ng of genomic DNA was double digested with *Eco*R 1 and *Mse* 1 in a restriction buffer in a total volume of 15 µl. *Mse* 1 and *Eco*R 1 adapters were subsequently ligated to digested

DNA fragments. The adapter-ligated DNA was pre-amplified using the following cycling parameters: 20 cycles of 30 s at 94°C, 60 s at 56°C and 60 s at 72°C. The pre-amplified DNA was diluted in a ratio of 1:50 prior to labeling it with γ^{33} P that was used as template for the selective amplification with *EcoR* 1 and *Mse* 1 primers having three selective nucleotides at their 3' end. The cycling parameter for selective amplification was 1 cycle of 30 s at 94°C, 30 s at 65°C, and 60 s at 72°C. The annealing temperature was lowered by 0.7°C $cycle^{-1}$ during the first 12 cycles, and then 23 cycles were performed at 94°C for 30 s, 56°C for 30 s and 70°C for 60 s. After the selective amplification, the reaction was stopped by the addition of 20 µl of formamide dye. The amplification product was separated by denaturing 6% polyacrylamide gel electrophoresis, and autoradiographs were manually scored as 1 for the presence and 0 for the absence of band from higher to lower molecular weight products.

Pair-wise genetic similarity (S_{ij}) between accessions i and j was estimated using the similarity coefficient of Nei and Li (1979) as $S_{ij} = 2 N_{ij} / (N_i + N_j)$, where N_{ij}. is the number of bands common in accessions i and j, and N_i and N arc the total numbers of bands in accessions i and j, respectively. S_{ij} represents the proportion of bands in common between any two accessions and may range from 0 (no common bands) to 1 (identical band profile for the two accessions). S_{ij} values were used to estimate genetic dissimilarity, as $D_{ij} = 1-S_{ij}$ and D_{ij} values were later on used to determine the relationships among lines using principal coordinate analysis (PCoA) (Sneath and Sokal 1973). All computations were performed using statistical computing package Genstat5 Release 4.1. A band was identified as a unique AFLP molecular marker if present in one line at a specific molecular weight but absent in the remaining lines for a given primer pair.

Across the 10 accessions the 9 primer pairs identified 94 unique markers, with an average of 10.4 markers per primer pair. The number of unique markers ranged from 1 for ICG 10347 and ICG 11968 to 49 for ICG 11044. Primer pair E-ACC + M-CAA detected 26 of the 32 unique markers present only in ICG 11044. Other primer pairs that detected high frequency of unique markers are E-AAC + M-CAG with 17 markers in ICG 6466 and E-ACC + M-CAG with 10 markers in ICG 6323. These unique AFLP markers could differentiate only 7 of the 10 accessions included in this study (Table 1). Accession specific markers were not detected in ICGs 9558, 9723, and 12876.

The genetic dissimilarity (D_{ij}) values ranged from 3.92% to 50.53% with an average of 19.56%. The D_{ij} matrix was used to determine the genetic relationships among lines using principal coordinate analysis (PCoA). Accession ICG 11044 (quadrant IV) and ICG 6323 and ICG 6466 (quadrant I) were well separated from each other as well as from the rest of the lines (Fig. 1). ICG 11044 with ICG 3436, ICG 9558 and ICG 11968 showed greater genetic diversity (36.59% to 50.53%) amongst the rosette resistant accessions. The former is a landrace from China whereas the latter three are landraces from Africa. They all belong to subsp *hypogaea* var *hypogaea*, and possess high levels of resistance to rosette, average <2% compared to >90% in susceptible control ICG 7827 (JL 24) across four seasons in evaluation at Lilongwe, Malawi. These accessions therefore may be inter-crossed among themselves to produce diversified rosette resistant breeding populations. ICG 3436, ICG 6323 and ICG 11044 also showed greater diversity (26.50% to 41.52%) with the susceptible accession ICG 7827. ICG 11044 (rosette resistant) and ICG 7827 (rosette susceptible) should be crossed for developing appropriate mapping

Table 1. Unique AFLP markers identified in 7 of the 10 groundnut accessions tested.

Primer pair	ICG 11044	ICG 10347	ICG 11968	ICG 7827	ICG 6323	ICG 3436	ICG 6466	Total
E-ACA + M-CAA	7	1						8
E-ACA + M-CAG	7							7
E-AGC + M-CTG	6							6
E-AGC + M-CTA			1					1
E-ACT + M-CAG				3				3
E-ACC + M-CAG				5	10			15
E-ACC + M-CAA	26			1		3	2	32
E-AAC + M-CTG	2							2
E-AAC + M-CAG	1				1	1	17	20
Total	49	1	1	9	11	4	19	94

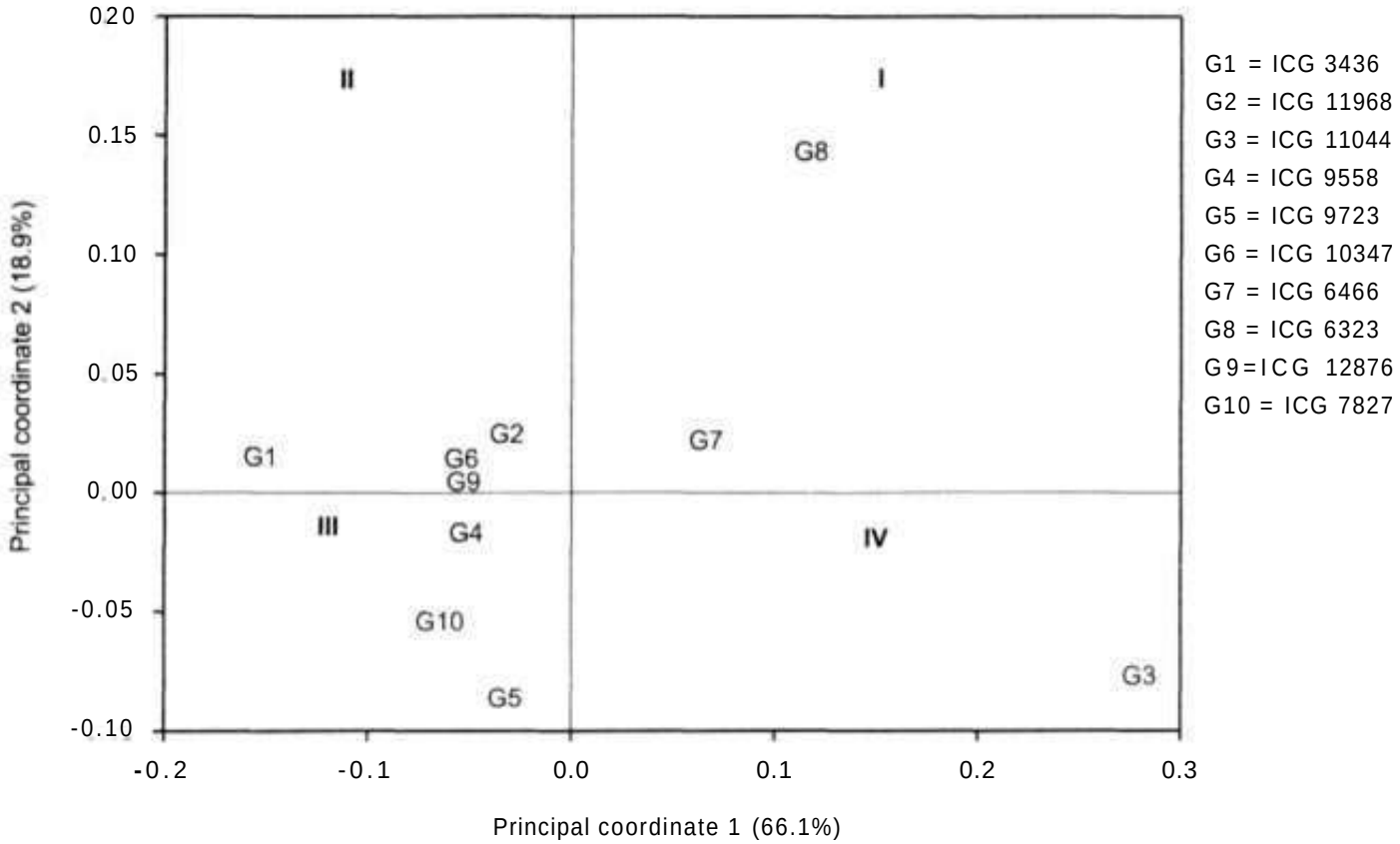

Figure 1. Relationships between 10 groundnut accessions as determined by principal coordinate analysis (PCoA) using AFLP-based dissimilarity matrix.

population (F_2 derived recombinant inbred lines) as their AFLP profiles differ by 41.52% and the former possess 49 unique AFLP markers that are absent in ICG 7827. The suggested AFLP primer pairs to identify markers linked with resistance to rosette in ICG 11044 x ICG 7827 are E-ACC + M-CAA, E-ACA + M-CAA, F-ACA + M-CAG and E-AGC + M-CTG as these showed maximum number of unique AFLP markers in ICG 11044.

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Pathology

Aflatoxin Resistance in Bacterial Wilt Resistant Groundnut Germplasm

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Bacterial wilt (BW) caused by *Ralstonia solanacearum* has been among the major constraints to groundnut *(Arachis hypogaea)* production in central and south China for several decades. As a soilborne disease, BW is difficult to control, and the only feasible management approach is planting resistant groundnut cultivars. Therefore, in most cases, BW resistant cultivars are essential for groundnut production in the heavily infested regions. China has assembled the largest collection of BW resistant groundnut germplasm worldwide and the wilt problem in most farmers' fields has been much reduced due to planting improved resistant cultivars. However, the warm and moist weather in all the BW epidemic areas in central and south China is also favorable for the perpetuation of *Aspergillus flavus* and *A. parasiticus* and aflatoxin contamination. All the BW diseased areas, therefore, are also affected with serious contamination by these two fungi. Genetic improvement for resistance to aflatoxin contamination along with BW resistance is crucial to comprehensive management of both the constraints, and the diversified BW resistant groundnut germplasm has made this possible.

By root cross-inoculation of *R. solanacearum* and *A. flavus* in the late growth stage of groundnut, it was found that infection of *R. solanacearum* in immature pods could encourage pre-harvest invasion of *A. flavus* and increase aflatoxin contamination, but the reaction varied among BW resistant genotypes. Several BW resistant groundnut genotypes were grown in a natural BW nursery with high inoculum pressure of *R. solanacearum* in Hongan and in a disease-free field in Wuhan, China and tested for their natural contamination of aflatoxin. The preliminary results showed that the groundnut lines with high latent infection or colonization of *R. solanacearum* and/or poor drought tolerance had higher aflatoxin contamination. Thirty lines with differing BW resistance levels were investigated in the laboratory for their resistance to seed invasion *of A. flavus* and to aflatoxin production. From replicated experiments for seed invasion resistance, Xiaohongmao was found to possess similar seed invasion resistance as that of J 11, a widely reported resistant cultivar released in India. It was interesting to note that Xiaohongmao had the highest oleic fatty acid content and the smallest pod size among the BW resistant genotypes. From experiments for resistance to aflatoxin production, two BW resistant genotypes, Taishan Zhenzhu and 93-76, were found to have lowest aflatoxin content after inoculation with a local strain of *A. flavus* (AF2202) with high capacity of aflatoxin production. Taishan Zhenzhu is the BW resistant parent of 93-76. Thus, it was concluded that it would be possible to improve resistance to aflatoxin contamination in BW resistant groundnut germplasm. The combined resistance to BW and aflatoxin contamination will not only increase and stabilize groundnut production but also improve its quality in BW endemic areas.

Aflatoxin Contamination in Groundnut in Uganda

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Concerns about health effects of aflatoxins urged the Peanut CRSP to indicate a project on investigating the levels of aflatoxin contamination in groundnut (*Arachis hypogaea)* at different nodes of the food chain and examining the knowledge, attitudes, and practices of farmers, traders and consumers in relation to anatoxins and health. This project is now being implemented at Makerere University in Uganda and at Kwame Nkrumah University of Science and Technology in Ghana. We report the progress made in Uganda.

A brief survey that we carried out in June 2003 showed no awareness among farm families in three villages in the groundnut-growing areas of Uganda as to potential side effects from consuming moldy groundnuts. Insufficient attention is paid to practices that might reduce mold and aflatoxin contamination. Particularly risky practices include leaving plants in the field after harvesting without picking the pods, lengthy drying time on the bare ground with little air circulation, and long periods of storage often in poor conditions prior to consumption.

An informal survey of a small number of women faculty and staff at Makerere University showed that most of them purchased groundnut for sauces in ground

Table I. Aflatoxin level (ppb) of different forms of groundnuts sampled from market wholesalers and retailers in St. Balikuddembe, Uganda.

Groundnut form	Wholesale samples		Retail samples	
	Range	Mean[1]	Range	Mean[1]
Unsorted seed	32-65	45 ± 6.71	-	-
Sorted (good) seed	14-25	19 ±4.36	24-33	29.3 ± 5.42
White flour	46-55	51 ±7.14	56-62	58.7 ± 7.66
Pressed (dark flour)	22-35	29.7 ±6.81	24-33	31.7 ± 5.63
Light brown paste (slightly roasted)	30-32	31 ±5.57	31 - 33	32.3 ± 5.72
Brown paste (medium roasted)	25-29	27.3 ± 5.23	28-31	30 ± 5.48
Dark brown paste (total roasting)	15-22	19 ± 4.35	38-39	38.3 ±6.19
Tanzania[2]	52-58	55.3 ± 7.44	-	-
Kenya[2]	63-68	65 ± 8.06	-	-

1. Average of three samples.
2. Samples were obtained from groundnuts imported from these countries by wholesalers in St, Balikudembe and were tested in seed form.

form (mainly from the market where the analyses below were made) and kept it in this form for some days or even weeks before consumption. Once more there was no awareness that this might constitute a health risk due to the potential for accelerated mold *(Aspergillus* spp) growth and aflatoxin production.

Farm-level testing

Samples of groundnut were purchased from the villages of Olupe (Kumi district) and Kiboyo (Iganga district) in Uganda in June 2003 and stored for two years and two months respectively. These samples were tested for aflatoxin content in the Food Science and Technology laboratory at Makerere University. The samples from Olupe were graded into small/diseased/shriveled seed suspected to have anatoxins, and good seed that apparently had no aflatoxins. while those from Kiboyo were not graded since the majority looked good, having been stored for only two months. These samples were purchased from the personal stores of farm families and originally intended for domestic consumption. In Olupe samples, the aflatoxin content was 52 ppb in the deseased seed and 49 ppb in the good seed. Aflatoxin content of 42 ppb was detected in Kiboyo samples. These results indicate that irrespective of appearance, all the seed samples had aflatoxin content well above the 20 ppb limit set by the US Food and Drug Administration and the 10 ppb limit set by the Uganda National Bureau of Standards.

Market-level Testing

In July 2003, samples of seed obtained from the largest wholesale and retail market in Kampala, St. Balikuddembe in Uganda were tested (Table 1).

For more detailed information see the Annual Report 2003-2004 of VT54 on the Peanut CRSP website (http://www.griffin.peachnut.edu/pnutcrsp.html).

Entomology

Pest and Natural Enemy Complex of Groundnut in Tuticorin and Tirunelveli Districts of Tamil Nadu, India

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Groundnut *(Arachis hypogaea)* is an important oilseed crop in India. The state of Tamil Nadu in India grows about 1.1 thousand ha of groundnut in three seasons (Anonymous 2001). Insect pests are the major constraints to groundnut production. More than 360 species of insects and mites were reported to attack the groundnut crop in field and pods in storage all over the world (Stalker and Campbell 1983). Recently, Sridhar and Mahto (2000) reported 37 insect and mite pests and six natural enemies in groundnut in Delhi, India. Moreover, pests are dynamic in nature and the pest complex changes with the agro-ecosystems (Islam et al. 1983, Amin 1988). Among various production constraints of groundnut, insect pests are well recognized by the farming

community in Tamil Nadu. Sahayaraj (1999) recorded *Rhynocoris marginatus*, a general predator, as a potential biocontrol agent for lepidopteran defoliators in groundnut fields in Tamil Nadu. No concrete report was available on the pest and natural enemy complex of the groundnut ecosystem in Tuticorin and Tirunclveli districts of Tamil Nadu. It was therefore considered necessary to record the pests and natural enemies of groundnut in these districts.

Field experiments were conducted in different blocks of groundnut-growing areas of Tuticorin (Ottapidaram, Srivaikuntam, Tiruchendur, Sathankulam and Kovilpatti) and Tirunelveli (Maanur, Vailliyoor, Kadayam, Tenkasi, Chenkottai, Alankulam and Pavoorchatram) during 2001 and 2002 [kharif (rainy season): June to August; *rabi* (postrainy season): September to January; and summer: February to May]. Although groundnut is cultivated in three seasons *(kharif, rabi* and summer) in Tamil Nadu, in our study area farmers cultivated in only two seasons *(kharif and* summer). The experiments were conducted to determine the pest and natural enemy complex of groundnut in one-acre (0.4047 ha) land from each block. The observations on pests and natural enemies on 100 randomly selected plants in each block were recorded from 7 am to 9 am and/or 4 pm to 6 pm on different days after sowing (DAS) until harvest. Those insects that occurred from the seedling stage till harvest and caused considerable damage were designated as major pests.

The groundnut crop in different blocks of Tuticorin and Tirunelveli harbored 29 insect pests (Table 1) and 21 natural enemies (Table 2). Among the pests observed, jassids were abundantly present in all the seasons. Among the nine jassids observed, *Cofana unimaculata* and *Batracomorphus angustatus* are present throughout the year. These are associated with the groundnut crop from the seedling stage till harvest causing direct damage by feeding on the sap. *Aphis craccivora*, a sap feeder, was observed from 30 DAS till harvest. The defoliators such as *Helicoverpa armigera, Spodoptera litura* and *Aproaeremu modicella* were common but sporadic in nature, in Villupuram, Thiruvannamalai, Chengalpet, Erode, Salem and Dharmapuri districts of Tamil Nadu, *A. modicella* was a major pest (Muthiah and Abdul Kareem 2000). However, both in Tirunelveli and Tuticorin districts it is not a serious pest of groundnut. *Helicoverpa armigera* prefers to feed on buds and flowers. Hence, it is also considered as a severe pest in these areas.

Among the soil insects, *Lachnosterna serrata* and *Euborellia stali* were observed from the pod developmental stage till harvest. Raguraman et al. (1998) reported that *L. serrata* has been the major problem in recent years for farmers growing groundnut under rainfed conditions in Tamil Nadu. The white grub *L. serrata* severely affects the young pod. White grub larvae feeding in roots cause plant mortality and those feeding on young pods also cause significant loss to the crop, in both *kharif* and summer seasons. These soil insects were the major pests predominant in Tuticorin.

Among the 21 natural enemies observed in Tuticorin and Tirunelveli districts, *Menochilus sexmaculatus* and *Componotus compresseus* were the most predominant species present in both *kharif and* summer seasons (Table 2). *Lycosa tista* and *Leptogenys processionalis* were observed in moderate numbers. Singh et al. (1993) reported that predators such as *M. sexmaculatus, Coranus* sp, *Isyndus heros* and *Endocus inornatus* feed on various leaf and planthoppers. Our observations reveal that both *M. sexmaculatus* and *Rhynocoris longifrons* prey on *A. craccivora* while *Rhynocoris marginatus* feeds on *S. litura* and *H. armigera* larvae. *Rhynocoris longifrons* also feeds on leafhoppers. Sahayaraj (1999) reported that *R. marginatus* greatly reduced both *H. armigera* and *S. litura* populations under field situations. The fanners in the region have been using synthetic insecticides such as monocrotophos, endosulfan, carbendazim and chlorpyrifos for eradicating groundnut pests. Since predatory insects and spiders are abundant in the groundnut ecosystem we are now advising farmers about the judicious use of various plant protection options. Moreover, we are providing the reduviids *Rhynocoris kumarii* and *R. marginatus* to fanners belonging to Munanchipatti, Moolakaraipatti and Melanedithanallor of Palayamkottai block and Maanur block of Tirunelveli district and Jakkammalpuram of Tuticorin block from Tuticorin district. Further studies are essential to understand the phenology, agroclimatic conditions, cultural practices and farmers' practices and the influence on the pest and natural enemy complex of groundnut in these areas.

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Table 1. Pest complex of groundnut ecosystem in Tuticorin and Tirunelveli districts of Tamil Nadu, India.

Family	Scientific name	Common name	Crop stage affected	Seasons
Hemiptera				
Cicadellidae	*Cofana unimaculata*	Jassid	Seedling to harvest	*Kharif* and summer
Cicadellidae	*Cofana spectra*	Jassid	Active vegetative	*Kharif*
Typhlocybinae	*Empoasca* sp	Jassid	Active vegetative	*Kharif*
Typhlocybinae	*Empoascanara prima*	Jassid	Active vegetative	*Kharif*
Typhlocybinae	*Amrasca splendens*	Jassid	Active vegetative	*Kharif*
Iassinae	*Batracomorphus angustatus*	Jassid	Seedling to harvest	*Kharif* and summer
Deltocephalinae	*Nephotettix virescens*	Jassid	Active vegetative	*Kharif*
Deltocephalinae	*Nephotettix nigropictus*	Jassid	Active vegetative	*Kharif*
Deltocephalinae	*Doratura* sp	Jassid	Active vegetative	*Kharif*
Aphididae	*Aphis craccivora*	Groundnut aphid	Active vegetative to harvest	*Kharif* and summer
Pentatomidae	*Nezara viridula*	Green stink bug	Flowering	*Kharif*
Dermoptera				
Carcinophoridae	*Euborellia stali*	Earwig	Pod maturity to harvest	*Kharif* and summer
Forficulidae	*Labidura* sp	Earwig	Pod maturity	*Kharif* and summer
Coleoptera				
Buprestidae	*Sphenoptera indica*	Jewel beetle	Pod development to pod maturity	Summer
Scarabeidae	*Lachnosterna serrata*	White grub	Pod development to harvest	*Kharif* and summer
Curculionidae	*Myllocerus discolar*	Ash weevil	Flowering to pod development	*Kharif* and summer
Curculionidae	*Myllocerus tenuiclavis*	Ash weevil	Active vegetative	*Kharif*
Curculionidae	*Neocleonus sannio*	Weevil	Active vegetative	*Kharif*
Tenebrionidae	*Gonocephalum* sp	False wireworm	Seedling to flowering	*Kharif*
Chrysomelidae	*Raphidopalpa foveicollis*	Leaf beetle	Active vegetative	*Kharif*
Meloidae	*Mylabiris indicus*	Blister beetle	Flowering to peg initiation	*Kharif* and summer
Meloidae	*Mylabiris pustulatus*	Blister beetle	Flowering to peg initiation	*Kharif* and summer
Isoptera				
Termitidae	*Odontotermes obesus*	White ant	Peg initiation to pod maturity	*Kharif* and summer
Lepidoptera				
Noctuidae	*Spodoptera litura*	Tobacco army worm	Active vegetative to pod maturity	*Kharif*
Noctuidae	*Heicoverpa armigera*	Gram pod borer	Active vegetative to pod maturity	*Kharif*
Noctuidae	*Agrotis segetum*	Common cutworm	Active vegetative to pod maturity	*Kharif*
Gelechidae	*Aproaerema modicella*	Groundnut leafminer	Active vegetative to pod maturity	*Kharif*
Orthoptera				
Acrididae	*Chrotogonus trachypterus*	Surface grasshopper	Active vegetative to pod development	*Kharif* and summer
Acrididae	*Atractomorpha crenulata*	Green grasshopper	Active vegetative to pod development	*Kharif* and summer

Table 2. Natural enemies of insect pests of groundnut observed in Tuticorin and Tirunelveli districts of Tamil Nadu, India.

Family	Scientific name	Common name	Crop stage affected	Seasons
Coleoptera				
Coccinellidae	*Micraspis* sp	Ladybird beetle	Active vegetative to pod development	*Kharif*
Coccinellidae	*Micraspis crocea*	Ladybird beetle	Active vegetative to pod development	*Kharif*
Coccinellidae	*Menochilus sexmaculatus*	Ladybird beetle	Active vegetative to pod development	*Kharif* and summer
Coccinellidae	*Harmonia octamaculata*	Ladybird beetle	Active vegetative to pod development	*Kharif* and summer
Coccinellidae	*Cocinella septumpunctata*	Ladybird beetle	Active vegetative to pod development	*Kharif*
Carabidae	*Ophionea nigrofasciata*	Ladybird beetle	Active vegetative to pod development	*Kharif*
Araneae				
Lycosidae	*Hippasa pisaurina*	Spider	Active vegetative to pod maturity	*Kharif* and summer
Lycosidae	*Lycosa tista*	Spider	Active vegetative to pod maturity	*Kharif* and summer
Oecobiidae	*Oecobius putus*	Spider	Active vegetative to pod maturity	*Kharif*
Gnaphocidae	*Drassodes carnivulvus*	Spider	Active vegetative to pod maturity	*Kharif*
Gnaphocidae	*Gnaphosa poonaenisis*	Spider	Active vegetative to pod maturity	*Kharif* and summer
Hymenoptera				
Myrmicinae	*Solenopsis germinata*	Spider	Active vegetative to pod maturity	*Kharif*
Formicinae	*Componotus compresseus*	Black ant	Active vegetative to pod maturity	*Kharif* and summer
Formicinae	*Componotus sericius*	Black ant	Active vegetative to pod maturity	*Kharif*
Formicinae	*Componotus invidus*	Black ant	Active vegetative to pod maturity	*Kharif*
Ponerinae	*Leptogenys processionalis*	–	Active vegetative to pod maturity	*Kharif*
Aenectinae	*Aenictus* sp	–	Active vegetative to pod maturity	*Kharif* and summer
Hemiptera				
Reduviidae	*Rhynocoris marginatus*	Assassin bug	Active vegetative to pod development	*Kharif*
Reduviidae	*Rhynocoris longifrons*	Assassin bug	Active vegetative to pod development	*Kharif*
Reduviidae	*Onchocephalus annulipes*	Assassin bug	Active vegetative to pod development	*Kharif*
Odonata				
Coenogrinidae	*Agriochemis femina*	Damsel fly	Flowering to pod maturity	*Kharif* and summer

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Biological Control Potential of Aphidophagous Reduviid Predator *Rhynocoris marginatus*

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Groundnut (*Arachis hypogaea*) is one of the important oilseed crops in India. Insect pest damage is one of the major constraints to groundnut production. Around 360 species of insects and mites were reported to infest groundnut crop and stored products (Stalker an^{-1} Campbell 1983). *Aphis craccivora* Koch (Hemiptera: Aphididae) is one of the important sucking pests of groundnut and other leguminous crops throughout India (Wightman and Rao 1993, Sridhar and Mahto 2000). Although chemical pesticides are being used widely by farmers, they have raised questions on environmental safety. Hence, several integrated pest management (IPM) strategies such as the use of natural enemies like reduviids have to be developed to ensure control of insect pests. *Rhynocoris marginatus* (Fab.) (Heteroptera: Reduviidae) is a general predator and feeds on groundnut pests (Sahayaraj 1995, 1999). However, studies on the response of this reduviid predator on *Aphis craccivora* are rather limited. Hence, this investigation is focused on evaluating the biocontrol potential of *R. marginatus* on *A. craccivora.*

Aphis craccivora was collected from black gram (*Vigna mungo)* field in Killikulam. Tamil Nadu, India and reared on 15-days-old cowpea *(Vingna unguiculata)* plants in pots. The predator *R. marginatus* was collected from Sivanthipatti, Palayamkottai, Tamil Nadu and maintained on *Corcyra cephalonica* Stainton larvae under laboratory conditions (28±2°C, relative humidity 73±4% and 13-h photoperiod) in 250 ml plastic containers. Newly emerged nymphs (all instars) and adults of the predator *R. marginatus* were used for this experiment. The groundnut cultivar T M V 7 was grown in tin trays (104 cm x 51 cm x 41 cm) covered with nylon mesh with 10 cm spacing between rows and 30 cm spacing between columns. Three replications were maintained with 12 plants tray^{-1}. The experiment was conducted on 25-day-old plants at 4 different prey densities, 1, 2, 4 and 8 prey plant^{-1}. Aphids were released on the meristcmatic tip of the plants and allowed to settle. One-day-old first instar nymphs (24 h starved) of the predator were released into the cage (one predator $^{-1}$ plant^{-1}) and after 24 h, the number of prey consumed was counted. It was expressed as predatory rate (no. of prey predator $^{-1}$ day $^{-1}$). A similar procedure was followed for all the other instars and adult and for other prey densities.

The biological control potential (predatory rale) of *R. marginatus* increased with increasing prey densities for all the life stages (Table 1). Similar observation was recorded by Sahayaraj (2000). However, the predatory potential decreased for late instars and adults. This could be attributed to the size of the prey and the complexity of the plant structure as late instar and adult predators prefer to stay in microhabitats such as stones, sand and stem base rather than meristematic region where the aphids are predominantly present. In this study, early instars (I, II and III) were found in more numbers on tender leaves whereas later instars and adult predators were mainly found on the stem and stem base. Therefore, late instars

Table 1. Predatory rate of *Rhynocoris marginatus* life stages on *Aphis craccivora* at different prey densities on groundnut plants (n = 36).

	Predatory rate (no. of prey consumed predator^{-1} day^{-1})					
Prey density (no. plant^{-1})	1	II	III	IV	V	Adult
1	0.39	0.42	0.26	0.11	0.03	0
2	1.34	1.07	0.74	0.58	0.08	0
4	3.37	2.82	0.90	0.84	0.11	0.08
8	6.47	6.21	1.29	1.68	0.79	0.26

and adults might have had little access to the aphids present in the meristematic regions owing to the plant structure complexity, resulting in decreased predatory potential. Among the life stages tested, first and second instars had higher predatory potential than late instars and adults. Higher response observed in the early instars (I and II) suggests that the predator *R. marginatus* can be mass reared and incorporated in IPM as an efficient biocontrol agent of the aphid *A. craccivora.* However, field trials have to be done to determine the true predatory potential of this reduviid predator.

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Socioeconomics

Status of Technological Gap in Groundnut Production

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Groundnut (*Arachis hypogaea*) is predominantly grown in Gujarat, India. Technologies are now available which can boost groundnut production. But these have not reached the farmers' fields or the farmers arc reluctant to use these technologies. This has contributed to low productivity of groundnut. To increase groundnut production and thereby raise the socioeconomic conditions of the farmers, rapid transfer of technology is essential. Hence, this study was planned to identify the technological gaps in groundnut production with the following objectives: (1) To find out the extent of technological gap in groundnut production practices; and (2) To examine the factors responsible for groundnut production.

Methodology

The study was conducted in South Saurashtra agroelimalic zone of Gujarat during 1999. By using proportionate random sampling technique, a total number

of 256 respondents were interviewed from 24 selected villages of 12 talukas. To find out the technological gap percentage, a score index was developed by seeking the opinions of 80 experts (scientists, extension workers and progressive farmers) working in the field. They were asked to assign the score to each selected practice, making a total of 100 for all the 17 selected practices. The mean scores were worked out for all the practices separately. These means were then assigned to the adopted technologies by the farmers. The mean scores were again converted into percentage. The following formula was used to compute the technological gap (%) for the 17 recommended technologies of groundnut production:

$$\text{Techchnological gap} = \frac{R-A}{R} \times 100$$

where R = Recommended score (weightage) and A = Obtained score.

Pod yield was selected as dependent variable and nine variables were selected as independent variables.

Findings and Discussion

The data supplied by the respondents indicated that the mean technological gap was 39.44% (Table 1). It also indicated that overall technological gap in groundnut cultivation was of medium order. The disparity between recommendations and actual practices of the farmers is the pointer of technological gap. When the findings were analyzed in this context, it was inferred that the groundnut growers have adopted most of the selected recommendations but only partially. Unless the complete recommended package is adopted fully, one cannot expect optimum yield of the crop.

The technological gap was high in some practices: soil testing (85.36%), chemical fertilizer (79.24%), plant protection (64.84%), row spacing (54.95%) and weed management (50.32%) (Table 2). However, it was low in tillage (4.80%), improved variety (12.49%) and harvesting (13.54%) whereas in remaining technologies, the gap ranged between 19 and 42%. This clearly indicated that low cost and easily adoptable technologies are more feasible for adoption as compared to high cost and skilled technologies.

Table 1, Distribution of the respondents based on technological gap.

Technological gap[1]	Number of respondents[2]
Low (up to 25%)	37 (14.45)
Medium (26 to 54%)	188 (73.44)
High (>55%)	31 (12.11)

1. Mean = 39.44%; SD - 14.44.
2. Total number is 256. Percentage is given in parentheses.

The data revealed that the variables knowledge and technology gap influenced pod yield of groundnut and the correlation was highly significant (Table 3). Also, size of landholding, income and cropping intensity were significantly associated with pod yield of groundnut. Negative correlation between technological gap and pod yield suggests that the technological gap is low when pod yield is high. Correlation between the remaining variables (age, education, risk preference and extension participation) and pod yield was not significant. Correlation between the independent variables namely, size of landholding, income, extension participation and technology gap was significant. It was interesting to note that the variables, size of landholding, income and extension participation had negative correlation with technology gap while the variables namely, age, education, risk preference and cropping intensity did not show significant relationship with technological gap.

The step-wise regression analysis of the data indicated that all the independent variables contributed to the variation in pod yields in farmers' fields ($R^2 = 0.58$). However, as knowledge and technological gap alone contributed to the maximum variability ($R^2 = 0.54$) in pod yield of groundnut, remaining variables were eliminated in the regression analysis. This clearly indicated that higher levels of knowledge and adoption of technologies ultimately affected the yield positively.

To examine the direct and indirect effect of all the selected independent variables on the dependent variable (pod yield), path analysis was employed. It revealed that the variable knowledge had the maximum direct effect on pod yield (Table 3). Other variables registered trivial direct effect on pod yield. The variables income and knowledge showed maximum total indirect effect on the pod yield. This clearly indicates that these variables, both having direct and indirect effects, may be contributing maximum variability to increase the pod yield of groundnut.

Conclusions

The findings of the study led to the conclusion that the overall technological gap was 39.44%. The variables size of landholding, income, knowledge, cropping intensity and technological gap were significantly correlated with

Table 2. Extent of technological gap of improved rainfed groundnut production.

Practice	Recommended score[1] (R)	Mean obtained score (A)	Gap[2] (%)
Soil testing	3.21	0.47	85.36
Tillage	3.33	3.17	4.80
Improved variety	13.37	11.70	12.49
Seed treatment	5.29	3.16	40.26
Seed rate	4.86	3.00	38.28
Sowing time	7.76	4.92	36.60
Row spacing	4. 44	2.00	54.95
Sowing method	3.71	2.44	34.23
Organic manure	7.93	5.47	31.02
Chemical fertilizer	7.37	1.53	79.24
Gap filling	3.20	2.57	19.69
Interculture	4.97	2.92	41.25
Weed management	6.30	3.13	50.32
Supplementary irrigation	9.04	6.67	26.22
Plant protection	9.07	3.19	64.84
Harvesting	3.62	3.13	13.54
Grading and storage	2.53	1.67	33.39

1. Total score = 100.
2. Technology gap = $\frac{R-A}{R}$ x 100

Table 3. Zero-order correlation, step-wise regression and path-coefficient between independent variables and pod yield.

Variable	r-value[1]	Regression coefficient[1]	t-value	Direct effect	Total indirect effect
Age	-0.062 NS	Eliminated	–	0.06X7	0.006
Education	-0.050 NS	Eliminated	–	-0.1 763	0.126
Size of land holding	0.1905*	Eliminated	–	0.0757	0.115
Income	0.1846*	Eliminated	–	-0.0972	0.282
Knowledge	0.6975**	62.37**	10.77	0.5556	0.141
Risk preference	0.077 NS	Eliminated	–	0.048	0.028
Extension participation	0.097 NS	Eliminated	–	0.041	0.055
Cropping intensity	0.1415*	Eliminated	–	0.1015	0.040
Technological gap	-0.579*	-9.71**	-5.63	-0.2846	-0.295

1. NS = Not significant; *Significant at 0.05 level; **Significant at 0.01 level.
R^2 = 0.54.36
Obtained equation: Yield = 183.72 + 62.37 KN - 9.71 TG where KN = Knowledge, and TG = Technological gap.

the pod yield of groundnut. The contribution of knowledge and technological gap to pod yield was 54.36%. The variable knowledge had direct effect on pod yield, whereas income and knowledge showed indirect effect on pod yield. Hence, efforts should be made to upgrade the knowledge level of the groundnut growers and also to generate low-cost, location-specific and appropriate technologies. If required, the available technologies may be modified to make these more readily acceptable to the growers. To realize the above, demonstrations and training programs should be organized frequently. Also the non-adopted technologies should be refined with the help of participatory rural appraisal (PRA) techniques.

Assessing Diffusion of Modern Groundnut Varieties in Mali

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Over the last three decades, groundnut *(Arachis hypogaea)* production in Mali has been relatively stagnant. Its importance as food and cash crop for rural households and supplier of foreign exchange earnings has declined. Groundnut yields have remained relatively low, about 962 kg ha^{-1} below the world average of 1,400 kg ha^{-1} (Ndjeunga et al. 2002). In the processing sub-sector, oil processing has almost stopped. Prospects for regaining production and market shares of Malian groundnut lie in the adoption of improved varieties and crop management technologies that will significantly increase productivity, production and the quality of produce as well as the development of the groundnut processing sectors.

Since the 1980s, ICRISAT. Bamako. Mali and the Institut d'Economie Rurale (IER) have been working in Kolokani, one of the largest groundnut-producing areas in the region of Koulikoro in Mali. Kolokani has a history of experiencing repeated droughts one year out of three. Groundnut is the main source of rural livelihoods representing 37% of the total cultivated area. It is mostly planted as sole crop and in rotation with cereals. Only about 8% of groundnut area is cultivated in association with pearl millet *(Pennisetum glaucum).* Groundnut is cultivated on collective plots by all household members or individual plots owned by either men or women in the household. This study assesses the diffusion and preferences of farmers for varieties tested on farms in the legion of Kolokani in Mali.

The Dissemination Process: On-farm Trials

On-farm evaluation was the major tool used in the dissemination process. Since 1998. ICRISAT initiated a series of on-farm trials in Kolokani. Until 2001, a total of 15 groundnut varieties were tested on farms by 169 farmers. These trials were of two types: trials designed by researchers but managed by farmers; and trials designed and managed by farmers. In the latter type, farmers who had participated in open field days at ICRISAT station chose the most preferred varieties to be tested. In general, farmers could choose up to 6 varieties. The distribution of farmers by year and the set of selected varieties are presented in Table 1. The distribution of farmers varied from year to year and/or according to the set of varieties tested. This has significant implications on the assessment of farmers' preference for varieties.

Nine modern groundnut varieties were tested: ICG 7878, ICG (FDRS) 4. ICG (FDRS) 10. Mossitiga. Demba Niouma (ICGS (E) 34), ICGV 92093. ICGV 92088. ICGV 92082 and ICGV 91225. Their major characteristics are resistance to foliar diseases, early- to medium-maturity.

Table 1. Set of modern groundnut varieties tested and distribution of farmers in kolokani, Mali.

	No. of farmers					
Set of varieties tested	1997	1998	1999	2000	2001	Total
ICG(FGRS)4			5	10		15
ICG (FDRS) 4, ICG (FDRS) 10, Mossitiga				3		3
ICG (FDRS) 4, ICG (FDRS) 10, Mossitiga, Demba Niouma		21				21
ICG 7878	1			2		3
ICG 7X78, ICG (FDRS) 4, Mossitiga					34	34
ICG 7878, ICG (FDRS) 4, ICG (FDRS) 10, Mossitiga, Demba Niouma			20			20
ICG 7878, ICG (FDRS) 4, Mossitiga			1	2	1	4
ICG 7878, ICGV 92088				1		1
ICG 7878, ICGV 92093, ICGV 92082, ICGV 92088, ICGV 91225, Mossitiga				20		20
ICG 7878, ICGV 92093, ICGV 92088, Mossitiga					19	19
ICGV 92082, ICGV 91225				1		1
ICGV 92093, ICGV 92088, ICGV 92082, ICGV 91225		2	20			22
Total	1	23	46	39	54	163

and medium size pods and grains. The yield of all these varieties in farmers' fields was more than 1 ton ha^{-1} pods and 2 t ha^{-1} fodder.

Selected farmers were given 1 kg seed of each of the selected varieties. This quantity was sufficient to plant a plot of 10 m x 10 m along with the traditional variety. Field monitoring and evaluation were conducted by ICRISAT and IER scientists, and a range of development partners including non-governmental organizations (NGOs) such as WlNROCK International and ADAF GALLE, rural development projects such as the Office de la Haute Vallee du Niger (OHVN) and la Companie Malienne du Developpement Textiles (CMDT). Every year data on yields and farmers' rapid assessment of their preferences were collected.

In 2000, ICRISAT initiated a small-scale seed production scheme with 4 farmers in 4 villages: Bambabougou, Kanekebougou, Tioribougou and Komokorobougou. These farmers produced about 3.6 t seed of ICG 7878, Mossitiga and Demba Niouma. Only 10% of the seed produced was sold to other farmers, ie, about 348 kg of which 65% was ICG 7878. A survey conducted from May to June 2003 assessed the use of improved groundnut varieties in the villages where seed production was undertaken.

Methodology and Data Collection

The survey involved 16 of the 43 villages that had participated in on-farm trials from 1998 to 2001. Villages were selected along the North-South transect and road accessibility. In each village, on-farm trial participants, who had completed at least one full season, were chosen. Non-participant farmers were selected among the groundnut producers. A total of 245 farmers were interviewed including 99 trial participants and 146 non-trial participants. About 60% of the trial participants were interviewed.

Questions focused on the household socio-demographic and economic profile, resource endowments with land and agricultural equipment in particular, and farmers' preferences for groundnut varieties. In addition, information on use of inputs at plot levels and household livelihood sources, especially cash sources, was gathered.

The socioeconomic profile (age, gender, education and family size) of farmers, institutional and infrastructural environment (access and availability of seed of preferred varieties and access to markets) under which farmers operate, and technological constraints [plant type, crop duration, seed size and color, utilization (oil, edible, confectionery and fodder for livestock) and resistance to foliar diseases] were hypothesized to be the main constraints to adoption and factors explaining farmers' preferences for modern or improved groundnut varieties. The number of farmers using groundnut varieties and area planted to improved varieties are the two simple indicators for adoption.

Results and Discussion

Resource endowments. About 92% of trial participants were male farmers. The average groundnut cropped area was estimated as 2.11 ha with significant differences between trial and non-trial participants. Trial participants planted on average 2.85 ha of groundnut against 1.62 ha for non-trial participants. The trial participants were selected by ICRISAT and based on farmers' experience of groundnut cultivation.

About 81% of groundnut plots were collective plots and the remaining were individual plots. Among individual plots, 50% of the plots were owned and managed by women. The belief that groundnut is a woman's crop is not very clear. More and more men are growing these crops especially in environments where there is no alternative cash crop such as cotton *(Gossypium* sp). Most households are poorly equipped. Most of the agricultural operations are done by hand tools. This low level of usage of farm equipment has significant implications on the potential for expanding groundnut cultivation in the region. Groundnut is highly labor intensive; thus there is a high probability that the returns to labor for groundnut production would be lower than the opportunity cost of labor. In this case the returns to investment in small-scale mechanization in the form of simple animal traction may be high. Household access to equipment is essential to improve productivity.

Inorganic fertilizers are seldom used for groundnut cultivation. About 2.4% of surveyed farmers use fertilizers and 14.1% use organic manure on groundnut plots. However, more farmers treat their seed; about 31% reported treating groundnut seed before planting. No significant differences were found between trial and non-trial participants. Less than 10% of trial participants have exchanged seed with other fanners. This was explained by the need for farmers to build their seed stocks. The initial seed capital given to farmers was very low (1 kg). To build seed stocks equivalent to plant one ha of groundnut, farmers need to plant the initial capital for at least 3 consecutive years assuming that they do not consume or sell any portion of the seed.

All farmers reported the lack of credit as the main constraint to expanding groundnut production. Access to

Table 2. Ranking of the four most preferred modern groundnut varieties by traits against the local check1.

Trail	ICG (FDRS) 4	ICG 7878	ICGV 92088	Mossitiga	Local check
High fodder yield	2	1	3	4	4
High pod yield	3	4	5	1	2
Large seed size	2	1	3	4	4
Early maturity	3	5	4	1	:
Taste	2	1	5	3	3
Marketability	3	5	3	1	2
Drought tolerance	3	5	4	1	2
Overall ranking	2	4	5	1	3

1. Ranking is scored on 1 to 5 scale, where 1 = the best; and 5 = the poorest.

credit will increase farmers' access to other inputs such as seed, fertilizers and fungicides. This is consistent with findings from Niger (Baidu-Forson et al. 1997).

Preferences for varieties. A simple mean ranking was used to assess farmers' preference for varieties. Of the nine varieties tested, farmers preferred Mossitiga, ICG (FDRS) 4, local variety, ICG 7878 and ICG 92088 by order of decreasing importance. There were no differences in ranking between trial and non-trial participants. The most preferred traits were the high pod and fodder yields, large seed size, taste and drought tolerance (Table 2). In particular, the variety Mossitiga was well rated because of its high drought tolerance, early maturity and high yield compared to the local variety. Similarly, ICG (FDRS) 4 was preferred for the same reasons at a lesser degree. Farmers ranked ICG 7878 as first for high fodder yield, good taste and large seed size. However, many farmers reported that it was not early maturing and drought tolerant. Specifically, farmers reported that during bad years, ICG 7878 performed poorly but produced excellent yields in good years.

Adoption of modern groundnut varieties. Overall, about 51% of trial participants continued to plant improved varieties after 2001. Specifically, 23.2% of farmers continue to plant Mossitiga, 21% ICG 7878, 22.2% ICC, (FDRS) 4 and about 8.1% ICGV 92088.

In terms of area planted, on average 32% of the groundnut area is planted with improved varieties. However, the proportion of area planted by trial participants is significantly higher than non-trial participants. On average, trial participants are planting more than half the groundnut cropped area to improved varieties as against 7% area by non-trial participants. This is mainly due to poor access to improved varieties by non-trial participants and little farmer-to-farmer exchange of seed.

There is a strong linkage between the presence of seed producing association and the use of modern varieties. In villages where there are seed producers, farmers are likely to have better access to seed of modern varieties than otherwise. These results are consistent with many other studies which support that adoption of modern varieties and technologies is high in environment where farmers have access to improved seed (Ndjcunga et al. 2003).

Conclusions

This study shows that the diffusion of modern groundnut varieties in the region of Kolokani is relatively high. Through farmer-to-farmer diffusion about 32% of groundnut area is planted with improved varieties in the Kolokani region. Several constraints are limiting the diffusion of modern groundnut varieties. Farmers have little access to seed and other essential inputs to increase productivity as well as to information on varieties. Technical, institutional and market solutions to improve access and availability of households to basic inputs should be vigorously pursued.

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Technical Efficiency Measures for a Sample of Senegalese Groundnut Producers Using Pooled Cross-section Time Series Data

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Productivity growth is crucial for improving the agricultural economy of developing countries and thus helps to alleviate rural poverty. Increasing farm productivity could have a positive impact on the economy while improving the well being of the rural population. The development of new technologies to increase productivity may be seen as the preferable option. However, this option might take considerable time and can require large investments. A reasonable alternative is to take maximum advantage of available inputs and the existing technology through the improvement of farm efficiency. An important issue then is to measure existing efficiency gaps in various environments to determine the potential contribution of efficiency gains on agricultural productivity and output (Ali and Chaudhry 1990).

In recent years, studies based on frontier methodology have provided much insight into farm-level performance. A considerable amount of literature exists that analyzes the efficiency of farmers in developing countries (Battese 1992. Thiam et al. 2001). However, there are many countries, particularly in Africa, for which there is little or no empirical work focusing on farm efficiency; for example, Senegal. Therefore, the purpose of this paper is to present an analysis of technical efficiency using pooled cross-section and time series farm-level data for groundnut *(Arachis hypogaea)* producers in Senegal.

The Senegalese agricultural economy accounts for nearly 20% of GDP and involves more than 60% of the total population. Agriculture is dominated by groundnut production and processing. Groundnut is grown on 40% of the cultivated land and is the most significant cash and export crop. The growing challenges facing the Senegalese agricultural sector are clearly revealed by a decline in production, yields, and the quantity of seed planted over the last 20 years for the two major crops, groundnut and millet (Diagne 1998). In addition, agricultural imports have almost doubled during the same period. Therefore, increasing production and productivity of both food and cash crops has become a significant challenge and an important policy objective in Senegal.

Methodological Framework and Data

Technical efficiency is analyzed in this paper by estimating a translog stochastic production frontier following the approach of Battese and Coelli (1995). The translog stochastic production frontier for the i"' farm, where all continuous variables are normalized by their geometric mean and expressed in logarithmic form, is given as Equation 1 in the chart below (Fig. 1).

The stochastic error-term (v - u) is farm-specific and is composed of two independent components, v and u (Aigner et al. 1977, Meeusen and van den Broeck 1977). The component v, a two-sided normally-distributed random error ($v \sim N(0, \sigma_v^2)$), represents random variation in output due to factors outside the farmer's control. The component u is a one-sided inefficiency term, which captures the technical inefficiency relative to the stochastic frontier.

$$Y = \beta_0 + \beta_S S + \beta_F F + \beta_L L + \beta_H H + \beta_R R + .5\,\beta_{SS} S^2 + .5\,\beta_{FF} F^2 + .5\,\beta_{LL} L^2 + .5\,\beta_{HH} H^2 + .5\,\beta_{RR} R^2$$
$$+ \beta_{SF} S \times F + \beta_{SL} S \times L + \beta_{SH} S \times H + \beta_{SR} S \times R + \beta_{FL} F \times L + \beta_{FH} F \times H + \beta_{FR} F \times R$$
$$+ \beta_{LH} L \times H + \beta_{LR} L \times R + \beta_{HR} H \times R + \beta_{DF11} DF11 + \beta_t t + .5\,\beta_{tt} t^2 + \beta_{DVL} DVL$$
$$+ \beta_{DLTH} DL\text{-}TH + \beta_{FKKK} FK\text{-}KK + \beta_{TAMBA} TAMBA + \beta_{KOZI} KO\text{-}ZI + v - u \qquad \text{Equation 1}$$

$$\mu = \delta_0 + \delta_{FS} FAS + \delta_{Age} Age + \sum_{1982}^{1999} \delta_{Dt} Dt + \delta_{DMF} DMF + \delta_{LMF} DLF$$
$$+ \delta_{DLTH} DL\text{-}TH + \delta_{FKKK} FK\text{-}KK + \delta_{TAMBA} TAMBA + \delta_{KOZI} KO\text{-}ZI \qquad \text{Equation 2}$$

Figure 1. Estimation of translog stochastic production frontier and technical inefficiency.

In the model by Battese and Coelli (1995), the technical inefficiency effects are specified to be a function of farm-specific variables and then the parameters of the production frontier as well as those of the technical inefficiency factors are estimated simultaneously. The u's arc non-negative and are assumed to be independently distributed, such that u is obtained by truncation, at zero of the $N(\mu, \sigma_u^2)$ distribution. The mean of u (μ) is defined as a function of farm-specific variables in the inefficiency effects model for i^{th} farm, which can be written as Equation 2 (Fig. 1).

The ßs in Equation 1 and the δs in Equation 2 are parameters to be estimated. Maximum-likelihood is used to obtain parameter estimates for the production function and the inefficiency effects model simultaneously. The estimation is done with the program FRONTIER 4.1 (Coelli 1996), which determines the variance parameters $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/\sigma^2$. The latter has a value between zero and one and gives an approximation of the proportion of the overall variance in the model error explained by the inefficiency effects. The elements σ_v^2 and σ_u^2 represent the variances of the two-sided and one-sided error components, respectively.

The technical efficiency for the ith farm is defined by:

$$TE = e^{(-u)}$$

The definition of the variables used in equation 1 is as follows: Y = natural logarithm of annual total farm output of groundnut (in kg); S = natural logarithm of total quantity of groundnut seed sown (in kg); F = natural logarithm of total quantity of fertilizer used (in kg); L = natural logarithm of the sum of family and hired labor; H = natural logarithm of the total land area (ha) devoted to the cultivation of groundnut; R = natural logarithm of quantity of rainfall (mm), at the village level during the rainy season; DF11 = dummy variable equal to one if the farm used the groundnut variety La Fleur 11 and zero otherwise; t = time trend equal to one in 1982, 2 in 1983, etc. and 19 in 2000; and DVL = dummy variable equal to 1 for 1995 and zero otherwise.

The definition of the variables used in Equation 2, the inefficiency effects model, is as follows: FAS = total number of people in the household (family size); Age = age of the head of household; Dt = dummy variable equal to one for the tth year and zero otherwise; DMF = dummy variable equal to one for medium-size farms and zero otherwise; and DLF = dummy variable equal to one for large-size farms and zero otherwise. The definition of the variables included in both Equations 1 and 2 is as follows: DL-TH = dummy variable equal to one if the farm is located in either the region of Diourbel or the region of Thies and zero otherwise; FK-KK = dummy variable equal to one if the farm is located in either the region of Fatick or the region of Kaolack and zero otherwise; TAMBA = dummy variable equal to one if the farm is located in the region of Tambacounda and zero otherwise; and KO-ZI = dummy variable equal to one if the farm is located in either the region of Kolda or the region of Ziguinchor and zero otherwise.

The data used in this study are from extensive annual surveys organized and conducted by ENEA (Ecole Nationale d*Economie Appliquee - National School of Applied Economics), Senegal over a four-month period during the rainy season. The data set goes from 1982 to 2000, excluding 1983, 1993 and 1994, when no relevant data was collected. The data set for groundnut producers used includes 501 farmers distributed among 104 villages located in 35 rural communities from all 10 regions of Senegal.

Empirical Results

The study revealed that farmers who cultivate La Fleur 11 exhibit a significantly higher frontier output. This finding is consistent with previous studies that have shown greater yield performance of this variety compared to the traditional variety 55-437 (Grosshans and Mayeux 1996, Bravo-Ureta et al. 1997). The parameter estimate of the dummy variable reflecting the devaluation of the CFA currency is negative and statistically significant. This suggests that the devaluation has had a negative effect on groundnut output.

Geographic-zone dummy variables are introduced in the model to capture regional effects stemming primarily from differences in soil quality and the distribution of rainfall. These dummy variables have positive and statistically significant parameter estimates except for Kolda-Ziguinchor. Tambacounda has the most significant parameter estimate at the 1% level. These results suggest that frontier groundnut output tends to be higher in these geographic areas compared to the base zone, which includes the regions of Saint-Louis and Louga. Traditionally, most of the groundnut producers are located in Fatick and Kaolack in the peanut basin and in Tambacounda.

In the inefficiency effects model family size is positively related to inefficiency, suggesting that farmers with large families lend to be less efficient. However, the parameter estimate for this variable is not statistically significant. The effect of family size on inefficiency has attracted limited attention in the productivity literature focusing on agriculture in developing countries (Audibert 1997, Bravo-Ureta and Pinheiro 1997).

Age of the head of household has a positive but not statistically significant parameter estimate. This variable has been extensively analyzed in efficiency studies with mixed results. As explained by Coelli and Battese (1996), older farmers, because of their experience, are likely to have lower inefficiency. Conversely, because older farmers tend to be more conservative, they are also less likely to introduce improved practices and hence are more inefficient.

The results on the dummy variables for year show that in 1984, 1986, 1988 and 1998 groundnut producers in the sample, on average, experienced lower inefficiency in these years compared to 2000, the base year. However, in 1987,1990,1995 and 1999, fanners seem to have had higher levels of inefficiency than in the last year of the sample.

The parameters for the dummy variables for medium and large farms, considering small farms as the base category, are negative and statistically significant indicating that there is an inverse relationship between efficiency in groundnut production and farm size. The geographic-zone dummy variables show that farms located in Fatick and Kaolack, in the heart of the groundnut basin, and in Kolda and Ziguinchor are significantly more efficient than those in Saint-Louis and Louga.

The parameter associated with the variance of the technical inefficiency effects is estimated to be 0.83, and is statistically significant at the 1% level, implying that farm-specific technical inefficiency is an important factor in explaining the total variability of groundnut output. The estimated average technical efficiency for the sample is equal to 70.24%, which suggests that groundnut output can be increased by 29.76%, on average, with the same level of inputs and technology (Table 1). This estimate is very close to the overall average technical efficiency of 68% for agriculture in developing countries reported by Thiamet al. (2001).

Table 1. Distribution of technical efficiency of the sample of groundnut producers in Senegal.

Efficiency range	Number of farms[1]	
<10	1	(0.20)
10-20	9	(1.80)
20-30	25	(5.00)
30-40	21	(4.20)
40-50	27	(5.40)
50-60	31	(6.20)
60-70	73	(14.60)
70-80	110	(22.00)
80-90	150	(29.90)
90-100	54	(10.80)
Mean	70.24	
Standard deviation	19.80	
Minimum	9.18	
Maximum	94.33	

1. Percentage is given in parentheses.

Concluding Remarks

The analysis reveals an average level of technical efficiency for the sample equal to 70.24% and that large and medium farms are more efficient than small farms. The analysis also suggests that this sample of groundnut farmers is operating on the increasing returns to size segment of the production function. These two sets of results suggest that policies that promote farm growth should be implemented to increase overall output as well as technical efficiency. This is an area that has received considerable attention in the literature and still remains a controversial subject (Chavas 2001). A less controversial implication of the analysis presented here is that there is a significant role for farmer education and agricultural extension as a mechanism to decrease inefficiency and thus increase farm output and rural incomes.

Farmers who cultivate La Fleur 11 exhibit a significantly higher frontier output, which suggests that adoption of new technologies can indeed play an important role in increasing productivity among groundnut producers. Finally, the analysis also indicates that the devaluation of the CFA franc in 1994, which was part of a major macroeconomic adjustment package, has had a negative impact on groundnut production. Therefore, the macro-economic environment can also affect individual farm performance; thus, a thorough understanding of these more distant or indirect effects is necessary so that this element can be incorporated when evaluating possible effects of alternative policy scenarios.

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Notes

Notes

Information for I A N contributors

Publishing objectives

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.

What to contribute?

Send us the kind of information you would like to see in IAN.

- **Contributions should be current, scholarly, and their inclusion well-justified on the grounds of new information.**
- Results of recently concluded experiments, newly released varieties, recent additions to germplasm collections, etc.
- Genome maps and information on probe-availability and sequences, and populations synthesized for specific traits being mapped. Glossy black and white prints of maps should be included, if possible. Partial maps can also be submitted.
- Short reports of workshops, conferences, symposia, field days, meetings, tours, surveys, network activities and recently launched or concluded projects.
- Details of recent publications, with full bibliographic information and 'mini reviews' whenever possible.
- Personal news (new appointments, awards, promotions, change of address, etc.)

How to format contributions?

- Keep the items brief- remember, IAN is a newsletter and not a primary journal. About 1000 words is the upper limit (no more than lour double-spaced pages).
- If necessary, include one or two small tables (and no more). Supply only the essential information; round off the data-values to just one place of decimal whenever appropriate; choose suitable units to keep the values small (e.g., use tons instead of kg). Every table should fit within the normal type-written area of a standard upright page (not a 'landscape' page). Do not use the table-making feature of the word processing package; use simple tab set to prepare tables.
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