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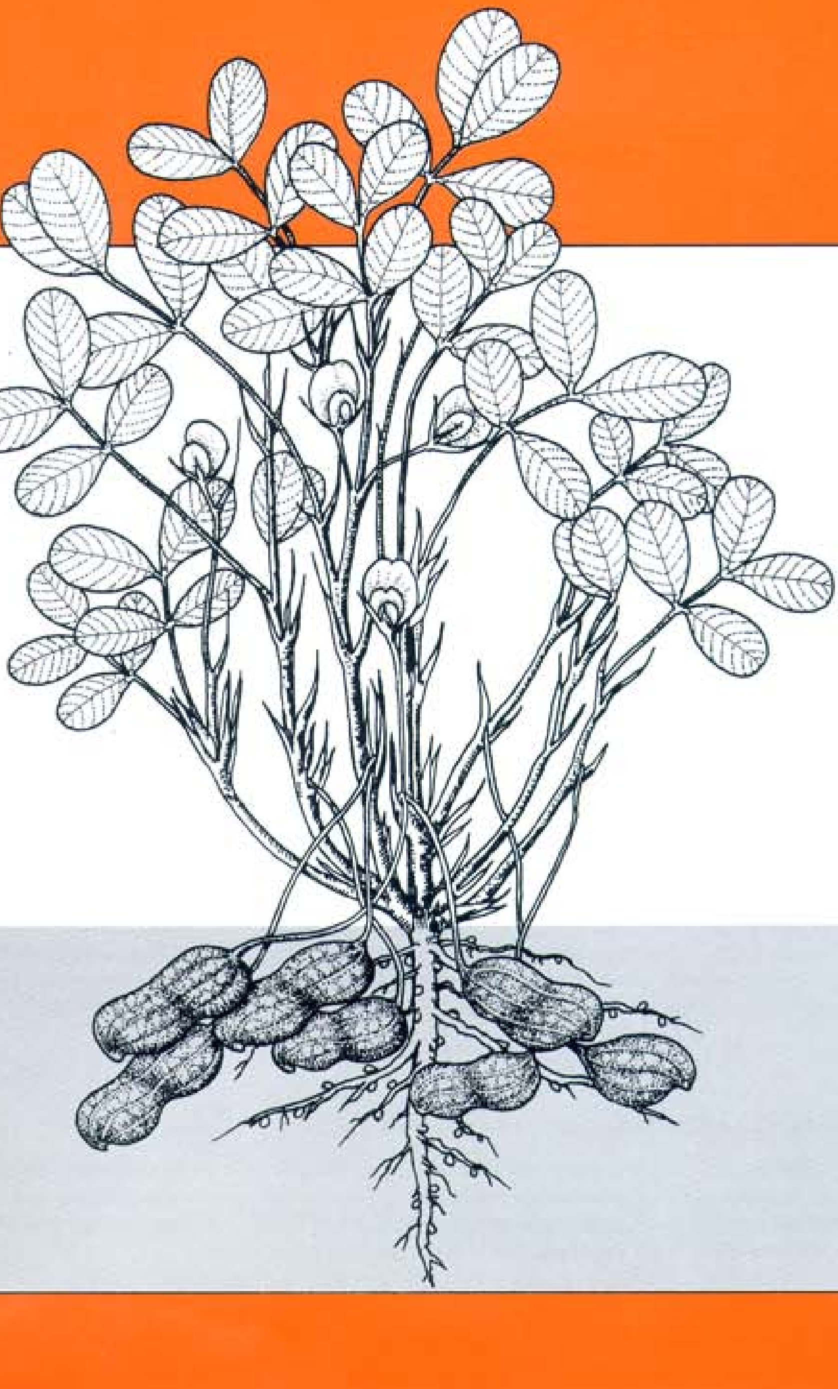

International *Arachis* Newsletter (IAN)

Co-publishers

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

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

About Peanut CRSP

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

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

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a nonprofit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).

IAN Scientific Editor

SN Nigam

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From the Editor

Dear Readers

ICRISAT has launched an electronic journal, SAT Agricultural Research, which can be accessed at http://www.icrisat.org/journal/. Its first issue came out in 2005. The journal accepts direct contributions besides publishing selected articles from the three newsletters, International *Arachis* Newsletter (IAN), International Chickpea and Pigeonpea Newsletter (ICPN) and International Sorghum and Millets Newsletter (ISMN) co-published by ICRISAT.

Although IAN accepted in the past only short articles based on preliminary results, it is now ready to accept a few high quality full length papers in each issue. Short review articles on emerging sciences/tools will also be welcome. The readers are encouraged to contribute to News and Views section of the IAN their interesting observations, happenings, episodes and stories, recipes and people associated with groundnut in their region. It is important to widen the scope of IAN to sustain the interest of groundnut community in the newsletter. The authors are advised not to submit articles based on the results of varietal evaluation alone and inconclusive trials/experiments. The articles submitted to IAN are peer reviewed. When needed, I will be requesting some of you to review the manuscript submitted to IAN. Your contribution will be duly acknowledged in IAN. Your help in reviewing and improving the manuscript will go a long way in enhancing the quality of articles appearing in IAN and also it would provide guidance to young researchers in research paper writing.

Last year we sent 1700 copies of IAN 25 to members and libraries (as per the existing mailing list of 2005) with a request to state their interest to receive future issues of the newsletter. So far we have received only 406 responses, some of them from libraries. Therefore we have decided to send IAN 26 only to these respondents. We once again request libraries and other readers to indicate their willingness at newsletter@cgiar.org if they would like to receive future issues of IAN. It will help us to minimize the cost of printing and mailing.

I would like to acknowledge R Aruna, Jayashree Balaji, BR Ntare, Piara Singh, GV Ranga Rao, KL Sahrawat, RP Thakur, V Vadez (ICRISAT); MS Basu and T Radhakrishnan [National Research Centre for Groundnut (NRCG), Junagadh, Gujarat, India]; and GV Subbaratnam [Acharya NG Ranga Agricultural University (ANGRAU), Hyderabad, India] who reviewed IAN articles and ICRISAT library for compiling SATSource listing.

The festive season in India continues. We celebrated Deepavali and Ramazan in October and now are awaiting X-mas in December. I wish all the readers merry X-mas and a very happy new year.

SN Nigam

News and Views

News from West Africa

CFC-ICRISAT-FAO groundnut seed project gets into fourth year

The CFC-ICRISAT-FAO project on Development of Sustainable Groundnut Seed Systems in West Africa, commonly known as groudnnut seed project (GSP), has successfully completed the third year of operation. This project aims at promoting utilization and uptake of improved groundnut varieties responding to market requirements through the development of sustainable community-based seed systems; promoting measures to minimize aflatoxin contamination; improving skills of farmers and other entrepreneurs in seed production, delivery, processing, marketing and small-scale seed enterprise management; and improving the flow of information between farmers and market intermediaries.

The project partners from Mali, Niger, Nigeria, Senegal, ICRISAT, FAO and CFC met for the annual project coordination and planning meeting at Bamako during 25–27 April 2006. BR Ntare (Country Representative and Project Manager), F Waliyar (PEA representative), Peter Thoenes and Robert Guei (FAO representatives) and Sieste van der Werff (CFC representative) gave opening remarks of welcome. The Deputy Director General of Institut d'Economie Rurale (IER) inaugurated the meeting and hailed the progress made by making available improved groundnut varieties, the efforts made to minimize aflatoxin contamination to improve quality and marketability, the efforts made to enhance skills of farmers and other entrepreneurs, and the initiation of community-based seed production and distribution systems in pilot areas.

ICRISAT technical support is helping farmers overcome the problem of access to improved varieties and also providing more suitable varieties. It is also providing socioeconomic support through targeted studies. The project partners reviewed progress achieved, the constraints encountered and strategies for sustaining the achievements. After an in-depth review of the various reports, together with ICRISAT, the partners prepared a comprehensive work plan and budget considering the sustainability of the achievements after the end of the project in 2007.

New groundnut varieties empowering women farmers in Mali

A 3-year long participatory research in the selection and evaluation of improved groundnut varieties has yielded positive results. Women groundnut farmers in the village of Wakoro in Mali have selected the varieties ICGV 86124, Fleur 11 and JL 24, which produce high quality seed. They are high yielding, mature early and are a sure way of increasing income and food security in Wakoro. The program which started with only 5 women farmers in this district has inspired 195 women farmers who are growing the three varieties in plots ranging from 0.25 to 2.0 ha, an indication of adoption process of groundnut varieties. The women are organized into a groundnut farmers' association and have taken up groundnut growing as a business. Similar progress is being made in other pilot areas where farmer groups, especially women are being empowered to grow quality groundnut seed as one of the strategies to increase availability of quality seed countrywide.

***Contributed by*:** BR Ntare
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CLAN Steering Committee Meeting Held in the Philippines

The Eighth Cereals and Legumes Asia Network (CLAN) Steering Committee Meeting was held at the Central Luzon State University (CLSU), Science City of Munoz, Nueva Ecija, Philippines during 4–6 November 2005. It was co-sponsored by ICRISAT, ICARDA, AVRDC and APAARI, and co-hosted by Philippine institutions, namely, CLSU, Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), and the Bureau of Agricultural Research (BAR), Philippines. All CLAN Country Coordinators (except India and Yemen) participated along with representatives of AVRDC, ICARDA, ILRI, IRRI, ICRISAT and APAARI. In addition, there were 20 observers from Philippines national program.

JE Eusebio, Director – Crops Research Division, PCARRD, Philippines was elected as Chairperson of CLAN Steering Committee for 2006–07. SH Sabaghpour (Iran) was elected Deputy Chair.

The Steering Committee reviewed the 2004–05 accomplishments of the network in the areas of germplasm exchange, varieties released, training, exchange of scientists, and adoption and impact of technology. The meeting noted substantial progress in the number of germplasm samples, breeding lines and sets of trials/nurseries on CLAN mandated crops supplied by ICRISAT (sorghum, pearl millet, chickpea, pigeonpea and groundnut), AVRDC (mung bean) and ICARDA (lentil) to member countries.

Considering the role of crop-livestock systems for sustainable agriculture in Asia, the Steering Committee requested ILRI to join the network as one of the co-facilitators along with ICRISAT, ICARDA and AVRDC. CLAN membership consists of 13 countries in Asia, namely, Bangladesh, China, India, Iran, Indonesia, Myanmar, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand, Vietnam and Yemen. ICRISAT, AVRDC, ICARDA and other regional and international institutes in the Asia-Pacific region are a part of the network, providing genetic material, technology and research information, and training input.

The expanded CLAN is now co-facilitated by ICRISAT, ICARDA and AVRDC. The coordination unit is located at and supported by ICRISAT-Patancheru. APAARI has committed support to help sustain the network activities.

The participants reviewed the ICRISAT's vision and strategy to 2015, and offered feedback, comments and suggestions to enhance the document. A concept note on "Crop diversification with food legumes for improving income and nutrition of rural poor, and sustainable productivity of cereal-based cropping systems in South and Central Asia" was discussed and endorsed for submission to the International Fund for Agricultural Development (IFAD) for funding.

Other CLAN-related activities

Varieties released in CLAN countries during 2005–06.

Crop	Country	ICRISAT name	Release name	Year
Sorghum (1)	India (1)	NSSH 104	NSSH 104	2005
Pearl millet (4)	India (4)	HHB 67-2 (improved)	HHB 67-2	2005
		Sagar 205	Sagar 205	2005
		PHB 2168	PHB 2168	2006
		GICV 98771	JBV 4	2006
Chickpea (4)	India (4)	ICCV 88202	Pratap Chana 1	2005
		ICCV 96329 (LBeG-7)	Lam Senaga	2006
		ICCV 95332	JGK 2 (Jawahar Gram Kabuli 2)	2006
		ICCV 93952	JAKI 9218	2006
Pigeonpea (4)	India (4)	ICPL 88039	JK Champion (JKPL 2)	2005
		ICPL 99050	JK Sania (JKPL 3)	2005
		ICP 7035	JK Sweety (JKPL 5)	2005
		ICPL 13092	JK Sixer (JKPL 6)	2005
Groundnut (4)	India (2)	ICGV 92195	Pratap Mungphali-2	2005
		ICGV 91114	ICGV 91114	2006
	Nepal (2)	ICGV 86300	Rajarshi	2005
		ICGV 90173	Baidehi	2005

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The Peanut CRSP

The Peanut Collaborative Research Support Program (CRSP) was established in 1982, and the present grant-period will end in 2007. The goal of the program is to link US agricultural universities with research institutions in developing countries to enhance the role of peanut (groundnut) in food production and economic development. The CRSPs implement a portion of Title XII of the US Congress and are funded through USAID by grants to US universities. The Peanut CRSP is managed by the University of Georgia and involves a number of US universities and host/developing countries. Linkages exist between other institutions such as ICRISAT to assure development goals are met. In late 2004 and early 2005 an External Evaluation Panel reviewed the Peanut CRSP and concluded that it had been highly effective in developing technologies through research in the five thematic/cluster areas, across the whole value chain; and the technologies transferred to farmers, entrepreneurs and key stakeholders have resulted in significant impacts in the host countries and the US. Long- and short-term training, institutional capacity development and information dissemination has been accomplished. Notable is the development and use of a Web-based program and fiscal management system that has been efficient and cost-effective in the timely management of a worldwide program. Impacts, achievements and mechanisms for technology transfer within the five thematic/cluster areas were identified and evaluated for their importance in the host countries and USA, and for the benefits to women who are often peanut farmers and village-level or small-scale peanut-food processors. These impacts and achievements are summarized as follows.

Market driven development

The Peanut CRSP has over the past increased the emphasis on enhancing demand for peanuts in the market place. Too often we have seen that a production technology is initially adopted, farmers do well for a while until the production increases significantly and then the prices collapse leaving discouraged farmers. Sustainable development requires a balanced development of consumption to provide a market pull and crop technologies to respond to this situation.

A significant achievement in the Philippines has been the development of strong partnership with the food industry. The partnership was described as the Peanut Industry Incubator Model (PIIM) and identifies and solves peanut industry problems, and transfers relevant Peanut CRSP technologies to the user. This model requires that the research institution and private food industry partners agree on the projects to be developed early through intensive interactions, and allows the food industry to access the public research capacity and technologies while cost-sharing where resources allow. The model has now been applied in other developing countries with some modification to consider country-specific situations. Among the first successes of the PIIM was the co-development of vitamin A-fortified peanut butter. Successful marketing of the product resulted in a 37% increase in peanut butter production by the partner company in the Metro-Manila area; this result was established through impact studies conducted in the past phase of the CRSP. Children who are most a risk of vitamin A deficiency were the highest consumers.

The PIIM resulted in the adoption of hand-sorting technology by a company to assure aflatoxin-free peanuts for production of a peanut sauce ("Kare-kare") and led to the company entering the export market, with significant economic returns from increasing export volumes. The PIIM trained women's cooperatives in the central Philippines to improve the quality and packaging of a peanut candy product and obtain significant increase in their income because of expanding their market from bus stops to access to the Manila supermarkets. Similar results were obtained in Thailand among village-level peanut processors. In Thailand, villages generally concentrate on processing of one product for the market. Market pull was a key factor in the successful transfer of the technologies developed by research. In Europe a honey-coated roasted peanut product developed by a PIIM effort should be on the market in Bulgaria in 2006.

Production driven/market sustained development

Improved cropping practices and increased areas have doubled yields and caused five-fold increase in peanut production in Guyana. Before market forces depressed prices and farmers became discouraged, the local collaborator (Beacon Foundation, an NGO), the US scientists and the local government worked together in the Rupununi region to develop a school lunch program. A pilot program based on seven villages which produced peanut butter and cassava bread for their schools was found to be highly successful and is now being expanded to a much larger number of schools. This PIIM-like market development effort which connects the producer to markets is helping to sustain profitability to the growers.

Health induced market development

Nutrition research showed that peanut consumption is associated with improved blood-lipid profiles and reduced cardiovascular disease risk and has provided critical evidence that peanuts have a satiety factor that offsets the high-energy content making the food neutral for obesity. The initial Peanut CRSP research inspired other research and the pool of information contributed to the US Food and Drug Administration (FDA) awarding a "heart healthy" claim for peanuts (including some tree nuts). Peanut CRSP nutrition research contributed to the reversal of an 18% reduction in peanut consumption in USA during the 1990s, and current sales of peanut products are increasing more than 10% annually. The value of industries promoting the health benefits of peanut as a food is something that can help develop the peanut industry on a global scale.

Preventing human aflatoxicosis – food safety and development

Peanut is well recognized as having significant aflatoxin problem. Indeed this problem is recognized as a major barrier to the trade in peanut; but very little has been done to protect the people living in countries where foods cannot be exported because of the levels of contamination. The Peanut CRSP focused on preventing human aflatoxicosis, which requires an integrated approach to preventing contamination in the field, at harvest and during storage. Decontamination and protection of consumers are also viable strategies in the management of the problem.

Our plan focused on determining the levels of exposure in developing countries, in determining what the health consequences of that exposure would be, and in the risks of different interventions to prevent exposure. Exposure is very widespread; in our and other studies everyone had biomarkers for exposure.

Our studies of interventions using a toxin binding additive have just been completed. These studies are based on evaluating a specialized clay (NovaSil-TM) that was found in earlier Peanut CRSP research and which is highly adsorptive of aflatoxins in the digestive tract of the animal. NovaSil as a feed additive (0.5% of the feed) binds aflatoxin and prevents adsorption, metabolism and subsequent aflatoxicosis in animals and is being adopted for livestock worldwide. Research to transfer this to human application was added in 2001. A study showed that lifetime exposure to NovaSil was harmless to rats. Based on these results, a human study was conducted in USA that showed no adverse nutritional effects from consuming the clay. Although aflatoxins have been shown to be immune-suppressive agents in animals, the potential role of aflatoxins in modifying the distribution and function of leukoctye subsets in humans has never been assessed. The cellular immune status of a group of Ghanaians was examined in relation to levels of aflatoxin B_1-albumin adducts in plasma, and the alterations shown in immunological parameters in participants with high aflatoxin B_1 levels could result in impairments in cellular immunity that could decrease host resistance to infections. Results are near completion from a subsequent study in Ghana to measure the effect of NovaSil to reduce the ingestion/metabolism of aflatoxin in humans.

Gender studies in Uganda show that women farmers and housewives have no knowledge of aflatoxin, showing the need for extensive outreach and education. The socioeconomics project in Ghana has trained 900 professionals in three workshops to increase awareness of the aflatoxin problems. Producers, consumers and processors (male and female) will be familiar with the prevalence and health effects of aflatoxins, and available interventions to manage contamination.

Production driven development

The experience in Bolivia shows that for adoption of peanut production technologies by farmers, research has to be complemented by a strong technology transfer effort and a seed production program, which connects multiple sectors of the whole value chain. Participation of technology transfer/extension institutions and farmers' associations with the research efforts has facilitated the access of farmers to new peanut varieties, management practices and information. It also generated the interest of the Bolivian government that increased the priority of peanut in its agricultural development plan. Local consumption and exports are presently providing adequate markets to use the double yields and expanded production areas that are a result of the new technologies adopted by the farmers.

In Ghana, farmers (50% are women) who adopted environmentally-friendly integrated pest management (IPM) practices have increased yields two-fold. The IPM technology has been transferred through farmer field schools, television, radio and other extension means. In Ghana and Benin, crop models have identified major constraints to production and showed that yield increase and reduced cost of production are attainable.

Rosette virus has been a devastating disease of peanuts for several years in Africa. Resistant varieties have been long season and not adapted to all the affected production systems. In Malawi, the national agricultural research programs released rosette-resistant, short-season cultivars bred by ICRISAT and tested by Peanut CRSP participating scientists, extending the use of resistant varieties to short-season environments. CRSP/Uganda collaboration transferred the varieties to Uganda where it was estimated that the new varieties, when fully adopted by farmers, could contribute about US$47 million annually to the economy.

The collaborative research has altered oil quality and increased product shelf life. New cultivars with disease resistance, seed dormancy, and oil quality (high oleic acid to linoleic acid ratio) that increases shelf life are near release in Senegal and Burkina Faso. A ‘high oleic’ variety was released in Texas, which through reduced rancidity is benefiting processors and consumers by extending the shelf life of peanut products. US processors have said that this is one of the most important technologies made available to the processing industry in many years.

Other variety development contributions have been realized. Impact studies in North Carolina show continued benefit from cylindrocladium black rot (CBR) disease resistant varieties developed earlier with Peanut CRSP support. Cultivars introduced from Bulgaria yield 5–20% more than the local Valencia types in New Mexico, and should have short-term impact on variety development. Germplasm exchanges between Bolivia and Georgia/Florida have resulted in the development of higher yielding, disease resistant varieties in Bolivia and the US. In Florida, genetic marker research is identifying genes for drought tolerance and other traits that have potential to decrease the time and cost for developing new varieties.

In North Carolina, farmers who adopted the tomato spotted wilt virus (TSWV) index reduced virus incidence by 50% in a single year. Since its adoption, there has only been one year of significant virus incidence. Also, the adoption of the southern corn rootworm (SCR) advisory index by farmers and extension agents has reduced pest damage by 50% per year. The SCR treatment of preventive applications of insecticides has been reduced to only “high risk” areas. These environmentally-friendly advisory programs utilized Peanut CRSP research outputs.

Socioeconomic, gender and policy research

Significant socioeconomic impacts that related to gender concerns and aflatoxin awareness were observed. Economic impact studies have documented the impacts of variety adoption and IPM practices in North Carolina, Thailand, Malawi, Uganda, Senegal and the Philippines. Peanut CRSP also documented the economic and health benefits of vitamin A-fortified peanut butter and aflatoxin-free peanut sauces in the Philippines. Poverty could be reduced by 1.3% through the full adoption of the rosette resistant varieties released in Uganda.

In Senegal, impact studies have shown a 25% yield increase when farmers adopted new varieties developed earlier by the Peanut CRSP. Socioeconomic data in Senegal resulted in an increased number of publications on the impact of new varieties, pricing and marketing of peanuts, optimizing farm planning to reduce poverty, and peanut production and processing. The capacity of the host country institution was greatly increased in socio-economic research and in the desire to publish information.

Postharvest and utilization research-development potentials

In USA, a patent is pending for 2005 for peanut enhanced with resveratrol. Peanut processors, globally, will benefit from the introduction of resveratrol-enhanced peanuts for use in many products. Consumers will benefit from the nutraceutical peanuts with their anti-cancer and anti-cardiovascular disease properties.

Production of new high-protein food products and other nutraceuticals from peanut processing by-products resulting from Peanut CRSP research has potential to add value to the peanut industry worldwide. It could also meet the fast growing demand for meat substitutes in vegetarian diets. The meat analog industry in USA is growing rapidly providing an opportunity to increase peanut market demand. Peanut-derived nutraceuticals will also tap into the large and growing nutraceuticals and functional food market, currently estimated at US$17 billion per year.

Information, training and technology transfer

In the CRSP model every project has a role in capacity development and technology transfer. In addition to this we have had a number of projects dedicated to these objectives.

A Peanut CRSP developed Web-based World Geography of Peanut (http://lanra.anthro.uga.edu/peanut/knowledgebase) is a significant repository for worldwide peanut publications and information. It includes data on the status of peanut production and industry in many countries, with potential use in policy making.

A technology transfer project in Thailand continues the partnership with this USAID "graduate country" in regional training efforts, resulting in Thailand being a center of excellence for training of trainers. Frequent workshops, largely attended by women, focus on product development and food safety practices. The program is also reaching many villages in Thailand and assisting women entrepreneurs in improving the production and marketing of peanut food products. Most villages follow the "one village-one product" scheme of processing, fostered by the Thai Princess' development program for poor villages, utilizing Peanut CRSP-developed technologies.

Capacity development results from projects providing fiscal support for equipment and supplies and by training activities. Long-term, degree training of host country personnel is usually done at the collaborating US university. Short-term training has been done in the US and at ICRISAT, as well as the regional efforts such as cited above for Thailand.

The importance of multiple-institutional involvement in technology transfer was seen in the host country institution/CRSP/ICRISAT effort in developing and introducing to farmers the new, rosette resistant peanut varieties in Malawi and Uganda. Similar cooperation led to the success in technology transfer in Bolivia and Guyana, and the success of the PIIM in the Philippines, Thailand and Bulgaria. The close relationship between the research and extension programs and the farmers contribute to the success in the reduction of incidence of TSWV and SCR in North Carolina.

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Current ICRISAT Groundnut Research and Integrated Projects

Investor	Project title	Project coordinator	Grant (US$ ’000)	Duration
Australia/ACIAR	Regional Workshop on Minimizing Aflatoxin Risk in Peanuts	SN Nigam	22	2006
Common Fund for Commodities	Development of sustainable groundnut seed systems in West Africa	F Waliyar B Ntare	2,103	Apr 2003–Mar 2007
Canada/CIDA	An aflatoxin risk early warning system to improve nutrition, health and income in West African smallholder farms	PCS Traore	188	Apr 2006–Mar 2009
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	34	2001–2006
CGIAR Global Challenge Program – HarvestPlus	Genetic engineering of groundnut for enhanced β-carotene production to combat vitamin A deficiency in the semi-arid tropics	KK Sharma	170	Nov 2003–Dec 2006
GCIAR – Generation Challenge Program – CIMMYT/EMBRAPA	Unlocking the genetic diversity in peanut’s wild relatives with genomic and genetic tools	V Vadez	276	Jul 2005–Dec 2007
CGIAR/IFAR	Identification and field-testing of salinity tolerant groundnut in saline areas of India	Namita Srivastava V Vadez	11	2006
India/MoA&C	Development and popularization of ‘Model’ seed system(s) for quality seed production of major legumes to ensure seed-sufficiency at the village level	SN Nigam	1,000	2006–2010
India/ISOPOM/DoA&C	Farmers’ participatory groundnut improvement in rainfed cropping system	SN Nigam	109	2005–2008
India/Govt. of AP	Establishment of aflatoxin testing laboratory at Anantapur	F Waliyar	49	2005–2006
International Fund for Agricultural Development (IFAD)	Farmer-participatory improvement of grain legumes in rainfed Asia	SN Nigam	1,300	Sep 2001–Dec 2006
McKnight Foundation	ALIVE and nutritious cropping systems: A participatory approach to legume intensification and variety enhancement	E Weltzien-Rattunde R Tabo	251	Mar 2006–Feb 2010
McKnight Foundation	Developing short and medium duration groundnut varieties with improved yield performance, acceptable market traits and resistance to foliar diseases	EM Monyo	194	2006–2010
Norway/Development Fund	Enhancing groundnut production in the non-traditional and dry-land areas of Malawi for improved nutrition and poverty reduction	M Siambi	180	Jan 2004–Dec 2006
Philippines	Enhancing adoption of ICRISAT legume varieties and technologies in the Philippines	CLL Gowda	50	Jul 2004–Jun 2007
	Introduction, promotion and efficient seed support system of ICRISAT ‘Asha’ peanut variety in Region 2, Philippines	SN Nigam	55	Apr 2005–Apr 2007
USA/Univ of Georgia (Peanut CRSP)	Peanut CRSP support for regional workshop and publications	F Waliyar	141	2000–2006
USAID/US Univ Linkages – Univ of Georgia	Quantifying yield gaps and abiotic stresses in soybean- and groundnut-based production systems	P Pathak	90	2001–2006
USANID/US Univ Linkages – Univ of Georgia	Management of aflatoxin in peanut through the use of atoxigenic strains of *Aspergillus flavus*	RB Jones	60	Jan 2005–Dec 2006
USAID/US Univ Linkages – Univ of Wisconsin-Madison	Elucidation of the peanut/*Aspergillus* interaction	F Waliyar	60	Jan 2005–Dec 2006
USAID/ABSP II (Sathguru Consultants)	Development of tobacco streak virus resistant sunflower and groundnut	KK Sharma	50	Apr 2005–Sep 2007

Research Reports

Genetic Resources and Enhancement

Use of 2n Pollen in Generating Interspecific Derivatives of Groundnut

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Numerically unreduced gamete called 2n pollen is a product of meiosis that bears sporophytic rather than the gametophytic chromosome number. Abnormalities in the division during meiosis or during spore wall formation result in 2n pollen. Often, such pollen are fertile (Christopher 1971).

The presence of dyads and triads at the microspore tetrad stage indicates the presence of 2n gametes. One of the main reasons for 2n pollen formation is meiotic nuclear restitution, which was first proposed by Rosenberg (1927). It is defined as the formation of a single nucleus with unreduced chromosome number, and the failure of the first or the second meiotic division. In the first division restitution, abnormal meiosis takes place with the formation of many univalents, and according to Wagennar (1968), it is a cellular mechanism for terminating the prolonged first division. Nevertheless the resultant restitution forms unreduced pollen. Restitution following the second meiotic division in pollen formation also yields 2n pollen. In some plant species there can be double restitution, although rarely, resulting in the formation of giant pollen. Triad formation occurs as a result of second division restitution (Sosa and Hernandez de Sosa 1971). Here, one group of chromosomes resulting from first meiotic division undergoes normal second meiotic division whereas in the other group, there is restitution nucleus.

During the development of interspecific hybrids in groundnut (*Arachis hypogaea*), cytological-tetrad analysis of F_1 hybrids revealed the presence of dyads, triads and tetrads. Detailed cytological analysis revealed the restitution of second division. This meant that the first meiotic division was normal, but the cytokinesis in the second division was impaired, resulting in the formation of dyads and triads. Formation of 2n restitution nucleus or the 2n pollen was observed in crosses with wild species from section *Arachis*, to which cultivated groundnut belongs (Singh and Moss 1984). Formation of 2n pollen in F_1 hybrids from crosses *A. hypogaea* × *A. chiquitana* (Figs. 1a and 1b), *A. hypogaea* × *A. kretschmeri* (section *Procumbentes*), and *A. duranensis* × *A. glabrata* (section *Rhizomatosae*) is a new finding. The 2n pollen from the cross *A. hypogaea* × *A. chiquitana* and *A. hypogaea* × *A. kretschmeri* were used to cross with *A. hypogaea* and develop tetraploid hybrids without going through the hexaploid route of backcross.

Use of 2n pollen in *Arachis* crossing program requires a large number of pollinations, but the process amply compensates by the development of tetraploids in one step, without the need to double the chromosome number

Table 1. Formation of dyads, triads and tetrads in interspecific derivatives of groundnut (*Arachis hypogaea*).

Cross	No. of dyads formed	No. of triads formed	No. of tetrads formed	Pollen stainability
A. hypogaea × *A. hoehnei*	48 (5)[1]	123 (13)	773 (82)	28
A. hypogaea × *A. cardenasii*	53 (5)	205 (20)	759 (75)	26
A. hypogaea × *A. chiquitana*	16 (1)	150 (12)	1091 (87)	15
A. hypogaea × *A. kretschmeri*	10 (2)	53 (12)	366 (85)	10
A. diogoi × *A. glabrata*	15 (6)	23 (9)	209 (85)	30
A. duranensis × *A. glabrata*	30 (32)	8 (9)	56 (60)	38
A. hypogaea × *A. glabrata*	9 (3)	16 (5)	299 (92)	26

1. Figures given in parentheses are percentage values.

of triploids and the laborious backcrossing program of the hexaploids to generate tetraploids. By this method it was possible to develop interspecific tetraploid derivatives from the crosses *A. hypogaea* × *A. chiquitana* and *A. hypogaea* × *A. kretschmeri.*

Dyads were observed as a result of restitution of both the groups of chromosomes at anaphase II. The number of dyads formed was low compared to the total number of pollen grains (Table 1), but the advantage of dyads is that they are fertile, which is evident from the acetocarmine stainability and in vivo pollen germination studies. Crosses using triploid pollen (*A. hypogaea* × *A. cardenasii*) (Table 1) gave rise to a few pegs and pods, which is a further confirmation that some of the triploid pollen are fertile. Reciprocal crosses using the triploid (*A. hypogaea* × *A. cardenasii*) as the female parent and *A. hypogaea* as the pollen donor, gave rise to 6% peg formation as a result of 500 pollinations, resulting in 7 pods. The resultant hybrids, obtained using *A. hypogaea* × *A. cardenasii* as the female parent and *A. hypogaea* as pollen donor, were tetraploids, which was confirmed by pollen diameter analysis. It is fairly simple to observe dyads and triads in tetrad analysis, which may not be the case with megasporogenesis, as the eggs are embedded deep in the ovular tissues.

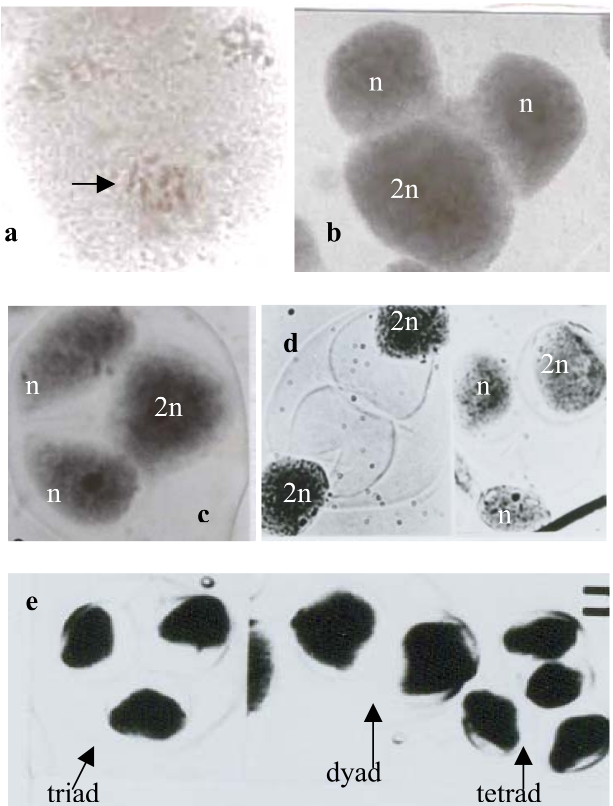

Figure 1. Formation of dyads and triads in *Arachis* interspecific hybrids: (a & b) Telophase with a normal separation of chromosomes and a restitution nucleus, leading to the formation of a triad in *A. hypogaea* × *A. chiquitana* (Note: Arrow points towards restitution nucleus); (c) Triad formation in *A. hypogaea* × *A. cardenasii*; (d) Dyads and triads in *A. duranensis* × *A. glabrata*; and (e) Dyads, triads and tetrads in the hybrid *A. hypogaea* × *A. glabrata*.

Singh and Moss (1984) reported the formation of pegs and pods in triploid interspecific derivatives from the crosses *A. hypogaea* × *A. chacoense* and *A. hypogaea* × *A. cardenasii*, which were obtained as cuttings from the University of Reading, Reading, UK. Interestingly in Reading, the triploids were sterile, but some of the plants grown at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India were partially fertile with the formation of a few pegs and pods. Cytological analysis of triploids showed that there were meiotic irregularities and the formation of restitution nucleus. Second division restitution was observed in the interspecific hybrids which were developed at ICRISAT (2000–05) between *A. diogoi* and *A. glabrata*, *A. hypogaea* and *A. hoehnei*, *A. duranensis* and *A. glabrata*, and *A. hypogaea* and *A. cardenasii* (Table 1). The action of restitution nucleus was evident by the presence of dyads and triads in pollen tetrad analysis (Figs. 1c and 1d). Dyads and triads have been observed in the tetraploid cross *A. hypogaea* × *A. glabrata* (Fig. 1e), which may not be of use in the improvement of *A. hypogaea*.

The report by Singh and Moss (1984) shows that environment may have a role to play in the formation of restitution nucleus in *Arachis* interspecific hybrids obtained as a result of crossing wild *Arachis* with cultivated groundnut. The results from our study show that 2n pollen can be effectively used to obtain tetraploids interspecific derivatives, without the use of colchicine to double the chromosome number of triploids and avoid the laborious hexaploid route to obtain tetraploids.

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Arachis hoehnei, the Probable B Genome Donor of *Arachis hypogaea* Based on Crossability, Cytogenetical and Molecular Studies

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Cultivated groundnut (*Arachis hypogaea*) is made up of two genomes, A and B. It is presumed that polyploidization event between diploid A and B genome species gave rise to cultivated tetraploid groundnut some 3500 years ago (Singh and Simpson 1994). There is no ambiguity regarding *A. duranensis* as the A genome donor of *A. hypogaea* (Gregory and Gregory 1979, Singh 1988, Kochert et al. 1991, Paik-Ro et al. 1992, Stalker 1992). Different species from the B genome pool have been proposed as the B genome donor. According to Singh (1998), *A. batizocoi* is the B genome donor. Based on RFLP (restriction fragment length polymorphism) studies, Kochert et al. (1991) have suggested *A. ipaensis* as the B genome donor. According to Paik-Ro et al. (1992), *A. batizocoi* is not closely related to *A. hypogaea* and hence cannot be the B genome donor. Karyotype studies of Fernandez and Krapovickas (1994) support *A. duranensis* and *A. ipaensis* as the A and B genome donors of *A. hypogaea*.

We studied the crossability relationship between *A. hypogaea* and six B genome species. Cultivated groundnut was crossed with *A. hoehnei*, *A. benensis*, *A. valida*, *A. magna*, *A. batizocoi* and *A. ipaensis*. *Arachis hoehnei* when crossed with *A. hypogaea* set bold seeds without the application of growth regulators. Majority of the seeds germinated in vitro and hybrid plants were obtained and a few (5%) mature seeds were obtained. Fertility in the hybrids ranged from 14 to 21%, whereas *A. benensis*, *A. valida*, *A. magna* and *A. ipaensis* set immature seeds, when crossed with *A. hypogaea*. The seeds were less than 3 mm in size. This indicated that the hybrid embryos aborted early. Embryo rescue technique was necessary to obtain hybrid plants if *A. benensis*, *A. valida*, *A. magna* and *A. ipaensis* were used as pollen donor. *Arachis batizocoi* set mature seeds with *A . hypogaea*, but pollen fertility was low (7%). Singh and Moss (1984) reported that in the crosses involving *A. batizocoi* and diploid A genome wild species from section *Arachis*, mean bivalents ranged from 3.2 to 6.9 with pollen fertility ranging between 3 and 7%. When *A. hypogaea* was crossed with *A. batizocoi*, the survival of the seedlings was poor.

Crosses were also carried out between *A. duranensis* and *A. hoehnei* (Fig. 1a). Large number of seeds (15%) was obtained. Cytogenetical study of the hybrid between *A. duranensis* and *A. hoehnei* showed 10 bivalent formation in 30% of the pollen mother cells analyzed (Fig. 1b). Amongst the bivalents, 4–6 were ring bivalents. The formation of large number of bivalents and in ring formation shows that there is homeology between the genomes of *A. duranensis* and *A. hoehnei*. For a hybrid between A and B genomes to survive in nature, greater degree of homeology between the genomes would be a contributory factor and would play a major role in the perpetuation of the hybrid. Such a hybrid could have doubled its chromosome number to give rise to the amphidiploid groundnut.

Simple sequence repeat (SSR) analysis of *A. duranensis*, *A. hoehnei* and the hybrid between *A. duranensis* and *A. hoehnei* was carried out. The SSR 4F07 profile of *A. duranensis* was different from that of *A. hoehnei*. The hybrid had the DNA profile with bands from both the parents. The interesting feature of the hybrid DNA profile was that it resembled the DNA profile of *A. hypogaea* with some differences (Fig. 1c). This shows that the hybrid, which has the genomes of both *A. duranensis* and *A. hoehnei*, has close resemblance to the genome of *A. hypogaea*. The difference between the hybrid *A. duranensis* × *A. hoehnei* and *A. hypogaea* may be due to ploidy difference and the synthesis of *A. hypogaea* which took place some 3500 years ago.

Based on crossability between *A. duranensis* and *A. hoehnei*, cytogenetical data and molecular analysis of the hybrid between *A. duranensis* and *A. hoehnei*, we propose *A. hoehnei* as the probable B genome donor of cultivated groundnut.

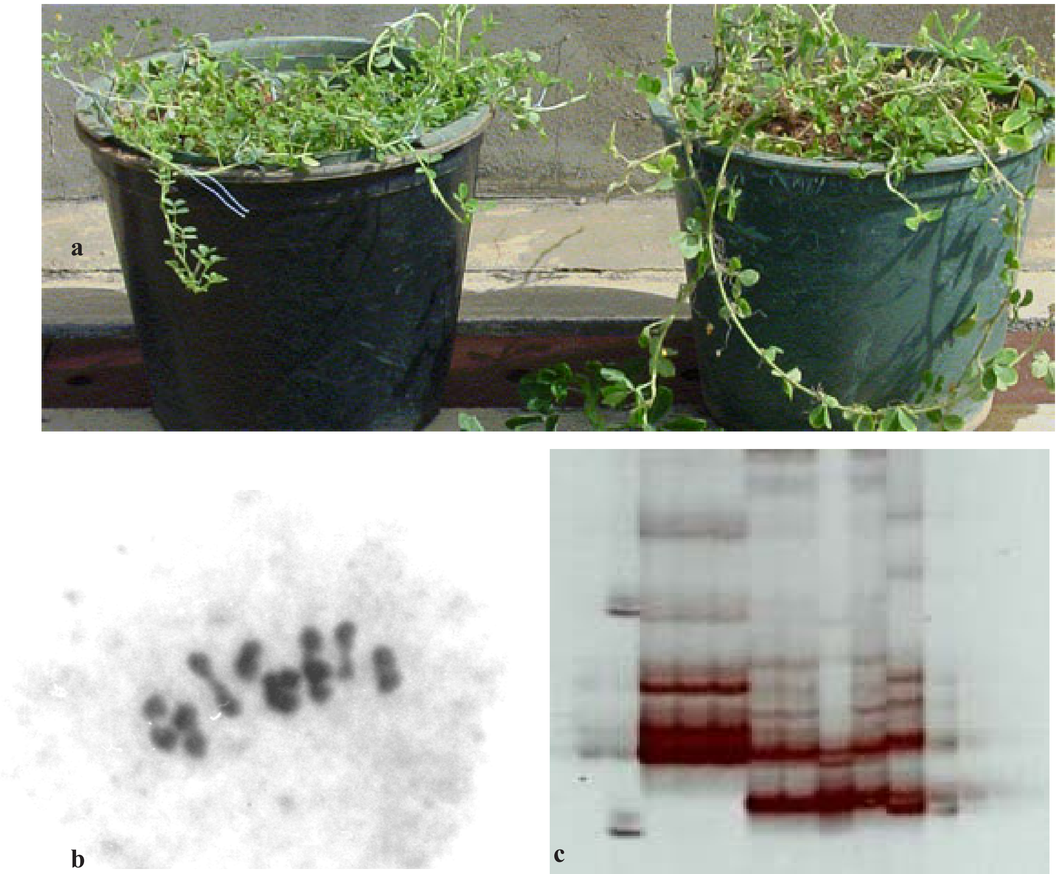

Figure 1. *Arachis hoehnei* as the B genome donor of cultivated groundnut *A. hypogaea*: (a) *Arachis duranensis* (left) and *A. hoehnei* (right); (b) metaphase plate of *A. duranensis* × *A. hoehnei* (note the presence of 10 bivalents); and (c) SSR marker 4F07 profile: Lane 1- 100 base pair ladder, Lanes 2–4 - *A. duranensis*, Lanes 5, 6 & 8 - hybrid between *A. duranensis* and *A. hoehnei*, Lane 7 - *A. hoehnei*, Lane 9 - *A. hypogaea*.

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Differences in Pod Characters Among Groundnut Cultivar L7-1 and its Chemical Mutants

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Early studies on mutation breeding in groundnut (*Arachis hypogaea*) were conducted in USA by Gregory (1955) using X-rays, in Africa by Tuchlenski (1958) using γ-rays, in Israel by Ashri and Goldin (1965) and Ashri (1970) using diethyl sulfate (DES), and in India by Patil (1968) and Lin (1960) in China by using X-rays. Most of the recent efforts in groundnut mutation breeding have been made through irradiation in India and China (Branch 2002).

Until now, over 30 groundnut varieties have been released worldwide with the help of induced mutations (Knauft and Ozias-Akins 1995). In China, for example, Luhua 12, a cultivar of *Hsuji™* (Spanish) market type, was developed after treatment of hybrid pegs with EMS (ethane methyl sulfonate). Previous attempts at chemical-induced mutation in groundnut reported alterations in external characters, but did not mention if there were changes in internal quality traits (Wan 2005). Considering the narrow gene base of the cultivated groundnut, the potential of chemical-induced mutation in groundnut breeding deserves further evaluation. This is extremely important for Shandong province, the leading groundnut producer of China, where groundnut breeding for yield and quality has remained stagnant for more than 8 years (Wang et al. 2006).

We have obtained large-podded and small-podded groundnut mutants following sodium azide (NaN_3) treatment of groundnut cultivar L7-1 (Wang et al. 2002). The pod size and seed size of these mutants were stable based on the observations over 6 years. The objective of this study was to examine the differences, if any, in both external and internal quality traits among the large- and small-podded mutants and L7-1.

The cultivar L7-1 is a hybrid derivative of *A. hypogaea* cv Shilihong and *A. glabrata* with bold, pink, elliptical oblong seeds desirable for export. L7-1 and its two NaN_3-induced mutant lines with either large or small pods were planted in adjacent rows for sampling.

The seed was sown under polythene (with Acetochlor) mulch, with a population of 124,995 plants ha^{-1} at Qingdao Agricultural Academy Experimental Region, Shandong

Table 1. Difference in external and internal quality traits among groundnut cultivar L7-1 and its mutants.

Trait	Type[1]	Mean[2]		SE±
Pod length	LP	52.31	A	0.57
	SP	33.40	B	0.31
	L7-1	40.77	C	0.38
Pod width	LP	18.66	A	0.23
	SP	13.80	B	0.11
	L7-1	17.32	C	0.20
Pod thickness	LP	17.33	A	0.18
	SP	12.61	B	0.10
	L7-1	15.46	C	0.16
Pod mass	LP	3.97	A	0.09
	SP	1.86	B	0.04
	L7-1	3.11	C	0.06
Apical seed length	LP	25.46	A	0.42
	SP	17.04	B	0.18
	L7-1	21.69	C	0.22
Apical seed width	LP	8.96	a	0.11
	SP	8.61	ab	0.09
	L7-1	8.31	bc	0.23
Apical seed thickness	LP	12.02	A	0.21
	SP	9.03	B	0.12
	L7-1	11.16	C	0.14
Apical seed mass	LP	1.46	A	0.05
	SP	0.71	B	0.02
	L7-1	1.13	C	0.03
Basal seed length	LP	23.77	A	0.43
	SP	16.08	B	0.16
	L7-1	20.63	C	0.25
Basal seed width	LP	9.73	A	0.15
	SP	9.17	B	0.09
	L7-1	10.21	C	0.09
Basal seed thickness	LP	12.97	A	0.17
	SP	9.44	B	0.09
	L7-1	11.77	C	0.10
Basal seed mass	LP	1.59	A	0.04
	SP	0.72	B	0.02
	L7-1	1.28	C	0.02
Protein (%)	LP	27.40	ab	0.00
	SP	27.36	a	0.00
	L7-1	27.81	b	0.00
Oil (%)	LP	42.80	AC	0.00
	SP	45.05	B	0.00
	L7-1	44.09	BC	0.00
Oleic acid (O) (%)	LP	48.29	A	0.01
	SP	36.21	B	0.02
	L7-1	45.33	A	0.01
Linoleic acid (L) (%)	LP	34.74	A	0.01
	SP	44.62	B	0.01
	L7-1	36.71	A	0.01
Palmitic acid (%)	LP	11.83	A	0.00
	SP	14.35	B	0.00
	L7-1	12.06	A	0.00
O/L ratio	LP	1.39	A	0.05
	SP	0.82	B	0.06
	L7-1	1.24	A	0.03

1. LP = Large-podded mutant; SP = Small-podded mutant.
2. Means of specific trait within the same column followed by the same letter are not significantly different, for lower case letters at $P = 0.05$ and for upper case letters at $P = 0.01$.

on 1 May 2005. Weeds were pulled out by hand, and pesticide was sprayed a week before wheat (*Triticum aestivum*) harvest (Wan 2003). During the whole plant growth period, no irrigation was needed due to plenty of rainfall and adequate soil moisture. Groundnut was harvested on 10 September 2005. After drying, 48 representative pods from each entry were randomly selected for measurement of length, width and thickness of pod, apical seed, and basal seed using vernier calipers. The protein, oil, and oleic, linoleic and palmitic acids contents (percentage of total fatty acids) were determined in 18–20 bulked seed samples (5 groups for each entry) by near infrared reflectance spectroscopy (NIRS) (Yu et al. 2003a, 2003b). Each sample was measured 4 times, and the average was used in subsequent statistical analysis. For external quality traits, where equality of error variances was not assumed according to Levene's test, robust tests of equality of means by Welch and Brown-Forsythe methods and multiple comparisons of differences by Games-Howell test were conducted (Quinn and Keough 2002). For internal quality characters, multivariate analysis of variance (MANOVA) using Pillai's trace/Wilks' lambda, and multiple comparisons of differences by Tukey's Honest Significant Difference (HSD) test were exploited (Quinn and Keough 2002).

Significant differences between the mutants and the control for pod and seed length and mass were detected by visual inspection (Fig. 1). Robust tests of equality of means of external quality traits in the mutants and L7-1 indicated that length, thickness and mass of pod/seed of the 3 types differed significantly ($P = 0.01$), and apical seed width differed at 0.05 ($P = 0.05$) level. Multiple comparisons further showed that the large-podded and the small-podded mutants exhibited a drastic change in pod and seed length, thickness and mass as compared with the control L7-1, whereas the apical seed width of the small-podded mutants was not significantly different from that of L7-1 (Table 1).

Figure 1. Pods (left) and seeds (right) of groundnut cultivar L7-1 (bottom), and its derived large-podded (top) and small-podded (middle) mutants.

MANOVA of internal quality traits in the mutants and L7-1 revealed that internal quality characters inclusive of protein, oil, and oleic, linoleic and palmitic acids contents differed significantly ($P = 0.01$) among the 3 types. Multiple comparisons showed that for protein content, significant difference ($P = 0.05$) existed only between the small-podded mutant and L7-1; for oil content, significant difference ($P = 0.01$) existed only between the large-podded mutant and the small-podded mutant. In contrast to the large-podded mutant, the small-podded mutant showed a reverse tendency in fatty acid composition. The oleic acid (O) of the small-podded mutant was lower, and linoleic acid (L) and palmitic acid contents were higher than those of L7-1, and the differences were significant at $P = 0.01$. The O/L ratio of the small-podded mutant was much lower than the large-podded mutant and L7-1 (significant at $P = 0.01$). The O/L ratio of the large-podded mutant, however, was not statistically different from L7-1 (Table 1).

The change in internal quality in the "wrong" direction in this study does not necessarily mean the same case as in additional mutants. Conversely, alterations in traits of the two mutant lines from this study indicated the necessity for large-scale evaluation of the groundnut mutant bank of EMS, DES and NaN_3 for broad internal quality variation range. In conclusion, this study demonstrated the possible utility of chemical-induced mutation in groundnut germplasm enhancement not only for external quality traits but for internal quality traits as well. Mutants with much larger and smaller seed size, even with altered fatty acids composition, may be produced following chemical mutagen treatment. This is especially important for the cultivated groundnut, whose genetic base is narrow, as a result of genetic bottleneck where ploidy difference and pre-/post-fertilization barriers make gene exchange difficult with its wild relatives; this situation is further aggravated in cultivars by the limited number of core parents exploited by breeders. Chemical induced mutation techniques, when used in TILLING (Targeting Induced Local Lesions IN Genomes), may facilitate creation and identification of mutations in DNA regions of interest, and when combined with NIRS, may speed up the process of groundnut quality improvement.

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Seed Releases

A High-yielding Drought-tolerant Groundnut Variety Abhaya

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Groundnut (*Arachis hypogaea*), an important oilseed and food crop of Andhra Pradesh, India is grown largely as a rainfed crop during the rainy season. Drought is the major abiotic stress affecting yield and quality of rainfed groundnut in the state. Yield losses due to drought are highly variable depending on its timing, intensity and duration coupled with other location specific environmental factors such as irradiance and temperature (Nigam et al. 2001). Thus the groundnut productivity in rainy season in the state ranges between 500 kg ha^{-1} and 1200 kg ha^{-1} (Reddy et al. 2003). To stabilize yield under rainfed conditions, it is necessary to develop varieties that tolerate moisture stress at different stages of crop growth. To achieve this objective, research was initiated to identify donor parents for drought tolerance traits such as low specific leaf area (SLA), high SPAD chlorophyll meter reading (SCMR) and high harvest index (HI) that confer advantage under drought conditions. Through principal component analysis, ICGV 86031, CSMG 84-1, ICGS 76 and TAG 24 were identified as genotypes with most of the useful traits for drought tolerance (Nageswara Rao and Wright 2003). Hybridization was effected in 1998 involving these genotypes as male parents. From K 134 × TAG 24 cross, TPT 25 was developed through modified pedigree method with focus on drought tolerance traits in segregating generations. It belongs to supspecies *fastigiata* and variety *vulgaris*. TPT 25 is a short-statured, drought-tolerant, high-yielding Spanish bunch groundnut variety (Fig. 1). Its special attributes are: plant height 27–34 cm, sequential branching pattern, short internodes, narrow dark green leaflets, 4–6 primary branches, decumbent plant type, slender pods without beak, higher frequency of three-seeded pods, thin shell, higher shelling outturn, and high oil content of 52% (Table 1). It matures 105–110 days in the rainy season.

TPT 25 was tested in yield trials at Regional Agricultural Research Station (RARS), Tirupati, in different All India Coordinated Research Project (AICRP) centers and on farmers' holdings in Chittoor, Kadapa and Anantapur districts extensively (Table 2). It was also tested in state

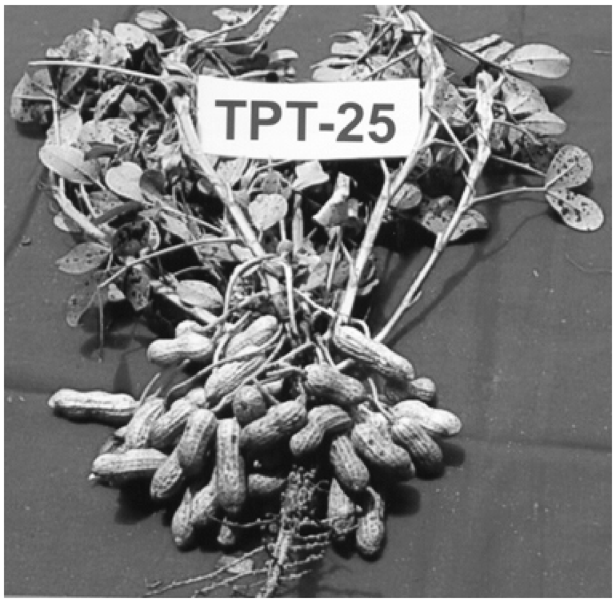

Figure 1. A mature plant of groundnut variety TPT 25.

Table 1. Morphological and physiological traits of groundnut variety TPT 25[1].

Variety	Plant height (cm)	Time to maturity (days)	SCMR	SLA (cm^2 g^{-1})	RWC (%)	Shelling outturn (%)	SMS (%)	Oil content (%)
TPT 25	30.7	105.6	42.5	167	83.3	72.2	84.5	52.3
Narayani (check)	52.5	90.0	40.9	217	77.9	70.6	82.0	48.3

1. Mean of values recorded during rainy season 2003, 2004 and 2005.
SCMR = SPAD chlorophyll meter reading; SLA = Specific leaf area; RWC = Relative water content in leaf; SMS = Sound mature seed.

Table 2. Pod yield (kg ha^{-1}) of groundnut variety TPT 25 in different trials during rainy season at Regional Agricultural Research Station, Tirupati, AICRP centers and on farmers' holdings in Andhra Pradesh, India.

Variety	Station trials					AICRP trials (early season stress)			Minikit trials (mid-season stress)			Mean	
	2003	2004	Mean	2004–05	2005	2004	2005	Mean	2004	2005	Mean	2004	2005
TPT 25	2741	1945	2343	3756	2303	1235	1203	1219	1134	1545	1340	1191	890
Narayani/TMV 2/Local (check)[1]	2257	1302	1780	3444	1787	1065	932	999	860	1353	1107	810	710
Increase over control (%)	17	49	29	10	29	16	29	22	32	14	21	47	14
CD at 50%	580	204						251			261		
CV (%)	15	21											

1. Narayani in station trials, TMV 2 in AICRP trials, and Local in minikit trials.

multilocational varietal trials at different research stations of Acharya NG Ranga Agricultural University (ANGRAU) for two years covering different agroclimatic situations of Andhra Pradesh. It outperformed the existing varieties JL 24 and TMV 2 at many locations with additional attributes of tolerance to drought and late leaf spot. Based on these results, the Andhra Pradesh State Varietal Release Committee released TPT 25 as Abhaya in June 2006 for general cultivation in the state. It is recommended for both rainy and postrainy season cultivation throughout Andhra Pradesh. Due to its compact nature, TPT 25 is also suitable for high rainfall areas where excess vegetative growth in the existing varieties leads to drastic reduction in yield and the quality of the produce during the rainy season.

In trials at RARS, Tirupati during rainy season 2003 and 2004, TPT 25 produced an average pod yield of 2343 kg ha^{-1} that was 29% higher than Narayani and 13% higher than Vemana, the two recently released varieties in the state. Its seed yield was 1608 kg ha^{-1}, which was 34% higher than Narayani and 15% higher than Vemana. It was tested at AICRP centers identified for their drought pattern – early season drought stress (Tirupati, Anantapur and Vriddhachalam) and mid-season drought stress (Jalgaon, Chintamani and Raichur). The average pod yield of TPT 25 under early season drought stress was 1219 kg ha^{-1} (mean of rainy season 2004 and 2005) with an overall increase of 22% over the check variety TMV 2. In the mid-season drought stress situation, the average pod yield of TPT 25 was 1340 kg ha^{-1} which was 21% higher than the check variety TMV 2 (Table 2). In end-of-season drought stress situation, the pod yield of TPT 25 was limited to that of check variety (data not given).

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New High-yielding Groundnut Varieties GG 8 and GG 16

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Groundnut (*Arachis hypogaea*) is the major oilseed crop of India. It is grown in 11 states in the country in an area of 7.6 million ha with a production of 7.8 million t of pods per annum. The average productivity of groundnut in India is about 1000 kg ha^{-1} and is stagnating for the last several years. To overcome such stagnation in production and productivity of groundnut, efforts on varietal improvement with emphasis on high yield and resistance/ tolerance to biotic and abiotic stresses, and development of low-cost crop management practices are needed.

In this direction, the Main Oilseeds Research Station, Junagadh Agricultural University (JAU), Junagadh, Gujarat, India has developed two new high-yielding groundnut varieties GG 8 and GG 16 for Zone III and Zone V, respectively. Gujarat Groundnut 8 (GG 8), a Spanish bunch variety (*A. hypogaea* subsp *fastigiata* var *vulgaris*) and Gujarat Groundnut 16 (GG 16), a Virginia runner variety (*A. hypogaea* subsp *hypogaea* var *hypogaea*), were developed from the crosses 27-5-1 × JL 24 and JSP 14 × JSSP 4, respectively following pedigree method of selection. After preliminary evaluation at the Main Oilseeds Research Station as J 53 (GG 8) and JSP 39 (GG 16), they were proposed in rainy season 2002 for evaluation in the All India Coordinated Varietal Trials, IVT-SB-I and IVT-VG-I, respectively. Then they were tested in IVT-II and AVT during rainy season 2002–04.

For J 53 (GG 8) the trials were conducted at 11 locations in Akola, Khargone, Jalgaon and Raipur centers, while for JSP 39 at 27 locations in Aliyarnagar, Vriddhachalam, Jagatial, Kadiri, Raichur, Dharwad, Chintamani, Kayumkulam, Digraj and Latur centers. In three years of testing, J 53 produced a mean dry pod yield of 1716 kg ha^{-1} as compared to 1493 kg ha^{-1} of JL 24 (national check) and 1608 kg ha^{-1} of TAG 24 (zonal check). The yield

Table 1. Comparative dry pod yield (kg ha^{-1}) and seed yield (kg ha^{-1}) of groundnut variety J 53 (GG 8) in the All India Coordinated Varietal Trials (AICVTs) conducted in Zone III, India during rainy season 2002–04.

		J 53 (GG 8)		JL 24 (national check)		TAG 24 (zonal check)	
Year	Number of locations	Dry pod yield	Seed yield	Dry pod yield	Seed yield	Dry pod yield	Seed yield
2002	4	1205	836	1269	865	1888	1244
2003	3	2567	1812	2112	1403	1859	1172
2004	4	1375	930	1108	760	1076	725
Mean		1716	1193	1493	1009	1608	1047
Increase over check (%)				14.9	18.2	6.7	13.9

Table 2. Reaction of groundnut variety J 53 (GG 8) to major diseases and pests.

	Mean values (2002–04)		
Diseases/insect pests	J 53 (GG 8)	JL 24 (national check)	TAG 24 (zonal check)
Late leaf spot[1]	6.1	5.3	5.2
Rust[1]	4.7	3.9	1.5
Stem rot incidence (%)	6.3	5.2	2.6
Bud necrosis intensity (%)	1.5	3.3	NA[2]
Collar rot intensity (%)	0.5	6.0	NA
Root rot intensity (%)	2.7	4.3	4.4
Thrips damage (%)	30.3	41.4	41.0
Jassids demage (%)	23.3	23.3	NA
Prodenia damage (%)	2.9	4.3	2.0
No. of leaf miners $plant^{-1}$	0.5	0.4	NA

1. Scored on a 0–9 rating scale, where 0 = no disease, 1 = ≤1%, 3 = 1–5%, 5 = 6–20%, 7 = 21–50%, 9 = ≥51% disease damage.
2. NA = Data not available.

Table 3. Comparative dry pod yield (kg ha^{-1}) and seed yield (kg ha^{-1}) of JSP 39 (GG 16) in All India Coordinated Varietal Trials (AICVTs) conducted in Zone V, India during rainy season 2002–04.

		JSP 39 (GG 16)		M 335 (national check)		ICGV 86325 (zonal check)	
Year	Number of locations	Dry pod yield	Seed yield	Dry pod yield	Seed yield	Dry pod yield	Seed yield
2002	9	2079	1526	867	616	1466	1121
2003	8	1978	1227	1447	1031	1383	1113
2004	10	1979	1262	1645	1122	1472	1069
Mean		1992	1338	1373	923	1459	1024
Increase over check (%)				45.1	45.0	27.0	18.6

Table 4. Reaction of groundnut variety JSP 39 (GG 16) to major diseases and pests.

	Mean values (2002–04)		
Diseases/insect pests	JSP 39 (GG 16)	M 335 (national check)	ICGV 86325 (zonal check)
Late leaf spot[1]	4.6	3.8	3.9
Rust[1]	4.1	3.1	2.7
Stem rot intensity (%)	3.9	4.2	5.7
Bud necrosis intensity (%)	1.8	3.1	4.8
Collar rot intensity (%)	3.0	2.3	4.1
Root rot intensity (%)	4.8	8.6	15.0
Thrips damage (%)	30.2	32.0	19.9
Jassids demage (%)	19.2	16.7	29.8
Prodenia damage (%)	3.0	9.0	4.7
No. of leaf miners plant^{-1}	1.8	0.1	1.7

1. Scored on a 0–9 rating scale, where 0 = no disease, 1 = ≤1%, 3 = 1–5%, 5 = 6–20%, 7 = 21–50%, 9 = ≥51% disease damage.

advantage over national check was 14.9% and over zonal check 6.7%. The seed yield of J 53 (1193 kg ha^{-1}) was 18.2% higher than JL 24 (1009 kg ha^{-1}) and 13.9% higher than TAG 24 (1047 kg ha^{-1}) (Table 1). This variety also showed higher shelling outturn (69%) than JL 24 (68%) and TAG 24 (66%). It exhibited slightly higher incidence of late leaf spot, rust and stem rot diseases but lower incidence of bud necrosis, collar rot and root rot diseases as compared to both the checks. This variety was similar to the check varieties in jassids and leaf miner reactions. Thrips and prodenia damage was low on J 53 compared to JL 24 (Table 2).

GG 8 (J 53) is erect in growth habit and takes 106 days to mature. The leaves are medium green and oblong in shape. Pods are two-seeded with slight reticulation and constriction, and pod beak is absent. Seeds are medium, round and rose in color. The oil content in GG 8 (46%) is less than JL 24 (47%) and TAG 24 (49%).

During the three-year testing, JSP 39 (GG 16) recorded dry pod yield of 1992 kg ha^{-1} as compared to 1373 kg ha^{-1} of M 335 (national check) and 1459 kg ha^{-1} of ICGV 86325 (zonal check). The yield advantage in GG 16 was 45.1% over M 335 and 27.0% over ICGV 86325. The seed yield of this variety was 1338 kg ha^{-1}, which was 45.0% and 18.6% higher than M 335 (923 kg ha^{-1}) and ICGV 86325 (1024 kg ha^{-1}), respectively (Table 3).

GG 16 (JSP 39) showed similar reaction to rust, late leaf spot, stem rot and collar rot diseases as that of check varieties, while it was superior in bud necrosis and root rot diseases reaction. Leaf damage by thrips and jassids was similar in GG 16 and the check varieties under field condition (Table 4). GG 16 is a spreading type with profuse branching and takes 119 days to mature. The leaves are green and elliptical. Pods are big and two-seeded with moderate constriction and reticulation, and have slight beak. Seeds are medium, elongated and rose in color. The 100-seed mass is 43 g and the shelling outturn is 63%. The oil content in this genotype is 46%.

GG 8 and GG 16 were identified for Zone III (northern Maharashtra and Madhya Pradesh) and Zone V (Tamil Nadu, Andhra Pradesh, Karnataka, Kerala and Southern Maharashtra), respectively by the Variety Identification Committee meeting of the All India Coordinated Research Project (AICRP) on Groundnut held at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India during 2–4 October 2005.

Performance of Groundnut Cultivar ICGV 93468 During Summer Season in Uttar Pradesh, India

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Groundnut (*Arachis hypogaea*) is an important oilseed crop of Uttar Pradesh, India primarily grown during the rainy season. In early 1980s, groundnut was grown in Uttar Pradesh on 0.3 million ha during the rainy season with a production of 0.19 million t. Since then, both area and production have shown a steady decline due to biotic and abiotic stresses. During 1997–98, groundnut area declined from 0.3 million ha to 0.13 million ha and production from 0.19 million t to 0.12 million t. Efforts to arrest this decline in area and production did not succeed due to various administrative and economic reasons. A strong need was felt to develop a suitable technology to make groundnut cultivation more profitable in Uttar Pradesh. The main function of the National Agricultural Research Project (NARP), Mainpuri, Uttar Pradesh was to lead research on groundnut. Therefore, scientists of NARP deliberated on this important issue with SN Nigam at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India and planned to introduce summer cultivation of groundnut in the state targeting the area vacant in summer season after harvesting potato (*Solanum tuberosum*) (0.38 million ha), mustard (*Brassica* sp) (0.53 million ha) and field pea (*Pisum sativum*) (0.23 million ha). The seed of different genotypes supplied by ICRISAT was tested during summer season of 1998 at Mainpuri. Among the ICRISAT genotypes ICGV 93468 performed well during summer season. Due to high yield potential, low incidence of insect pests and diseases, better survival under water stress condition, thermo-tolerance and early maturity (90–95 days), ICGV 93468 was considered to be most suitable for the groundnut farmers of Uttar Pradesh.

In 2001, the farmers of Mainpuri district followed for summer season groundnut cultivation with genotype ICGV 93468. Summer season groundnut cultivation in traditional and non-traditional areas of Mainpuri, Firozabad, Etawah, Auraiya, Kanpur, Kannauj, Farrukhabad, Aligarh, Hathras, Etah, Unnao, Hardoi, Fatehpur and Shahjahanpur districts slowly spread on an area of about 27,500 ha. The Department of Agriculture, Lucknow later on organized a meeting of the officers of State Agriculture Department and scientists of different agricultural universities of the state and decided to evaluate the variety ICGV 93468 further at Regional Agriculture Testing and Demonstration Stations (RATDSs) located in the different regions of Uttar Pradesh.

A varietal trial with improved ICRISAT varieties and a local check G 201 (Kaushal) was laid out during summer season of 2005 at RATDSs, Hardoi, Mathura (at Raya) and Bareilly (at Belva). The crop was sown on 9 March 2005 at Hardoi, 19 March 2005 at Mathura and 4 April 2005 at Bareilly. The crop was harvested on 21 June 2005 at Hardoi, 5 July 2005 at Mathura and 30 July 2005 at Bareilly. Sowing was done in rows 30 cm apart with 10 cm plant spacing. Recommended dose of 20 kg nitrogen ha^{-1} + 30 kg P_2O_5 ha^{-1} + 45 kg K_2O ha^{-1} was applied at the time of planting of groundnut seed. Gypsum was applied at 300 kg ha^{-1} with 50% quantity applied at sowing and the remaining 50% top dressed between

Table 1. Performance of ICGV 93468 in comparison to the check varieties under state varietal trials conducted at different RATDSs of Uttar Pradesh, India during summer season 2005.

	Pod yield (t ha^{-1})			
Genotype	Hardoi	Mathura	Bareilly[1]	Average
ICGV 93468	2.91	2.46	1.13	2.17
ICGS 44	2.64	2.26	0.89	1.93
ICGS 1	2.55	1.84	0.90	1.77
ICGV 86590	2.02	1.72	1.05	1.60
G 201 (local check)	1.30	1.75	0.74	1.26
SEm±	0.11	0.05	0.06	
CD at 5%	0.36	0.17	0.19	
CV (%)	10.41	12.80	13.43	

1. The crop was sown one-month late on 4 April 2005 at Belva farm of RATDS, Bareilly.

Table 2. Maturity duration of different groundnut varieties at different RATDSs of Uttar Pradesh, India during summer season 2005.

	Time to maturity (days)			
Genotype	Hardoi	Mathura	Bareilly	Average
ICGV 93468	90	103	99	97
ICGS 44	97	105	101	101
ICGS 1	97	106	102	102
ICGV 86590	95	107	102	101
G 201 (local check)	93	108	103	101

Figure 1. A bumper crop of groundnut variety ICGV 93468 (Avtar) in Uttar Pradesh, India.

flowering and pegging stage to ensure supply of calcium and sulfur to developing pods.

The genotype ICGV 93468 gave higher average pod yield (2.17 t ha^{-1}) compared to ICGS 1, ICGS 44, ICGV 86590 and G 201 (local check) (Table 1). ICGV 93468 gave 71.15% higher pod yield than local check G 201. The maximum yield of ICGV 93468 was 2.91 t ha^{-1}, harvested in Central Plain Zone of Uttar Pradesh at RATDS, Hardoi closely followed by 2.46 t ha^{-1} in South Western Semi Arid Zone at RATDS, Mathura. The minimum yield obtained was 1.13 t ha^{-1} in Middle Western Plain Zone at RATDS, Bareilly. The yield variation in ICGV 93468 was not due to agroclimatic zones of Uttar Pradesh but due to time of sowing. In Hardoi and Mathura, sowing was done under recommended time while at Bareilly it was planted one-month late.

The variety ICGV 93468 (Avtar) matured at 97 days after planting (Fig. 1; Table 2). This maturity time was found conducive to the production of groundnut during summer season where the crop with longer duration is usually caught by rains at maturity/harvest.

Release of Groundnut Variety Huayu 23 in Shandong Province in China

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The groundnut (*Arachis hypogaea*) variety Huayu 23 is derived from a cross of two advanced breeding lines, ICGS 37 and R1(8124-19-1). ICGS 37, developed at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, is a released cultivar in India; R1(8124-19-1) is a breeding line developed at Shandong Peanut Research Institute, China. Huayu 23 was released by the Shandong Crop Variety Approval Committee in 2004 for cultivation in Shandong province in China.

In Shandong provincial trials, Huayu 23 ranked first during 2002/03. The pod yield averaged 4.69 t ha^{-1}, 13.5% more than Luhua 12 (control) over 22 locations, and the seed yield averaged 3.51 t ha^{-1}, 16% more than the control. In national test, Huayu 23 produced 4.11 t ha^{-1} pod yield, 26.71% more than Luhua 12 (control).

Huayu 23 matures in 125 days in the spring season. It has an erect growth habit, sequential flowering and dark green leaves. The main stem height of the plant is 37 cm, and the average length of branches is 43 cm. Huayu 23 has 9 primary branches. The pod has moderate to prominent reticulation with slight to moderate pod beak (Fig. 1). Pod constriction is medium. Seed coat is pale red. One-seeded and two-seeded pods account for 10% and 72% of all pods, respectively. The 100-pod mass is 154 g and the 100-seed mass is 64 g, with a shelling outturn of 75%. The seed contains 53.1% oil and 22.9% protein. The oleic acid/linoleic acid ratio is 1.55, making Huayu 23 a breakthrough in quality breeding for export of small-seeded groundnut after Luhua 15 in China (Table 1). It has good resistance to cercospora and phaeoisariopsis leaf spots.

Huayu 23 grows well on sandy soil with good drainage. The seed rate should be around 165,000 hills ha^{-1} with two seeds in each hill for spring sowing.

Figure 1. Mature plants, pods and seeds of groundnut variety Huayu 23 in China.

Table 1. Seed quality traits of groundnut varieties Huayu 23 and Luhua 15 in China.

Variety	Protein (%)	Oil (%)	Oleic acid (O) (%)	Linoleic acid (L) (%)	O/L ratio
Huayu 23	22.9	53.1	49.3	31.9	1.55
Luhua 15	28.6	50.9	44.7	34.1	1.31

Registration of Foliar Disease Resistant and High-yielding Groundnut Varieties ICGV 92099 and ICGV 90084

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Groundnut (*Arachis hypogaea*) is an important crop for small-scale farmers in Ghana. Although the crop is produced in all agro-ecologies of the country, the bulk of production occurs in the northern region, which spans the Guinea and Sudan savannah ecologies lying within 8–11° N. The crop is produced mainly for oil, although a significant proportion of the seed is consumed in confectionery products or soups.

In Ghana, the major constraint to groundnut production is disease incidence, mainly early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Cercosporidium personatum*), although rosette, rust (*Puccinia arachidis*) and *Aspergillus flavus* incidence may be severe depending on year and location. The effects of drought are particularly important in the northeast corner of the country where varieties that mature after 110 days are particularly unsuitable (Marfo and Padi 2000). Seed yield loss from leaf spot alone occurs in more than 40% of yield potential of the crop in northern Ghana (Tsigbey 1996). Bavistin (carbendazim) and Topsin-M (thiophanate methyl) are recommended for control of leaf spot; however, cost and availability of these fungicides have restricted their widespread use. The effects of foliar diseases and their interaction with moisture availability during the cropping season on groundnut performance has restricted early-maturing varieties that are susceptible to the major foliar diseases in the Sudan savannah ecology whereas late-maturing varieties with resistance to foliar diseases are more preferable in the wetter Guinea savannah ecology (Marfo and Padi 1999).

Host plant resistance to the major diseases, and tolerance to drought will maintain yield stability of the crop and increase the profitability of production. To meet these objectives the Savanna Agricultural Research Institute (SARI), Ghana has been evaluating a number of advanced breeding lines of groundnut developed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India for high seed yield and stability of yield at benchmark sites. Lines identified as high yielding are further evaluated for oil content. A number of lines that have high seed yield and high oil content have been identified over the years and were further tested in farmers' fields (Marfo 1997).

The National Varietal Release Committee of Ghana has released the groundnut varieties ICGV 92099 and ICGV 90084 on 9 October 2005 as Gusie-Balin and Kpanieli, respectively, for the northern sector of Ghana. ICGV 92099 is early in maturity (100 days) with high seed yield and resistance to early and late leaf spots. ICGV 90084 is a late-maturing variety (120 days) and is resistant to early and late leaf spots with high seed and oil yields. On a scale of 1 to 9 (where 1 = no leaf spot and 9 = complete defoliation due to leaf spot), scores for reaction to leaf spots for ICGV 92099 are consistently lower (4 to 5) than that of Chinese (7 to 9), the most important commercial cultivar in northern Ghana. Similarly, ICGV 90084 shows better resistance to leaf spots (score of 3 to 4) compared to Chinese or Manipintar (score of 4 to 5) and has similar reaction as F-mix. In advanced yield trials involving 17 lines tested at four sites across northern Ghana, ICGV 92099 produced seed yields

Table 1. Average seed yield (t ha^{-1}) of groundnut varieties ICGV 92099 and ICGV 90084 across northern Ghana.

Variety	1996	1997	2001	2002	2003	2004
Early maturity group						
ICGV 92099			0.98	1.18	0.73	1.11
Chinese (check)			0.56	0.85	0.64	0.90
Sinkarzie (check)			0.70	0.98	0.91	1.10
Trial mean			0.69	0.96	0.75	1.13
LSD at 5%			0.23	0.20	0.15	0.27
Late maturity group						
ICGV 90084	1.16	1.22	1.05	1.51	1.18	2.12
F-mix (check)	0.89	1.21	0.88	1.06	1.25	1.92
Manipintar (check)	0.71	0.82	0.82	1.31	1.27	1.74
Trial mean	0.66	1.06	0.75	1.09	1.00	1.52
LSD at 5%	0.22	0.29	0.27	0.34	0.21	0.41

Table 2. Some characteristics of groundnut varieties ICGV 92099 and ICGV 90084 in northern Ghana.

Plant character	ICGV 92099	ICGV 90084
Branching pattern	Alternate	Alternate
Height of main stem[1] (cm)	33	35
Plant spread[1] (cm)	42	32
Stem pigmentation	Absent	Present
Peg pigmentation	Present	Present
Type of inflorescence	Compound	Compound
Standard petal color	Yellow	Yellow
Leaf color	Green	Light green
Leaflet length (cm)	4.2	5.0
Leaflet width (cm)	2.0	2.0
Leaflet shape	Wide-elliptic	Oblong-elliptic
Seed color	Brown	Red
Pod constriction	None	Very deep
Pod beak	Slight	Moderate
Pod length (cm)	3.2	3.2
Pod width (cm)	1.3	1.2
Seeds pod^{-1}	2	2
Seed length (cm)	1.7	1.5
Seed width (cm)	1.1	1.0
100-seed mass (g)	70	67
Time to 50% germination (days)	5	5
Time to 50% flowering (days)	29	27
Time to maturity (days)	100	120
Potential seed yield (t ha^{-1})	2.0	2.5
Potential haulm yield[2] (t ha^{-1})	4.0	5.0
Shelling outturn (%)	66	70
Oil content (%)	46	51

1. Sixty days after sowing.
2. After 4 days of continuous sun drying.

similar to, or better than the commercial varieties Chinese and Sinkarzie (Table 1). Also, among the late maturity group in which 14 advanced breeding lines were tested, ICGV 90084 produced seed yields similar to or higher than the late-maturing commercial cultivars Manipintar and F-mix. In 30 farmer-managed trials conducted between 2003 and 2004, ICGV 92099 and ICGV 90084 performed on average better than farmers' current varieties.

ICGV 92099 has alternate branching pattern, and the pods are typically two-seeded, slightly beaked, with no constriction between the seeds (Table 2). The oil content of 46% in ICGV 92099 is similar to that of Chinese. The large seed size of ICGV 92099 makes it attractive for developing confectionery-type products. ICGV 90084 also has alternate branching pattern, two-seeded pods that are moderately beaked with a deep constriction between the seeds (Table 2). ICGV 90084 has high oil content (51%) similar to that of F-mix (50%).

These new varieties provide opportunities for integrated management of leaf spot in northern Ghana, as the levels of resistance are high. ICGV 92099 being early maturing will provide greater flexibility in planting time to obtain maximum yields in the Guinea savannah ecology, and proper utilization of available rainfall with reduced risks of terminal drought in the Sudan savannah ecology. ICGV 90084 is recommended for the Guinea savannah ecology alone because of its longer maturity period.

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BRS Havana: A New Early-maturing Groundnut Variety for the Northeast Region in Brazil

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Groundnut (*Arachis hypogaea*) is one of the major oilseeds and food legumes in the world. It is an excellent food crop to reduce malnutrition due to rich nutritional properties of its oil and protein. As a short-season, annual tropical legume, it can be adopted in environments with low rainfall availability and distribution.

In Brazil, specially in the Northeast region, where malnutrition is a very serious problem, the consumption of groundnut derivatives represents a way to minimize this dietary deficiency, considering the low consumption of protein from animal origin.

The Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA) has researched groundnut crop for more than 20 years aiming to obtain high-yield potential and short-cycle groundnut cultivars, adapted to the semi-arid conditions and improvements in its seed quality, attending to Brazilian *in natura* market demands (low oil content, 3–4 seeds pod^{-1} and red testa color seeds). Recently, confectionery market has increased in Brazil occupying 30% groundnut market. To cater to this demand, EMBRAPA released in 2005 BRS Havana, an early-maturing, tan-testa color and drought-tolerant bunch type cultivar, recommended for confectionery market segments.

Table 1. Agronomical traits of groundnut cultivar BRS Havana.

Traits	Description
Pod beak, constriction and reticulation	Slight
Seeds pod^{-1}	3–4
Flowering (days after plant emergence)	23
Maturity (days after plant emergence)	90
Pods plant^{-1}	35–55
"Pops" (%)	<10
100-seed mass (g)	44–48
Pod yield (t ha^{-1}) (rainy season)	1.9
Shelling outturn (%)	70–72
Oil (%)	43
Protein (%)	28
Oleic acid/linoleic acid ratio	1

Origin and development

BRS Havana is a Valencia bunch type derived from CNPA 75 AM, a Brazilian accession belonging to Germplasm Collection of EMBRAPA and originated from Southeast region in Brazil. This accession was submitted to several selection cycles to shorten cycle (earliness), low oil content and adaptation to semi-arid environmental conditions. The breeding process lasted four years and was carried out in semi-arid region in five northeastern states.

Agronomic performance

In 30 yield trials, where evaluation was done under different ecological conditions in Northeast region, including nine breeding lines and two control cultivars, BR 1 (high yield) and BRS 151 L7 (early maturing), BRS Havana showed high pod yield and tolerance to drought. In rainy season, the pod yield was 1.9 t ha^{-1} and shelling outturn was about 71% (Table 1). BRS Havana has medium seed with 3–4 seeds pod^{-1} and is early maturing.

Nutritional aspect

BRS Havana has tan testa color and is the lowest in crude oil (43%) among other Brazilian cultivars. The seed is composed mainly of linoleic acid (L) and oleic acid (O), which together make up 88% of the total unsaturated fatty acids. The O/L ratio is 1. BRS Havana contains 28% protein.

Pathology

Collar Rot of Groundnut Caused by *Lasiodiplodia theobromae* in North Vietnam

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Collar rot of groundnut (*Arachis hypogaea*), caused by *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl. (syn *Botryodiplodia theobromae* Pat., *Diplodia natalensis* Pole-Evans and *Diplodia gossypina* Cooke), the anamorph of *Botryosphaeria rhodina* (Berk. & M.A. Curtis) Arx, was first recorded in the early part of the 20th century by Miller and Harvey (1932). In USA, *L. theobromae* caused severe damage in North Carolina in 1947 (McGuire and Cooper 1965) and some other sites. After these instances, there were no further reports of collar rot in USA until 1998 when the disease caused severe losses on groundnut in Virginia (Phipps and Porter 1998). *Lasiodiplodia theobromae* has now been isolated from stems, shells and seeds of groundnut from a number of countries including Australia (Bell et al. 2003), Chad (Sougnabe and Foko 2003), Egypt (El Habbaa et al. 2002), Gabon (Ndzoumba et al. 1990), India (Ramakrishna and Kolte 1984, Rao and Pande 1992), Indonesia (Dharmaputra and Retnowati 1996), Ivory Coast (Savary 1987) and Nigeria (Osuinde and Daibo 1999).

In Vietnam, collar rot was first reported on groundnut by Dan et al. (2000) and was especially severe in spring 2003, when the disease was found on more than 20% of plants at Dong Anh, Hanoi. Instances of this disease seem to be increasing especially in areas that have sandy soil and two crops of groundnut during one season. In this article, we present a description of the pathogen, the symptoms that it causes on groundnut in Vietnam and media for its culture.

Materials and methods

Seedlings and mature plants of groundnut were collected from fields at Tuliem and Dong Anh, Hanoi in 2002 and were incubated in a humid chamber for 3–8 days at 28°C. At the end of the season seeds were also collected, sterilized in 1% NaHClO for 1 min and rinsed with sterilized distilled water. The seeds were then placed on moistened filter paper in petri dishes and incubated under 12-h light-dark cycle at 26±2°C for 3–10 days. *Lasiodiplodia theobromae* on infected plants and seeds was identified by examination of spore-producing structures.

Isolate #77 obtained from groundnut stems collected from Tuliem, Hanoi in 2002 was used to determine mycelial growth on four different media: potato dextrose agar (PDA), Czapek Dox agar (CZA), carrot agar (CA) and white bean agar (WBA). These media were prepared according to the methods described by Dhingara and Sinclair (1995). Discs of 5-mm diameter from 2-day-old

Figure 1. A young groundnut plant infected by *Lasiodiplodia theobromae*.

mycelium of isolate #77 cultured on PDA at 30°C in the dark were placed on each medium and the plates incubated at 28°C for 3 days. Colony diameter was measured everyday for 3 days. There were 5 replicates per treatment.

After autoclaving, aliquots of PDA were adjusted to pH 4.0–7.5 using 0.1M HCl or 0.1M NaOH. These media were inoculated with 5-mm diameter discs of mycelium of *L. theobromae* #77 as described above. Mycelial growth was assessed 2 days after incubation at 28°C. There were 3 replicates per treatment.

Analyses of variance were performed using SAS statistical analysis software (SAS Institute Inc., Cary, North Carolina, USA) or STATISTICA software release 6.0 (StatSoft Inc., Tulsa, Oklahoma, USA, 2001). Treatment means were compared by Tukey's Honest Significant Difference (HSD) test at the 5% significance level.

Results and discussion

Although collar rot was first identified by Miller and Harvey in 1932, there have been few reports of this disease until relatively recently. Only one previous observation of collar rot has been made in Vietnam (Dan et al. 2000); however, the authors did not describe the symptoms. We have isolated *L. theobromae* from stems, seeds and necrotic tissues of infected groundnut and the symptoms were similar to those described by McGuire and Cooper (1965) and Subrahmanyam et al. (1992).

In Vietnam, infection with *L. theobromae* caused pre- and post-emergence damping-off or wilting of seedlings (Fig. 1). The leaflets and stems remained green until the seedlings died. Many black pycnidia were found on the collar of the seedlings at soil level. On mature plants, infection occurred on the collar region of the plant. The first symptom observed was chlorosis on leaflets on lateral branches followed by wilting and dehydration of single or several branches or the whole plant within a few days. Many black pycnidia were produced at the collar near soil surface and on stems, petioles and other necrotic tissues (Fig. 2). Infected seeds were covered with white to dark gray mycelium and caused soft rot. Black pycnidia were produced 3–8 days after incubation at 28°C.

Lasiodiplodia theobromae produced white, gray or black mycelium on PDA. On plant tissues, the pathogen produced black, nearly round pycnidia consisting of either single or multiple chambers. Single-chambered pycnidia ranged from 160 to 260 mm in diameter. The pycnidia and pycnidiospores from the isolate of *L. theobromae* used in this study were similar to the descriptions of Roger (1953), McGuire and Cooper (1965), Punithalingam (1976) and Phipps and Porter (1998). Immature conidia were single-celled and hyaline. Mature conidia were black, 2-celled, thick walled and elliptical in shape measuring 10–16 µm × 17–28 µm. This size is within the range reported by Phipps and Porter (1998) (10–18 µm × 17–34 µm), Roger (1953) (11–15 µm × 20–30 µm) and Punithalingam (1976) (10–15 µm × 18–30 µm).

Some authors studied various features of the culture of *L. theobromae* isolated from yam (*Dioscorea* sp), pineapple (*Ananas comosus*) and citrus (*Citrus* sp). However, there are no reports on the nutritional requirements of *L. theobromae* isolated from groundnut. In our study, *L. theobromae* grew well at pH 4 to 7 (Fig. 3); outside this range, growth was reduced. The mycelial growth of *L. theobromae* differed significantly ($P < 0.05$) on the four media tested. Growth was greatest on CZA and PDA, followed by WBA and CA resulting in colony

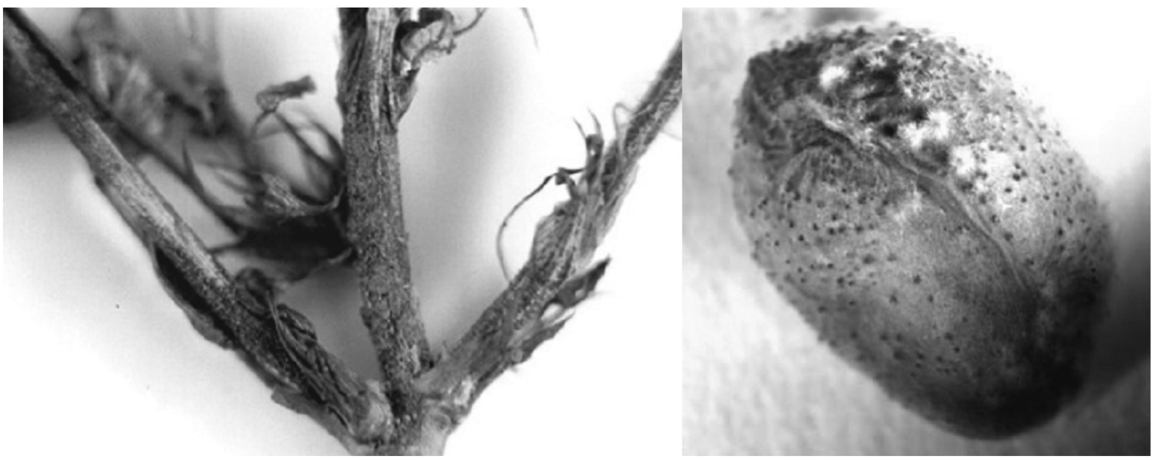

Figure 2. Black pycnidia of *Lasiodiplodia theobromae* produced on collar region of plant (left) and on seed (right) of groundnut.

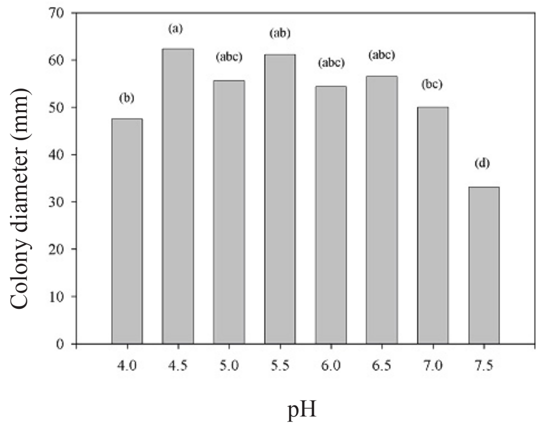

Figure 3. Mycelial growth of *Lasiodiplodia theobromae* on potato dextrose agar adjusted to different pH values. (Note: Means with the same letter are not significantly different at $P = 0.05$ according to Tukey's HSD test.)

diameter of 86, 81, 57.8 and 49.2 mm, respectively, after 3 days. On all media, colonies were lighter when young, and darker when old with the color changing from grayish to dark gray to black. However, further work is required to optimize the conditions for spore production as significant interactions occur among temperature, nutrition and irradiation in terms of both number of spores produced and the virulence on their host plant (Ghajar et al., in press).

Collar rot may occur more widely in Vietnam but may not be recognized clearly as some symptoms are similar to those caused by *Aspergillus niger*. Therefore, further investigations are necessary to help build a comprehensive picture of *L. theobromae* in Vietnam. Given that *L. theobromae* is a weak pathogen, work will be needed to determine why it is becoming more prevalent and to propose suitable methods for its control.

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Entomology

White Grub Species Attacking Groundnut in the Saurashtra Region in Gujarat, India

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Groundnut (*Arachis hypogaea*) is extensively grown in the Saurashtra region of Gujarat state in India. Since 2003, white grub infestation has been frequently encountered in farmers' fields in the southern part of the Saurashtra region. The white grub damage varies with soil type. The lighter soils favor more activity of the pest. In heavily infested fields, 80% plant damage and 50% pod damage by white grubs, particularly *Apogonia rauca*, have been observed. An intensive survey and collection of white grubs was carried out during the rainy season in 2005 in the problematic areas of Visavadar taluka (Pindakhay, Sanosara, Kalsari and Jaliya villages) and Keshod taluka (Sergadh and Anida villages) of South Saurashtra. The grubs and adults were collected in August 2005 from the soil and also adults from host trees such as neem (*Azadirachta indica*), and *ber* (*Zizyphus* spp) and *babul* (*Acacia* spp), growing near the fields. The collected grubs were reared in the laboratory until adult emergence. Fourteen species of white grubs were identified in groundnut fields (Table 1).

Among these, *Holotrichia consanguinea* is a well known soil pest of groundnut. However, in our study, *A. rauca* was found predominant. The proportion of various white grub species population was: 80% *A. rauca*, 12% *H. consanguinea* and the remaining 8% all the other species. Some observations on biology and ecology of *A. rauca* were made. Its huge adult population was attracted to the host trees, particularly *babul* and was observed feeding upon them during early to midnight. Food preference of *babul* was confirmed in laboratory also. They were also attracted to light. As many as six grubs were seen near the plant root zone. They did not cut the root but fed on the nodules, rootlets and immature pods (Fig. 1). The adults also fed on the leaves of groundnut. The infested plants did not die but remained stunted with weak growth. Thus the feeding habit of *A. rauca* apparently differed from the feeding habit of *H. consanguinea*. The full grown *A. rauca* grub measured 18 to 20 mm in length and 4 to 9 mm in width. The grub period lasted for 60 to 75 days. It pupated in earthen cocoon. The pupal stage lasted for 7 to 10 days. The freshly emerged beetle was reddish and then turned blackish the next day. It measured 10 mm in length and 5 mm in width (Fig. 2). It might have 2 to 3 overlapping generations during the groundnut season.

The infestation of *A. rauca* was noticed throughout the groundnut season (July to October). Severely infested fields failed to yield the healthy pods. Yadav (1987) listed predominant white grub species recorded in different parts of India whereas Nandagopal and Prasad (2004) compiled the world list of white grub species attacking groundnut. All the white grub species recorded in our study have previously been reported damaging groundnut except *Schizonycha ruficollis*, *Phyllognathus* sp and *Adoretus bicolor*. The investigation on seasonal activity and habitats of *A. rauca* and its management in groundnut has been initiated.

Acknowledgment. The authors are grateful to TM Mustak Ali, Principal Investigator, AINP on white grubs and other soil arthropoda, University of Agricultural

Figure 1. White grub damage in groundnut: (a) damaged plants; (b) healthy plants; (c) damaged pods; and (d) healthy pods.

Table 1. White grub species recorded on groundnut in Saurashtra region in Gujarat, India.

White grub species	Coleopteran family
Phyllognathus sp	Dynastinae
Apogonia rauca Fabr.	Melolonthinae
Holotrichia consanguinea Blanch.	Melolonthinae
Holotrichia fissa Br.	Melolonthinae
Holotrichia serrata Hope.	Melolonthinae
Maladera sp	Melolonthinae
Schizonycha ruficollis F.	Melolonthinae
Adoretus bicolor Br.	Rutelinae
Adoretus deccanus Ohaus	Rutelinae
Adoretus versutus Harold	Rutelinae
Adoretus sp	Rutelinae
Anomala bengalensis Blanch.	Rutelinae
Anomala dorsalis Fabr.	Rutelinae
Anomala varicolor Gyll.	Rutelinae

Figure 2. Different growth stages in white grub.

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Occurrence of White Grubs in Groundnut Crop in Uplands of South Vietnam: A New Report

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Groundnut (*Arachis hypogaea*) is an important crop in South Vietnam covering more than 125,000 ha under different cropping systems. Crop surveys, and the on-farm research organized in Trang Bang, Cuchi, Duc Hoa and Go Dau during the past (until 2000), brought out the importance of the foliage feeding insect pests (*Spodoptera, Helicoverpa*) as economically important in farmers' fields (Ranga Rao 1995). Field visits during the last week of May 2004 and interactions with the farmers in Tra Vinh province, villages around Cau Ngang town revealed the occurrence and importance of white grubs in this region. This soil-inhabiting pest is a menace in this area, which is in the heart of Mekong delta mostly covered by irrigated rice (*Oryza sativa*) cultivation with multiple cropping system.

During field visits, white grub adults were found feeding on nearby trees. Discussions with the farmers of My Thap village (Mai Van Tiep and colleagues) clearly brought out the importance of white grubs in their groundnut crops. According to farmers, these grubs infest crops such as groundnut, sugarcane (*Saccharum officinarum*), cowpea (*Vigna unguiculata*), cassava (*Manihot esculenta*) and maize (*Zea mays*) in uplands. The adults cause foliar damage in orchards particularly mango (*Mangifera indica*), cashew (*Anacardium occidentale*), litchi (*Litchi chinensis*), guava (*Psidium guajava*), etc. Among the various crops, groundnut and sugarcane were most severely affected. Though the adults were active during the nights, search for few hours in nearby mango and cashew orchards during daytime may yield several hundred adults.

Population dynamics of white grubs in Tra Vinh province

Based on the field observations and the farmers' experience, it was concluded that adults emerge soon after the summer rains (April–May) from their pupation sites (soil). The adults feed and mate at their feeding sites (cashew and mango trees). After feeding and mating, the adults return to their ovipositon sites (groundnut or any other upland crops). The young grubs are seen during June–July while weeding the groundnut crop. Generally groundnut is sown in these villages in the last week of May, which coincides with the adult emergence. Since the adult feeding sites are nearby the groundnut crops, it is easy for adults to locate the oviposition sites. After the harvest of May-sown crops, farmers takeup another groundnut crop in October. Thus two groundnut crops are grown in a year in the same field.

The adults are dull brown in color, measure about 25 mm in width and 40 mm in length with white markings on the posterior end of the elytra. The adults are identified as *Lepidiota signata* (Fig. 1). According to the farmers, the grub damage to May-sown groundnut crop was not severe, probably because the crop would be harvested before the grubs reach considerable size to inflict damage. The October-sown crops are affected severely because the crop is sown directly into grub-infested fields and the well-grown grubs kill groundnut plants. Farmers observed grubs until November. Hence it is clear that the grub period extends from June to November (Table 1). However, detailed studies are required to define the developmental biology of this species in this region. According to farmers, total loss due to severe infestation on groundnut was not uncommon.

Table 1. Calendar of events in white grub biology in Tra Vinh province, Vietnam.

Stage of the insect	Month of activity
Adults	May–June
Young grubs	June–July
Well-grown grubs	September–October
Grub developmental period	June–November
Pupae	November–April

Figure 1. *Lepidiota signata* adult.

Though information is available on the importance of white grubs in North Vietnam pertaining to groundnut crop (Tran Huy Tho et al. 2001), the occurrence and the importance of white grubs in South Vietnam was not known. In view of the importance of Mekong delta for agricultural productivity and stability, the information pertaining to this pest is of immense value for sustaining the agricultural productivity in the upland areas of this region.

Control

Generally farmers apply basudin 10H at 10 kg ha^{-1} as basal application in groundnut to manage this pest. Some farmers are also aware that soil application of carbofuran (furadan) granules 3 G at 1 kg ai ha^{-1} controls the pest. However, the farmers are not clear about the efficient management of this pest.

Conclusions

- White grubs occur in upland areas of Mekong delta.
- *Lepidiota signata* causes loss to groundnut crops in Tra Vinh province of South Vietnam.
- Adults emerge in April–May soon after the summer rains.
- White grubs cause severe plant mortality in groundnut crop sown in October than in the crop sown in May.
- Basal application of basudin at the time of sowing gave satisfactory control.
- Several dryland crops such as sugarcane, cassava and maize are also infested by white grubs.
- Studies on the detailed biology, crop loss assessment, taxonomy and potential management strategies of white grub species are of high priority.
- We suggest to have a nation-wide white grub research project for effective control.
- Since the grubs pupate by November, delaying groundnut sowing to December wherever possible can help to overcome this menace.

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Assessment of Integrated Pest Management Modules in Groundnut on Farmers' Fields

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Currently India is facing shortage of edible oils which is being met through large-scale imports. To meet the growing requirement of oil and to ensure nutritional security to the population of over one billion in the country, groundnut (*Arachis hypogaea*) has to play a pivotal role. Groundnut is a principal oilseed crop that suffers severe yield losses due to insect pests and diseases at different stages of crop growth. The defoliating caterpillars *Spodoptera litura*, *Helicoverpa armigera* and *Amsacta albistriga*, groundnut leaf miner (GLM) *Aproaerema modicella*, sucking pest *Aphis craccivora*, jassids and thrips attack the crop and cause economic loss. Early and late leaf spots, rust and blight are serious foliar diseases. Seedling crown rot, collar rot, stem and pod rot, and dry root rot are important soilborne diseases. Bud necrosis disease is one of the serious viral diseases of groundnut. When groundnut is grown in poor soil under inadequate growing condition, the crop becomes highly affected by these pests and diseases. Since groundnut is raised predominantly under rainfed conditions by resource-poor farmers who cannot afford the expensive agrochemicals (Rabindra 2004), intensive use of chemical pesticides as practiced during the era of green revolution is not a sustainable practice.

Though chemical pesticides have played an important role in increasing groundnut production, their indiscriminate use for the control of pests has led to several environmental problems such as development of resistance in pests to pesticides, pesticide residues and the destruction of beneficial parasites and predators of pests. Thus, a holistic, integrated pest management (IPM) program was developed in groundnut based on six years of independent research on entomological, pathological and weed management aspects conducted by the scientists of the National Research Centre for Groundnut (NRCG), Junagadh, Gujarat and All India Coordinated Research Project (AICRP) on groundnut at various centers in India. This IPM technology gave control of major insect pests ranging from 24 to 46% and diseases from 28 to 48% with an average increase in yield by 19% (Ghewande et al. 2002).

Integrated pest management options include disease-free seeds of resistant/tolerant varieties, cultural practices [viz, use of castor (*Ricinus communis*) as a trap crop and intercropping system], usage of pheromones as monitoring tool, biocontrol agents, biopesticides and economic threshold level (ETL)-based chemical pesticides application. The IPM modules for groundnut based on production system can lead to higher crop production and conservation of biotic fauna. In shifting from chemical control to management of pests and diseases, IPM has to play a crucial role (Amerika Singh et al. 2004).

To attain high production level with minimum risk of pesticides contamination and risk of crop failure, this attempt has been made to assess and demonstrate the profitable viable intercropping system of groundnut and soybean (*Glycine max*) followed by utilization of IPM modules in comparison with farmers' practice.

Materials and methods

Field demonstrations were conducted through frontline demonstrations in non-replicated trial on farmers' fields in Jalgaon and Dhule districts of Maharashtra, India for three years in 2003, 2004 and 2005 during rainy season (July–November). Groundnut variety JL 286 (Phule Unap) and soybean variety JS 335 were sown in 0.2 ha area with a spacing of 30 cm × 10 cm. A total of fifteen demonstrations (five in each year) was conducted including one at Oilseeds Research Station, Mahatma Phule Krishi Vidyapeeth (MPKV), Jalgaon Maharashtra.

The sowing was completed in 2nd week of July and the trials were harvested in 2nd week of November in each season. Two rows of castor were sown around the plot as

Table 1. Evaluation of IPM modules on farmers' fields in Maharashtra, India during rainy season 2003–05[1].

Item	IPM plot	Farmers' practice plot
Cultivation		
Date of sowing	2nd week of July	2nd week of July
Seed treatment	*Trichoderma* at 4 g kg^{-1} seed	–
Type of sowing	Hand dibbling	Drilling
Cropping system	Soybean and groundnut intercrop (4:1)	Sole crop (groundnut)
Soil amendment	Castor cake at 500 kg ha^{-1}	–
Trap crop	Castor	–
Pheromone trap	10 traps ha^{-1}	–
Plant protection[2]	5% NSKE at 30 DAS and 50 DAS	Spray of Dimethoate at 0.03% at 35 DAS and Endosulfan at 0.07% at 60 DAS
Pest incidence		
Aphids	1–5 $plant^{-1}$	5–10 $plant^{-1}$
Thrips	15–25% at 30 DAS	20–50% at 30 DAS
Leaf hopper	10–20% at 45 DAS	20–25% at 45 DAS
Spodoptera	10–30% at 60 DAS	35–50% at 60 DAS
Groundnut leaf miner	2–15% at 80 DAS	55–70 % at 80 DAS
Parasites/predators	Lady bird beetle, *Crysoperla*, *Bracon* sp, syrphid fly, parasitization 5–10%	Lady bird beetle, *Crysoperla*, *Bracon* sp, parasitization 5–10%
Disease incidence (one week before harvest)		
Collar rot[3]	2–5%	3–18%
Stem rot	2–7%	5–10%
Rhizoctonia root rot	<1%	1–2%
Bud necrosis	2–5%	5–15%
Early leaf spot	5–20%	10–20%
Late leaf spot	20–30%	30–80%
Rust	2–10%	20–25%
Economics		
Yield (kg ha^{-1})		
Groundnut	1149	1076
Soybean	516	
Gross income (Rs)	28558	20938
Cost of cultivation (Rs)	20213	16226
Net returns (Rs)	8345	4994
Increase in net returns over farmers' practice (%)	42.3	–
Benefit-cost ratio	1.43	1.31

1. Data are means of three years of evaluation on fifteen farmers' fields.
2. NSKE = Neem seed kernel extract; DAS = Days after sowing.
3. At 30 DAS.

trap crop. Basal application of castor cake at 500 kg ha^{-1} and seed treatment with *Trichoderma* spp at 4 g kg^{-1} seed were carried out. Groundnut was intercropped with soybean at 4:1 ratio. Bird perches at 50 ha^{-1} and pheromone traps at 10 ha^{-1} (*Spodolure* and GLM) were fixed in each demonstration plot. Need-based sprays of neem seed kernel extract (NSKE) at 5% and spodo nucleo polyhederosis virus (SNPV) at 1.5×10^{13} ha^{-1} were applied in each demonstration plot.

The demonstrations conducted at different locations were visited frequently and the incidence of pests and diseases was recorded periodically [starting from 30 days after sowing (DAS) to 80 DAS with 15 days interval] in both IPM as well as farmers' practice plots. To protect the groundnut crop from drought, two life saving irrigations were given. Dry pod yield of groundnut and grain yield of soybean were recorded after harvesting the crop. Economics of IPM and farmers' practice plots were worked out.

Results and discussion

The infestation of thrips and leaf hopper was severe at 30 to 45 DAS. The average damage by thrips was 15–25% in IPM plots as against 20–50% in farmers' practice plots (Table 1). The defoliators *Spodoptera* and GLM were observed at 60 and 80 DAS, respectively. The damage was reduced by 5–25% when spraying of NSKE at 5% and SNPV at 1.5×10^{13} ha^{-1} was done in IPM plots. Intercropping of soybean in groundnut reduced the infestation of GLM (2–15%) in IPM plots as compared to farmers' practice plots (55–70%) (Ghewande et al. 1993). Significant differences in natural parasitization were not observed in both the practices. The population of lady bird beetle was meager in plots sprayed with insecticide.

The incidence of soilborne diseases was reduced by 20–50% in IPM plots as compared to farmers' fields. The foliar disease intensity, particularly late leaf spot was up to 30% in IPM plots whereas it was up to 80% in farmers' fields (Table 1).

There was considerable reduction of pest and disease incidence after adoption of IPM modules which realized high net returns of Rs 8345 ha^{-1}. Increase in income of 42.3% over farmers' practice was realized in IPM plots. Higher benefit-cost ratio of 1.43 was found in IPM plots compared to farmers' practice plots (1.31).

Conclusion

On the basis of demonstrations conducted on farmers' fields and analysis of results of three years revealed that the application of various components in IPM modules, viz, basal soil application of castor cake at 500 kg ha^{-1}, groundnut and soybean intercroping (4:1), seed treatment with *Trichoderma* spp at 4 g kg^{-1}, spraying of NSKE at 5% and SNPV 1.5% $\times 10^{13}$ ha^{-1}, 50 ha^{-1} bird perches and 10 ha^{-1} pheromone traps gave high net returns and an increase in income of 42.3% was incurred over farmers' practice.

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Agronomy/Physiology

Companion Cropping of Spring Sugarcane and Summer Groundnut – A New Cropping System for Uttar Pradesh, India

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Among the cash crops grown in Uttar Pradesh, India, sugarcane (*Saccharum officinarum*) occupies a premier place and is grown on 2.1 million ha. It is a long-duration crop grown in widely spaced rows at 90 cm apart during spring season (15 February to March). From March to June, sugarcane planted during spring season attains around 30 cm height and the canopy does not cover the land adequately necessitating frequent weeding. If this period and the wide interrow spacing could be effectively used, not only weed infestation would be reduced but the farmers would get good return from the land early in the season. Earlier workers recommended intercropping of onion (*Allium cepa*), muskmelon (*Cucumis melo*), black gram (*Vigna mungo*), green gram (*Vigna radiata*), okra (*Abelmoschus esculentus*), etc with spring-planted sugarcane. No attempt was made on intercropping of summer groundnut (*Arachis hypogaea*) with spring-planted sugarcane because summer groundnut has been cultivated in Uttar Pradesh only since 2001. In Uttar Pradesh, since 1982 to date the area under rainy season groundnut has declined from 0.3 million ha to 0.09 million ha and total production declined from 0.19 to 0.07 million t during 2004–05 over 1982–83. With the introduction and diffusion of groundnut cultivars ICGV 93468 and Dh 86 for cultivation during summer, the area under groundnut crop has increased from nil in 2001 to 27,500 ha in 2005 and 63,710 ha in 2006. This unprecedented success led to further research on summer groundnut.

An innovative adaptive experiment was planned on sandy loam riverine soils of Central Plain Zone V of Uttar Pradesh to increase the area under summer groundnut through utilization of vacant wider space of sugarcane rows from March to June. The operational area is situated in village Bhadauna of Unnao district between Bithor and Jankikund-Pariyar in the river Ganga catchment area. Sugarcane was planted at 90 cm row spacing after harvest of winter season vegetables on 25 February 2006. After partial completion of cane germination, the summer groundnut was sown on 20 March 2006 at row spacing of 25 cm. Three rows of summer groundnut were sown in between two rows of spring sugarcane and, thus, 100% plant stand of both crops was adjusted. The distance between sugarcane rows and groundnut rows was maintained at 20 cm from both the sides of sugarcane rows for easy intercultural operations. Six genotypes of groundnut, ie, Dh 86, ICGS 1, ICGS 44, ICGV 86590, ICGV 93468 and G 201 were tested in the intercropping system of spring sugarcane and summer groundnut. The recommended package of practices was followed for both the main crop and intercrop. The harvesting of summer groundnut was started 95 days after planting from 23 June 2006 and completed at 100 days after planting on 28 June 2006.

The groundnut cultivars Dh 86 (2.63 t ha^{-1}) and ICV 93468 (2.61 t ha^{-1}) registered significantly higher pod yield in the intercropping system of spring sugarcane and summer groundnut. Cultivar G 201 gave lowest yield of 1.44 t ha^{-1}. Therefore, the order of varietal performance was Dh 86 and ICGV 93468, followed by ICGS 1, ICGS 44, ICGV 86590 and G 201 in companion cropping of spring sugarcane and summer groundnut without any adverse effect of sugarcane on summer groundnut and vice versa (Table 1).

Table 1. Yield of groundnut in spring sugarcane and summer groundnut intercropping system.

Genotype	Pod yield of groundnut (t ha^{-1})	Increase over local check (%)
Dh 86	2.63	82.6
ICGS 1	1.87	29.9
ICGS 44	1.75	21.5
ICGV 86590	1.73	20.1
ICGV 93468	2.61	81.3
G 201 (local check)	1.44	–

An Expert System for Cultivation and Management of Groundnut

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Expert system for crops such as wheat (*Triticum aestivum*), rice (*Oryza sativa*), maize (*Zea mays*), cotton (*Gossypium* spp) and rape (*Brassica napus*) have been developed successfully, but nothing is reported in the literature on the important oilseed crop groundnut (*Arachis hypogaea*). This article reports the development of an expert system for the cultivation and management of groundnut, which can not only improve the crop production but also modernize and standardize it.

Introduction of the system

Principle of the system. The basic design principle of the system is to combine cultivation technique with crop simulation, climate and soil condition. Because groundnut production system depends upon environmental factors and cultivation technique, the development of the system must consider these aspects (Shu-bo Wan 2003). The environmental factors refer to such factors as climate and soil. The technological factors are varieties chosen, sowing date, seed density, fertilizer use, seed treatment, prevention of waterlogging and drought, etc.

Structure and characteristics of the system. This system comprises databases, knowledge bases, simulation models, and data and knowledge acquisition system. It has a wide range of new knowledge and its practicability is strong. It is easy and simple to handle, easy to learn and use and is good at interaction. It includes multimedia and many kinds of accessory systems. This system also possesses edification, transparency and flexibility.

Functions of the system. The system mainly has three functions. First, make decisions on groundnut cultivation and management techniques. After getting the basic information, the system decides how to plant groundnut according to the user's field condition (Fig. 1). Second, dynamically simulate and regulate the growth of groundnut. In this part, the system can dynamically simulate groundnut growth, and also can judge whether there is a need to do some management. Third, retrieve and consult information about groundnut and its cultivation. In this part users will be given any technique or information they want to know about groundnut and its cultivation.

Agronomy management decision module prior to sowing

This module is designed to first consider what aspects are related to the planting process. Secondly, it considers the influence factors of each aspect in the first step, then looks for the relationships between these influence factors, and in the end it solves these aspects according to the influence factors and relationships. Based on this thought, we set up seven sub-modules as follows: ascertaining cultivation method, optimizing fertilizer management, selection of variety, optimizing seed density, optimizing sowing date, optimizing seed treatment and consulation. These seven sub-modules were linked up effectively.

Optimizing landform and management. Choice of cropping system is important in groundnut cultivation to obtain high yields. There is a range of cropping systems in China, eg, spring-sown groundnut, summer-sown groundnut, and wheat and groundnut intercropping system. Planting is done on flat ground or on ridge. In most of the area, plastic mulching is adopted.

Users can follow the landform as required and then choose suitable cropping system and cultivation technique in this module. The system will teach the user these cultivation techniques through text and picture, and will provide guidance for better production.

Optimizing fertilizer management. In this module, the system carries out a method of nutrient balance to confirm the dosage of fertilizer. This method improves fertilizer-use efficiency that contributes to high income. The system considers the contents of soil nutrients, the contents of fertilizer and the dosage of the fertilizer (Zhen-wen Yu and Yong-shan Wan 1995). First, the system judges the soil fertility level according to the contents of soil nutrients, and then gives the objective yield according to the different soil fertility levels. If the user is satisfied with the objective yield, he/she can choose the fertilizer from the chemical fertilizer database, and the system will give the user the quantity of fertilizer to be applied. If the user does not agree with the objective yield, he/she can change it and then choose the fertilizer, then the system will calculate the quantity to be applied.

Selection of variety. For information on varieties, the system operates on the database directly. First, the system searches for useful groundnut varieties in the variety databases according to the user's demand, inserts them in a temporary table and expresses them to the user. To save space, after the user chooses the variety, the system will delete the table. It is easy to write the program codes and improve the efficiency of the system (Ai-hong Tong and Tai-ping Hou 2004).

Optimizing seed density. Confirming seed density should mainly consider three aspects. These are variety characters, soil fertility level and cropping system. First, we give every variety a suitable density according to its characters (Zhen-wen Yu and Yong-shan Wan 1995) and then judge the other two aspects. For example, if the soil fertility level is high, the system will give a lower density compared with the suitable density, and if the soil fertility level is low, the system will give a higher density. Because it is difficult to give an exact number of the density, we let each level of the soil fertility match a coefficient, and we let the coefficient multiply the suitable density and get different density in different soil fertility levels.

Optimizing sowing date. This system confirms the sowing date according to various factors. These factors are period of duration, accumulated temperature, air temperature, ground temperature, previous crop and following crop, soil moisture, planting method, etc. Considering all these factors the proper sowing date is confirmed to ensure that the crop is grown in the most suitable condition. By doing this, one can fully utilize the favorable climatic conditions, avoid the influence of the unfavorable climatic conditions, and get good harvest.

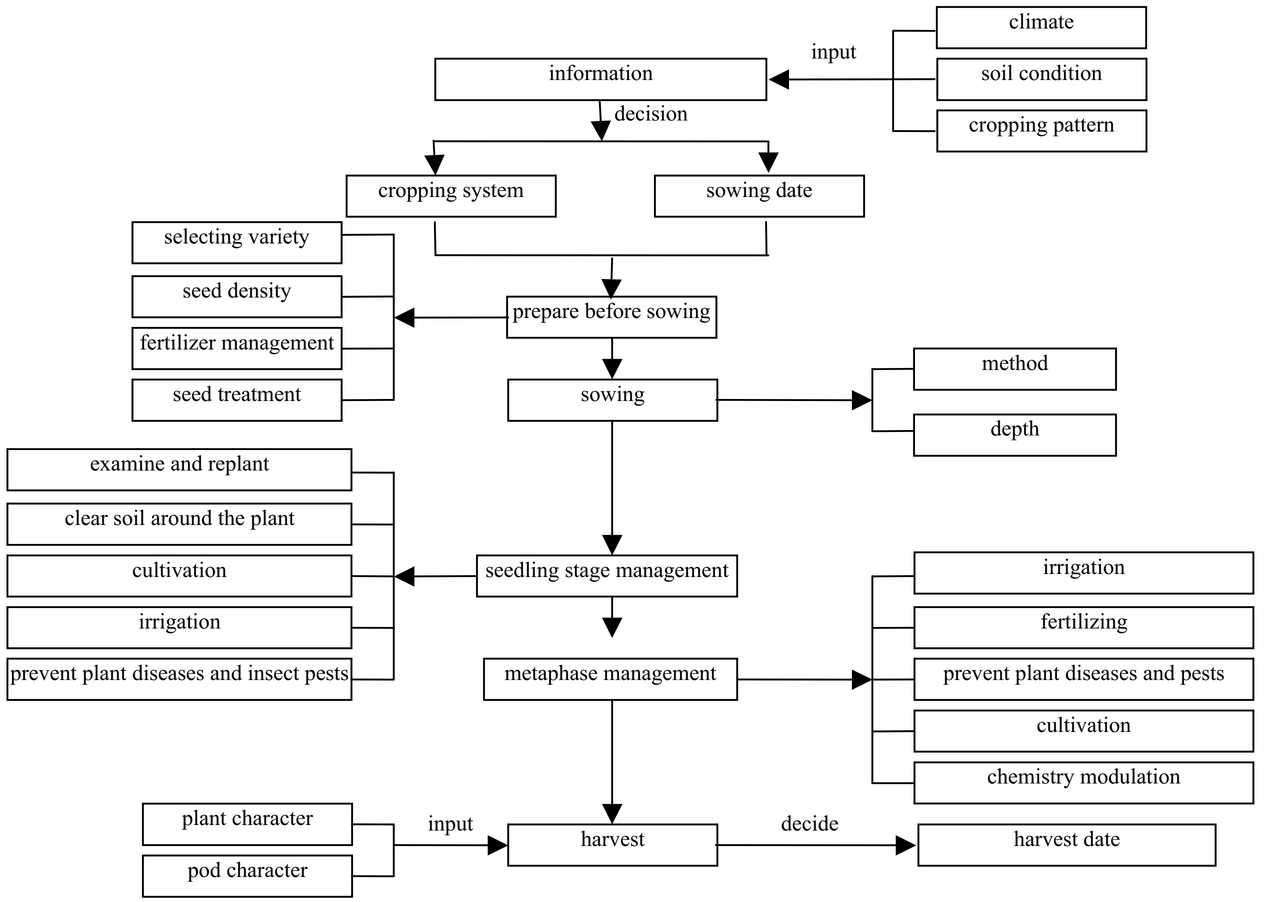

Figure 1. Flow diagram of the decision-making process of the expert system for groundnut cultivation.

Optimizing seed treatment. Seed treatment method is confirmed according to such factors as soil humidity, disease situation and soil nutrient condition. The method of seed treatment, the treatment step, the suitable chemical and the quantity will be given to the user through text, picture, video or kinescope before sowing.

Review of decisions. This module offers the decision scheme of individual event technology to the consultant before sowing. Users get advice about concrete questions when preparing before sowing. In addition, this module also offers information about groundnut variety resource, agriculture chemicals, chemical fertilizers, diseases, pests and weeds (Shu-bo Wan 2003).

Results and discussion

The advice of the system is based on the truthfulness of the user's response to the queries made by the system. The result can be saved in file, which contains record of the whole information across the process. We have now accomplished the program work and will start much more information related to groundnut cultivation, especially some simulation modules about groundnut growth. To make our expert system highly beneficial and acceptable, it will be based on multimedia technique, ie, the possibility of communication by text, pictures and sound. And then we will let it be examined in practice. We hope it will be applied to the production of groundnut widely in the future.

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Utilization

Quality Attributes of Peanut Butter Prepared from Some Indian Groundnut Cultivars

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Peanut (*Arachis hypogaea*), also known as groundnut, is a major oilseed crop of India. However, unlike other oilseeds, groundnut can be consumed directly as food. With the growing awareness among people about the importance of balanced diet, demand for low calorie-high protein foods is increasing as people tend to avoid consumption of high-fat foods lest it should cause obesity and associated health problems.

The dairy butter is almost 100% fat and does not contain any protein while the peanut butter besides 50% fat, contains about 25% protein and all the other nutrients that are naturally present in groundnut. Hence consumption of groundnut in the form of peanut butter is more beneficial on the basis of economic and health aspects. It is already quite popular in USA and other European countries. In India, however, this product is available commercially only in the metropolitan cities. In times to come the demand for peanut butter in India is likely to grow owing to its nutritional value. For expulsion of oil at the oil mills, groundnut shell is added to the seed as a crushing aid. Thus the groundnut protein, which is obtained almost entirely in the form of groundnut cake, is no more useful for human consumption as it contains several extraneous substances, crushed shells, dust particles, insects and microorganisms. However, when groundnuts are processed for preparing peanut butter, no portion, except the red skin, is lost and hence the seeds are utilized rather in a wholesome manner as all the nutrients become available for human consumption. Thus popularization of peanut butter can go a long way in combating the problems of malnutrition. Consumers/vendors would prefer the peanut butter to be easily spread and also have a long shelf life.

However, systematic information about the quality of peanut butter prepared from Indian cultivars is lacking. Therefore, it was of interest to study the quality attributes of peanut butter prepared from some of the Indian groundnut cultivars.

Materials and methods

Seven groundnut cultivars commonly grown in major groundnut producing states of India were selected for the study. The seeds of selected cultivars were obtained from the National Research Centre for Groundnut (NRCG), Junagadh, Gujarat, India. The peanut butter was prepared by following the procedure described by Tressler and Woodroof (1983). The seed lot of 150 g for each sample was spread over a petri dish of 177 cm^2 area, roasted at 130°C for 60 min using laboratory digital electrical oven (sensitivity 1°C). The seeds were cooled with forced air and then split to remove the skin and hearts. The weight of these roasted, blanched and split seeds devoid of hearts was recorded. Grinding was done in two steps. The blanched seeds were ground for 1 min at full speed in a domestic grinder and then the additives salt and sugar were added at the rate of 1% and 4%, respectively, of the weight of sample used for grinding. The mixture was again ground at full speed for 22 min. The butter samples were stored in glass jars with airtight plastic lids.

The butter samples so prepared were presented to a few persons for determining off taste, if any. A quantitative evaluation of organoleptic qualities by presenting the butter to panelists was not done owing to highly subjective nature of method.

Textural quality measurement. Textural quality was measured using Texture Analyser of Stable Micro Systems, UK (Model: TA-XT2i). The conical Perspex probe (code: P/45C) of 45° was penetrated into the sample by 14 mm with the pre-test, test and post-test speed as 2, 1 and 10 mm s^{-1}, respectively. The peanut butter samples were taken in a glass beaker (5.5 cm depth × 2.5 cm diameter) and placed atop the load cell. The crosshead was set to move downward and penetrate the peanut butter sample for a distance of 14 mm. At the point of maximum penetration the crosshead direction of travel was automatically reversed and the probe was withdrawn at 10 mm s^{-1} speed. Results were expressed as maximum force (g) required for cone penetration and withdrawal from peanut butter column. The adhesiveness measurements were selected according to the definition established

(Friedman, Whitney and Szezesniak 1963). The spreadability and firmness of butter was recorded in terms of maximum adhesive force required for cone penetration and withdrawal with the distance traveled by the probe. The probe used, represented the palate and the force required to remove the material from the probe complies with the definition of adhesiveness.

Proximate determination. For determination of moisture content, butter samples (10 g) were dried at 110°C for 10 hours in a hot air electrical oven. The oil and its fatty acid composition along with protein content of the butter prepared from selected groundnut cultivars were determined following the standard procedures. The oil content was determined gravimetrically by extracting the meal (10 g) with n-hexane in a Soxhlet extraction assembly for over 6 hours. The fatty acid composition of the oil was determined after converting the constituent fatty acids into their methyl esters, which were then separated on Nucon Gas Chromatograph (AIMIL, India) model 5700, fitted with a DEGS (polydiethylene glycol succinate) (2 mm internal diameter, 180 cm length) column. The temperature of the column was kept at 195°C while that of injection and flame ionization detector ports was kept at 250°C. The flow rates of carrier (nitrogen), fuel (hydrogen) and air were 40, 30 and 300 ml min^{-1}, respectively. The fatty acids were identified by comparison of their retention time with those of authentic samples. The area of a peak as fraction of the total area under all the peaks was expressed as per cent. The stability index (SI) was defined as the ratio of oleic acid (O) to linoleic acid (L) (Ahmed and Young 1982). The nitrogen content was determined by micro-Kjeldahl method using a Kjeltech auto nitrogen analyzer and the protein content was obtained by multiplying the nitrogen content of meal with a factor of 5.46 (St. Angelo and Mann 1973).

Color. The color code was assigned to butter preparations by visually comparing the color of butter preparation with those given in Methuen Handbook of Colour (Kornerup and Wanscher 1978).

Results and discussion

The moisture content of butter prepared from various cultivars was less than 1%. The butter of cultivar DRG 12 had the lowest moisture (0.54%) while that of cultivar JL 24 and BAU 13 had the maximum moisture content (0.74%).

No cultivar was found to produce any off flavor. Thus all the butter preparations were acceptable from the taste point of view.

As shown in Table 1, the butter prepared from GG 6 recorded the lowest adhesive force for cone penetration and withdrawal and this implied the ease in spreadability and firmness. This cultivar was followed by the butter prepared from ICGV 37 and Somnath. The maximum adhesive force for cone penetration and withdrawal was required for the peanut butter prepared from the seeds of BAU 13 followed by the butter prepared from DRG 12, JL 24 and ICGV 86325. The results revealed that among

Table 1. Quality attributes of peanut butter prepared from some Indian groundnut cultivars.

		Maximum adhesive force (dyne)					Unsaturated fatty acids		
Cultivar	Color[1]	Penetration	Withdrawal	Moisture ($g\ kg^{-1}$)	Oil ($g\ kg^{-1}$)	Protein ($g\ kg^{-1}$)	Oleic acid (O) (%)	Linoleic acid (L) (%)	O/L ratio
ICGV 86325	AL	82.0	52.4	5.6	456	195	10.6	8.1	1.3
Somnath	GO	73.2	44.8	5.6	490	211	6.2	3.1	2.0
DRG 12	GO	94.3	56.6	5.4	494	197	4.6	3.4	1.4
GG 6	AY	63.3	38.9	6.8	511	232	4.1	3.1	1.3
JL 24	RG	90.8	81.2	7.4	504	242	10.0	7.9	1.3
ICGV 37	RG	66.9	45.6	5.8	501	216	16.0	11.7	1.4
BAU 13	AL	108.4	81.7	7.4	494	224	12.5	3.7	3.4
Maximum		108.4	81.7	7.4	511	242	16.0	11.7	3.4
Minimum		63.3	38.9	5.4	456	195	4.1	3.1	1.3
Mean		82.7	57.3	6.3	493	217	9.1	5.9	1.6

1. AL = Autumn leaf; GO = Grayish orange; AY = Apricot yellow; RG = Reddish golden.

the selected groundnut cultivars GG 6 is the most appropriate followed by ICGV 37 and Somnath for the production of peanut butter. Thus it appears that firmness/spreading quality of peanut butter and oil content of the groundnut seed are closely related.

However, considering the peanut butter as an item of table-food both the nutritional quality as well as textural quality play an important role in the overall acceptability of the butter. The total oil and protein contents are important from nutritional point of view. The oil content of butter prepared from different groundnut cultivars varied between 45.6 and 51.1%. The lowest oil content was found in ICGV 86325 and highest in GG 6. Similarly, the protein content varied from 19.5 to 24.2%. Also, the shelf life of butter is determined by the SI, which is O/L ratio. The butter of BAU 13 cultivar exhibited the highest SI followed by cultivar Somnath. This implied that the butter prepared from cultivar BAU 13 had the highest shelf life followed by that from cultivar Somnath. The butter prepared from other cultivars recorded SI value less than 2.0 and thereby implying relatively a poor shelf life of the peanut butter.

Conclusion

The data indicated that the oil content in groundnut seed influenced the textural quality of peanut butter. Undesirable textural qualities might be due to low oil content. Therefore, on the basis of a combined textural and proximate evaluation, it could be recommended that amongst the cultivars evaluated, cultivar Somnath was the best suited for producing groundnut butter. While comparing the color attribute of the butter prepared from the selected cultivars, it was observed that those prepared from Somnath and DRG 12 reflected the most preferable grayish orange color. However, the differences among the colors of butter prepared from various cultivars evaluated were not significant.

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Publications

Publications from ICRISAT

Pande S, Upadhyaya HD, Rao JN, Lakshmi Reddy P and **Parthasarathy Rao P.** 2005. Promotion of integrated disease management of ICGV 91114, a dual-purpose, early maturing groundnut variety for rainfed areas. Information Bulletin no. 68. Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. ISBN No. 92-9066-480-0. Order code IBE 068. 28 pp.

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop that provides high quality oil for human consumption and fodder for ruminants. Its yields are very low in India due to several diseases as well as the non-availability of improved cultivars and their production technologies. Of these diseases, two foliar diseases, late leaf spot (*Phaeoisariopsis personata*) and rust (*Puccinia arachidicola*) are particularly destructive and together cause more than 70% of the losses in yield and quality. To add to this, about 80% of the area under groundnut in the Deccan Plateau is covered by the traditional cultivar TMV 2, which is highly susceptible to these foliar diseases. Considering various factors that limit groundnut production in the Deccan Plateau, scientists at ICRISAT emerged with an early-maturing, dual purpose cultivar, ICGV 91114 that was highly responsive to integrated disease management (IDM). The IDM package succeeded in consistently obtaining higher pod and fodder yields under farm conditions. The IDM technology comprised the improved early-maturing cultivar ICGV 91114, fungicide seed treatment with bavistin + thiram at 2.5 g kg^{-1} seed, and one application of fungicide kavach at 65–70 days after sowing. The evaluation and promotion of ICGV 91114 and its IDM technology was carried out in three phases (1995–2004) in collaboration with ANGRAU, INGOs and NGOs. In all three phases, ICGV 91114 performed well, exhibiting lower severities of foliar diseases and higher pod and fodder yields. Moreover, in vitro tests at ICRISAT-Patancheru showed that the fodder from IDM-treated plots of ICGV 91114 had higher digestibility than TMV 2. During this period, the cultivar and its IDM technology spread to several villages in Andhra Pradesh, Karnataka and Tamil Nadu states in India. Through all the years of testing, ICGV 91114 gave higher returns than the local cultivar. Participating farmers in all three states felt the new cultivar gave them higher quantities of pods and haulms as well as higher quality fodder that in turn translated to higher milk yields. The cultivar ICGV 91114, therefore, has rapidly become the favorite of several participating and non-participating farmers in the three states. Thanks to these advantages, ICGV 91114 and its associate IDM technology, which began with 11 farmers in 1995, spread to nearly 5000 farmers in 2002 and about 10000 farmers by 2005.

Pande S, Sreenivas B, Parthasarthy Rao P, Narayana Rao J and **Lakshmi Reddy P.** 2006. Farmers' participatory management of diseases for higher yield and nutritive value of crop residues of groundnut, Deccan Plateau, India. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. ISBN 92-9066-485-1. Order code CPE 157. 168 pp.

Nigam SN, Aruna R, Giri DY, Ranga Rao GV and **Reddy AGS.** 2006. Obtaining sustainable higher groundnut yields: Principles and practices of cultivation. Information Bulletin no. 71. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. ISBN 92-9066-484-3. Order code IBE 071. 48 pp.

With a few exceptions, groundnut productivity in most developing countries continues to be low. Although many high-yielding varieties have been released, their full potential is not realized in the absence of appropriate crop management practices. General agronomic recommendations are broad based and do not help much because of large variation in soil characteristics and nutrient status and other agroecological factors across groundnut fields. This bulletin discusses the underlying principles of various aspects of crop cultivation to encourage farmers to develop their own package of cultivation practices suitable to their fields and needs. It also provides information on groundnut cultivation under polythene mulch, which has resulted in 20–50% increase in groundnut productivity in China and on a seed production method to build self-reliance in the seed of improved groundnut varieties.

SATSource Listing

The following 2005 list of publications have been generated from ICRISAT's electronic bibliographic database SATSource – online database of the Semi-Arid Tropical Crops. Copies of entries can be obtained by writing to:

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Groundnut publications

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Information for IAN 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.

IAN welcomes short contributions (not exceeding 1000 words) about matters of interest to its readers. **A few high quality full length papers may be accepted**.

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 four double-spaced pages). In exceptional cases, longer articles may be accepted.
- 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 (eg, 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.
- Black-and-white photographs and drawings (prepared in dense black ink on a white card or a heavy-duty tracing paper) are welcome – photocopies, color photographs, and 35-mm slides are not. Please send disk-files (with all the data) whenever you submit computer-generated illustrations.
- Keep the list of references short – not more than five references, all of which should have been seen in the original by the author. Provide all the details including author/s, year, title of the article, full title of the journal, volume, issue and page numbers (for journal articles), and place of publication and publishers (for books and conference proceedings) for every reference. Cite references as in this issue.
- Express all the quantities only in SI units.
- Spell out in full every acronym you use.
- Give the correct Latin name of every crop, pest or pathogen at the first mention.
- Type the entire text in double spacing. Please send a file, which should match the printout, on a double-sided/high density IBM-compatible disk using **Microsoft Applications**.
- **Include the full address with telephone, fax and e-mail of all authors.**

The Editor will carefully consider all submitted contributions and will include in the Newsletter those that are of acceptable scientific standard and conform to requirements. The language of the Newsletter is English, but where possible, articles submitted in other languages will be translated. Authors should closely follow the style of the reports in this issue. Contributions that deviate markedly from this style will be returned for revision, and could miss the publication date. Communications will be edited to preserve a uniform style throughout the Newsletter. This may shorten some contributions, but particular care will be taken to ensure that the editing will not change the meaning and scientific content of the article.

Contributions should be sent before 31 August to:

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About ICRISAT®

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a nonprofit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).

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