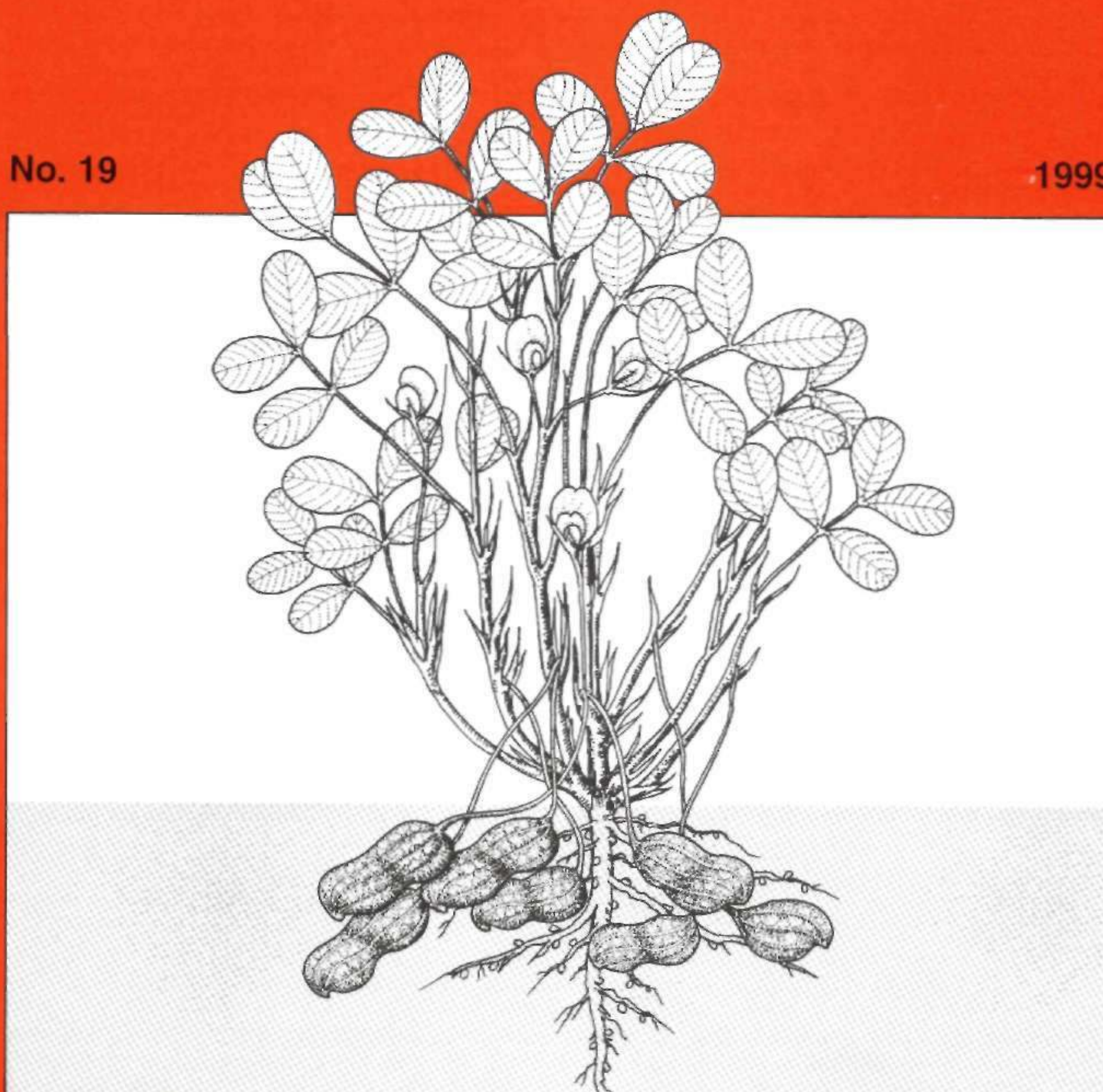
International *Arachis* Newsletter

No. 19

1999



International Arachis Newsletter

Co-publishers

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

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

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, socio-economic forces, post-harvest 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 10 universities in the USA linked to 14 host countries in the developing world. Both host countries and the USA are expected to benefit from the activities of Peanut CRSP. Peanut CRSP actively collaborates with other organizations with interest in advancing development through the application of science and technology.

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, pails of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

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

ICRISAT was established in 1972. It is one of 18 nonprofit research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CG1AR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the World Bank, and the United Nations Development Programme (UNDP).

Contents

News and Views

Research Reports

Genetics and Plant Breeding

Pathology

Entomology

Production and Management

Food Quality

Groundnut in the Caucasus and Central Asia

Publications

News and Views

From the Editor

The sudden demise of Dr O D Smith on 4 March 1999, in Bryan, Texas, saddened the groundnut community around the world. Those who knew or came in contact with Olin will always remember him as a thorough gentleman and a highly competent groundnut breeder. His students will miss him most. The IAN fraternity sends its condolences to the Smith family.

Compared with earlier issues, the publication of this issue of IAN has been advanced. In future also, we want to stick to a July/August publication schedule. The Editor's pleas seeking contribution articles have failed to motivate our friends in North America. The Editor would like to renew his pleas and hopes next time around they will have some effect.

In April 1999 we bade farewell to Ms Sue D Hainsworth, Manager, Editorial Unit of Partnerships and Information Management Division of ICRISAT. Sue was the moving force behind all the Newsletters published by ICRISAT. In addition to providing language editorial input when needed, she coordinated the preparation and publication of IAN and always had a soft spot for this Newsletter. Many thanks, Sue, for all that you did for the groundnut community.

Readers will be happy to note some contributions from the Caucasus and Central Asia to this issue of IAN. We welcome scientists from this region to our global groundnut family.

I would like to acknowledge the contribution of O Ajayi, R Bandyopadhyay, F R Bidinger, S Chandra, S L Dwivedi, C Johansen, N Kameswara Rao, J V D K Kumar Rao, V Mahalakshmi, N Mallikarjuna, E M Minja, R C Nageswara Rao, S Pande, A Ramakrishna, G V Ranga Rao, D V R Reddy, L J Reddy, T J Rego, O P Rupela, N P Saxena, H C Sharma, S B Sharma, P Subrahmanyam, R P Thakur, and H D Upadhyaya, as reviewers of the contributions to this issue of IAN, and the Library and Documentation Services at ICRISAT for compiling the SATCRIS listing and verifying the references cited in this issue.

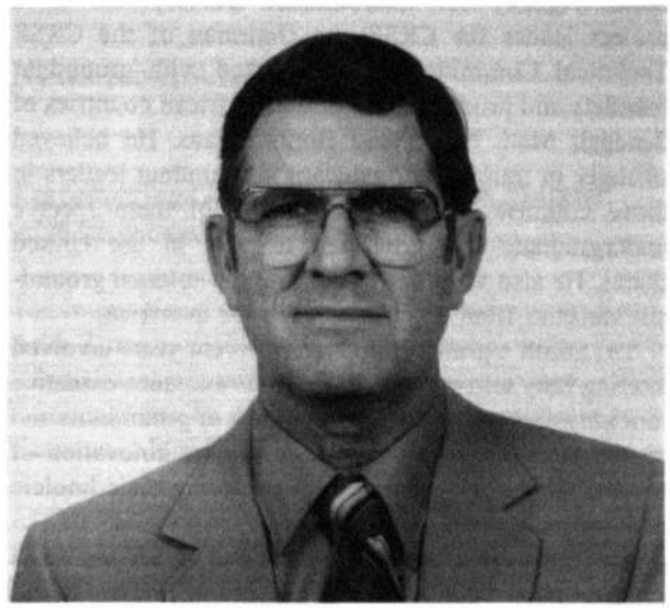
I look forward to your contributions to the 2000 issue of IAN.

S N Nigam

About Scientists

Vale Olin D Smith

Dr Olin D Smith, Professor of Soil and Crop Science at Texas A&M University, died suddenly on 4 March 1999, in Bryan, Texas.



Dr Smith was born on December 15,1931, in Tonkawa, Oklahoma. He earned a bachelor's degree from Oklahoma State University in 1954. Prior to receiving a master's degree from Oklahoma State in 1961, Dr Smith served as superintendent of the Wheatland Conservation Research Station for the Oklahoma Agricultural Experiment Station and was assistant manager of the Oklahoma Crop Improvement Association from 1952 to 1965. In 1969, Dr Smith earned a doctoral degree from the University of Minnesota.

Dr Smith began his career at Texas A&M University in 1970 as an assistant professor in the Department of Soil and Crop Science and was promoted to full professor in 1982. At Texas A&M, Dr Smith's appointment involved teaching and research in groundnut breeding.

Over three decades, he and coworkers released several varieties of Spanish groundnuts and established new benchmarks for yield performance and adaptation including Toalson, which provided good pod rot resistance.

Tamspan 90 possessed excellent resistance to sclerotinia blight, caused by *Sclerotinia minor.* With coworkers, Dr Smith also bred and released four runner varieties that were well adapted to the dry growing conditions of the southwestern USA. Tamrun 96 and Tamrun 98 provided growers with high-yielding varieties, disease resistance, and market appeal.

Dr Smith cooperated with scientists in breeding host-plant resistance and quality enhancement. His research also played a significant role in the development of tomato spotted wilt resistance, drought tolerance, and early maturity.

For 15 years, Dr Smith collaborated with the United States Agency for International Development as a project leader for CRSP. As chairman of the CRSP Technical Committee, Smith worked with groundnut breeders and producers in the West African countries of Senegal, Mali, Niger, and Burkina-Faso. He believed strongly in training and educating groundnut leaders in those countries and helped several of them receive undergraduate and advanced degrees in the United States. He also adapted several drought-tolerant groundnut varieties from his program for use in Africa.

Dr. Smith's primary research in recent years involved altering fatty acid ratios in groundnuts to reduce oxidative rancidity and to improve the shelf life of groundnuts and by-products. He was responsible for the innovation of several laboratory techniques in exploring oleic/linoleic acid ratios.

Dr Smith was a member of ASA and CSSA. He was a fellow, past president, and recipient of the Coyt T. Wilson Award for distinguished service in the American Peanut Research and Education Society. He served on most of the committees in APRES at one time or another. He was highly instrumental in the initiation of the journal, Peanut Science, and played key roles in three books produced by the Society. He received the American Peanut Council's Research and Education Award and was a member of the Council for Agricultural Science and Technology.

Dr Smith is survived by his wife, Thelma, three children, and six grandchildren. Expressions of condolence may be sent to the Soil and Crop Science Department, Texas A & M University, College Station, TX 77843-2474, USA, addressed to Family of Dr Olin D Smith.

Award

Associate Professor S L Brown and Professor J W Todd, of the Department of Entomology, and Associate Professor A K Culbreath and Assistant Professor H R Pappu, of the Department of Plant Pathology, University of Georgia, Coastal Plain Experiment Station, Tifton, GA, were jointly awarded the American Peanut Council's Peanut Research and Education Award for their work on management of tomato spotted wilt virus in groundnut. The research team developed a risk assessment index to advise growers of the factors that influence the relative impact of spotted wilt disease in groundnut. The award, consisting of a plaque and a cash prize, was given at the USA groundnut Congress held in Hilton Head, SC, in July 1998.

Peanut CRSP News and Renewal Plans

The Peanut CRSP, along with many of the groundnut fraternity, mourn the untimely death of Dr Olin Smith of Texas A & M University, who was a Principal Investigator in the CRSP since the inception of the program. All those who knew Olin were greatly saddened by the news. A tribute to Dr Olin Smith is a feature of this issue of the IAN.

Over the past year the Peanut Collaborative Research Support Program (CRSP) has made good progress towards the realization of the goals in each of the present priority thrust areas. As with all programs parts of it are progressing faster than anticipated while in other areas problems are resulting in a slower than desired progress. Our program continues to address five constraint areas for the groundnut sector. These are food safety (mainly aflatoxin), production efficiency, socioeconomic constraints, postharvest marketing and utilization, and information and technology transfer.

There has been a special effort on the part of the Program Office to deploy new technologies to make information on groundnuts more widely available. Our web site now includes all our reports and progress. It also is used by the scientists to provide workplans, and required reports, and will be used to collect proposals for research in the next phase of the program. The External Evaluation Panel (EEP) has made its first report on progress and we are planning now for the program to have the in-depth review needed prior to developing the renewal documentation. It is important for the continuation of the Peanut CRSP that the EEP supports a continuation of the program, based on the good science and management of the Peanut CRSP projects.

The Peanut CRSP is starting the process of renewing our grant. This process will follow the following steps.

Identification of groundnut research opportunities and priorities. We will review our program and priorities to help decide on the projects that are proposed, and selected for funding in the next phase.

To this end we seek opinions from stakeholders as to the nature of the program that would be most interesting and important over the next five years (2001-2006). People interested in providing us with feedback should send us their opinions about research needs and opportunities, their priorities, and logic. Soon we will make a form available on the internet that will collect these data. For those of you without internet access we ask that you write us a letter suggesting changes in our program, or new types of research that you believe important for the groundnut sector in your country.

Definition of program goals for the next phase. The input from various stakeholders will be considered and used in conjunction with expert opinions of the EEP and other advisors to define priority areas for projects that the program needs to consider in its request for proposals (RFP). The topics that will be selected will provide for the basic criteria of the CRSP, in that the research will need to be mutually beneficial to both developing countries and the USA. This information will be used to define the RFP which will be made available through the internet.

A competitive request for proposals. This process will require existing projects to compete with new proposals through an open competitive process, and successful projects will provide the core of research activities during the next five years. The last RFP provided the chance for new participants in the CRSP and this has been a particularly invigorating process and has greatly improved political support for the program.

The Peanut CRSP looks forward to your participation and hopes that the groundnut industry of the world will contribute to defining what we do during the next five years.

News from Africa

Empowering Groundnut Farmers in Malawi with Improved Technologies

The International Crops Research Institute for the Semi-Arid Tropics (ICR1SAT) in partnership with PLAN International organized a three-day (4-6 March 1999) training course on groundnut production technologies at Kasungu, Malawi.

Farmers examining the yield of CG 7 groundnut variety during a field visit to Nkhamenya.

Inaugurating the training course, Mr C C Khonje, the Program Manager of Kasungu Agricultural Development Division, stressed the importance of training courses to empower farmers with new and improved technologies in order to boost groundnut production in Malawi. He commended ICRISAT and PLAN International for organizing such a training course, which has drawn expertise from both ICRISAT and the Malawi national program.

Dr Pala Subrahmanyam, ICRISAT Country Representative, welcomed the guests and participants. The main objectives of the course were to develop and upgrade the skills of field technicians and empower the farmers in improved groundnut production technologies to increase groundnut production in Malawi. The course facilitated cross-fertilization of ideas between various participants through field visits in the Kasungu area and in problem-solving group discussions.

Groundnut is a very important crop to farmers in Malawi. It plays a very significant role in dietary requirements and income generation. Being a legume, groundnut also improves soil fertility and provides beneficial residual effects for the productivity of subsequent cereal crops like maize and sorghum. As such, groundnut plays a positive role in the nutritional status and well-being of the rural poor, especially women and children. Unfortunately, the intake of groundnut and its products in rural households is very low. Although groundnut is produced all over the country, about 70% of the crop is produced in areas of Lilongwe and Kasungu. It is grown and managed mostly by resource-poor farmers, especially rural women. In general, groundnut yields are low, averaging 700 kg ha^{-1}. Nonavailability of seed of improved varieties, poor cultural practices, diseases and insect pests, and lack of awareness of improved technologies limit increased groundnut production in Malawi.

Over 60 participants including 20 women from Lilongwe and Kasungu areas attended the course. The course was designed to address the above issues related to increased groundnut production in Malawi.

ICRISAT Helps Save Biodiversity of Groundnut Germplasm in West and Central Africa Through the Groundnut Germplasm Project (GGP)

One of the primary objectives of the GGP is to enable NARS researchers in West Africa to access the world groundnut germplasm collection held in trust by ICRISAT. The project plans to keep a core collection for the region in the gene bank at ICRISAT-Niamey, Niger, by duplicating and transferring suitable accessions from the large collection maintained at ICRISAT-Patancheru, India. Additional diverse material is being collected through exploration of important production areas in the region. Other activities include production and distribution of foundation seed, information dissemination, and training courses. The project is actively involved in research on aflatoxins and groundnut rosette virus, two major threats to groundnut production in the region.

GGP Seeks Alternatives to Cold Storage

One of the activities of GGP that could have an impact on in situ conservation of groundnut seed in the region is the Project's search for alternatives to cold storage. Cold storage, considered to be the best conservation method, requires high investment and operational costs. The unreliable power supply in many countries of West Africa also makes it difficult to use cold storage efficiently. One method that is being tested is to store seeds under vacuum or in an inert atmosphere (e.g., nitrogen) at ambient temperature. If shown to be effective for large-scale storage of foundation seeds, it would be much cheaper than cold storage.

Progress of Research into Socioeconomic Impacts of Alternative Groundnut Production and Marketing Systems in Senegal

Research activities during 1998-99 by the University of Connecticut, USA, and the Ecole Nationale d'Economie Appliquee (ENEA), Dakar, Senegal, pursued the following objectives:

1. To improve existing procedures used to collect farm-level data at ENEA, with emphasis on groundnut production with improved analysis techniques (FoxPro Program).
2. To evaluate the extent to which farm output can be increased by better utilization of existing resources.
3. To assess the impact of alternative groundnut management practices and farm policies on impact use, productivity, and farm profitability.

Towards the first objective, data including information on prior experience, formal schooling, participation in learning networks, and active reflection, as well as farm production and consumption data previously included, have been collected in 1998. These data are being automatically processed by a purpose-specific FoxPro program, for which one scientist has provided training in January 1999, to ENEA faculty and students. A paper on the use of this program for managing the ENEA data has been prepared for publication.

In May, Professor Bravo-Ureta visited Senegal and helped select sites where the farm level data will be collected in the 1999 and 2000 stages. The 1999 site is the same as that visited in 1984, while the 2000 sites will be those visited in 1991 and 1992.

In order to evaluate techniques to increase farm output based on better utilization of existing resources, the 1997 farm level data have been completely coded and coding of the 1998 data is under way. Completion of this will enable analysis of productivity differentials across groundnut producers, including the specific issues of the relationship between productivity and agricultural intensification versus extensification, adoption of new varieties, and socioeconomic characteristics of the household. This will result in a Ph.D. dissertation.

The third objective, the evaluation of alternative technologies, is being addressed by developing profiles of farm practices of typical farms for different agro-ecological zones, based on the 1996-97 data. The 1998 stage data will also be used to model additional typical farms by considering alternative groundnut management practices, and farm policies on input use, productivity and farm profitability.

Meeting of the Fourth Steering Committee of the Groundnut Germplasm Project (GGP) for West Africa

The fourth steering committee (SC) meeting of the GGP was organized by 1CR1SAT, the Project Executing Agent (PEA), 7-9 Apr 1999, at ICRISAT-Bamako in Mali. Representatives of the principal partners, ICRISAT, Institut Senegalais de Recherche Agricole (ISRA), and C1RAD, France, as well as a representative from the African Groundnut Council (AGC), participated. A representative from the Common Fund for Commodities (CFC), and the donor and representatives of the National Agricultural Research Programs (NARS) from Mali, Burkina Faso, and Senegal also attended the meeting as observers. Unfortunately, representatives from the supervisory body (SB) of FAO and from Nigeria were unable to come to the meeting. The steering committee examined and approved the work plan and budget for 1999-2000. The work plan and budget were prepared by the project staff and partners.

News from Cereals and Legumes Asia Network (CLAN)

Networks in Research and Technology Exchange

(Dr C L L Gowda and Dr A Ramakrishna have contributed this discussion of information and material exchanges through networks, using the particular example of the Cereals and Legumes Asia Network (CLAN). Ed.)

Funding for agricultural research in both national and international programs is either declining or stagnating and this is bringing institutions and scientists together to work cooperatively. Networks are becoming increasingly important in agricultural research as an effective way of using limited funds, staff, and facilities to achieve research goals. Networking approaches avoid duplication of effort, and engage, at a relatively low cost, a critical mass of personnel in research and development to address and solve specific problems. Networks enhance interaction and exchange of knowledge and materials among members.

An agricultural research network is a group of individuals or institutions linked together because of commitment to collaborate in addressing a common agricultural problem, or set of problems, and to using existing resources more effectively. Networks are dynamic and variable. Networks can be formal or informal. If a group of scientists meets to review the results and plan future research, it could be considered a 'network' if they interact and exchange information and material. Some of the common types of networks are:

- *Information exchange networks* that disseminate available information, methodologies and results to members.
- *Material exchange networks* that are involved in exchanging germplasm and breeding material (e.g., International Nurseries and Trials Network) or machinery among cooperating scientists.
- *Scientific consultation networks* that allow individuals or groups to conduct independent research, slightly modifying the on-going research to serve the goals of the network, and share the results.
- *Collaborative research networks* that involve joint planning and conduct of research on common research interests (e.g., CLAN).

There are five major components of any network: membership, coordination, communication, research, and assets.

Membership of interested scientists and administrators forms the body of a network. Commitment by members is essential for the success of network, and for its integration into a national program's agenda.

Coordination is required to organize and harmonize network activities. Usually a Coordination Unit provides administrative and logistic support.

Communication enables interchange of information, material, and technology. Planning meetings, workshops, monitoring tours, training courses, and formal and informal publications serve as communication channels.

Assets of a network include the members and facilities and resources available. Often, external funding is required to support special activities such as meetings, training, and workshops.

Research is the major component around which a network is organized. It encompasses all research-related components, such as information, literature, genetic material, technology, or methods. A shared research goal is the major link between the network's members.

Cereals and Legumes Asia Network (CLAN)

CLAN was established in 1992 to serve as a research and technology exchange network for Asia involving sorghum, pearl millet, chickpea, pigeonpea, and groundnut. CLAN amalgamated the activities of two earlier networks, the Asian Grain Legumes Network (AGLN) and the Asian component of the Cooperative Cereals Research Network (CCRN). It consists of scientists and research administrators in Asian countries who have indicated their interest and willingness to commit resources to undertake collaborative research, participate in network activities, and share results and technology. Membership includes staff from more than 15 Asian countries, regional and international institutions primarily in Asia and elsewhere, and ICRISAT scientists. Currently the Coordination Unit is located at and supported by ICRISAT.

The overall objective of CLAN is to support, coordinate, and enhance technology exchange involving CLAN priority crops and their resource management among Asian scientists. The ultimate goal is to improve the well-being of Asian farmers by improving the production and productivity of crops in a sustainable manner.

The specific objectives of CLAN are to:

- Strengthen linkages and enhance exchange of germplasm, breeding material, information and technology options among members;
- Facilitate collaborative research among members to address and solve high priority production constraints giving attention to poverty and equity issues as per needs and priorities of member countries;
- Assist in improving the research and extension capability of member countries through human resource development;
- Enhance coordination of regional research on sorghum, pearl millet, chickpea, pigeonpea, and groundnut; and
- Contribute to the development of stable and sustainable production systems through a responsive research capability in member countries.

Country Coordinator

Each member country nominates a senior scientist/ research administrator as the Country Coordinator for in-country coordination of network activities. The Country Coordinator is the main administrative link between the Coordination Unit (CU) and the national agricultural research systems (NARS) of that country, and between the network members within the country.

Network activities

CLAN supports diverse activities in the region and member countries, based on the priorities, interests, and needs of each member country.

Germplasm and breeding material exchange. The vast collection of world groundnut germplasm available at the ICRISAT gene bank, and the genetically improved breeding material are shared with the scientists in member countries either through responding to individual requests or through international nurseries and trials. CLAN facilitates the exchange, and assists NARS in testing, evaluation, and use of these materials in the national programs. On the other hand, the national crop improvement programs have contributed their collection of local land races to the ICRISAT gene bank for storage, multiplication, and sharing with other NARS.

Training. The CU assists the Training and Fellowships Program at ICRISAT and the CLAN members by identifying training needs and financially supporting the participants, partially or in full; organizing special training courses, and individual programs on specific topics to develop and upgrade research skills; and arranging in-country training programs to share the latest knowledge on research techniques, results, and technology related to the network's mandate.

Information exchange. CLAN members have access to the services provided by ICRISAT's Information Technology Unit and Library. These include research and information bulletins; proceedings of workshops, conferences, and meetings; field and laboratory handbooks and manuals; international newsletters; and other ICRISAT publications. Also selective dissemination of information, literature searches, and other documents/reprints can be requested.

In addition to these the CU collects reports, books, and unpublished manuscripts from member countries for sharing with other members.

Working groups. Working groups (also referred to as consortia or subnetworks) are formed by a group of committed scientists having a common interest in addressing and finding solutions to a high priority regional problem. The working group concept helps to avoid duplication of effort and engage, at a relatively low cost, a critical mass of scientists to solve research problems. The membership of a working group consists of scientists from NARS, regional, mentor, and international research institutions who have the interest, expertise, and commitment to work together, and share resources and results. Each working group nominates a Technical Coordinator (who is an expert in the subject) to liaise, coordinate, and harmonize research efforts. The Technical Coordinator of a working group is normally supported by a network or institution for providing logistic and administrative support.

Three groundnut working groups are currently operating in Asia, with logistic and administrative support provided by CLAN.

Groundnut viruses in the Asia-Pacific region. Virus diseases are one of major global constraints that reduce yield of groundnut. This working group started as the Peanut Stripe Virus (PStV) Working Group in 1987 to foster research on PStV. It was renamed the "Working Group on Groundnut Viruses for the Asia-Pacific Region" in 1989. CLAN provided financial support and liaised with other organizations (such as AGAR, 1DRC, FAO, and Peanut CRSP) to carry out joint research, provide seed money or support funding to training programs in detecting and diagnosing virus diseases, publication of proceedings and information bulletins. The working group on groundnut viruses and its predecessor PStV WG have pioneered the working group concept and served as a model for several others in CLAN. The current Technical Coordinator is Dr D V R Reddy, Principal Virologist, ICRISAT.

Groundnut bacterial wilt. Bacterial wilt is an important soil-borne disease of groundnut in many Southeast Asian countries. The Groundnut Bacterial Wilt Working Group was set up following a recommendation at the planning meeting held in Malaysia in 1990. The Asian Grain Legume Network (predecessor of CLAN) was requested to provide administrative and logistic support. The main objectives of this working group are to exchange lines resistant to bacterial wilt, exchange information and research results, and coordinate research to address issues related to managing the disease (including host-plant resistance, cultural and biological control). The fourth meeting of the working group was held from 11-13 May 1998, in Hanoi, Vietnam. Proceedings of all four working group meetings are available. In addition a technical manual on 'Techniques for diagnosis of *Pseudomonas solanocearum"* (now renamed *Burkholderia solanacearum*) has also been published. Mr Liao Boshou, Groundnut Breeder, Oil Crops Research Institute, Wuhan, China, is the Technical Coordinator.

Aflatoxin contamination problems in groundnut. Aflatoxins are highly toxic and carcinogenic substances produced by the fungus Aspergillus flavus, and are health hazards to both human beings and animals. Many developed countries have placed limits on the levels of aflatoxin ranging from 0 to 20 parts per billion (ug kg^{-1}), and thus restrict imports of groundnut and its products. The working group was established at the first meeting at Hanoi, Vietnam in 1996. The main objectives of the working group are: (i) Enhancing awareness among farmers, traders, processors, and consumers regarding the health risk to humans and animals, (ii) Testing and validating agronomic practices that can reduce aflatoxin contamination, (iii) Breeding for resistance to seed infection and aflatoxin production by *A.flavus,* and (iv) coordination of regional research to minimize the risk of aflatoxin.

Funding

Most of the funding support for network and working group research activities comes from the member countries. The NARS use existing staff, facilities, and resources in their institutions to carry out collaborative research. Using donor funding, the Coordination Unit partially supports the costs of scientists' travel, training, and workshops/meetings in addition to supporting collaborative research aimed at developing technologies for the member NARS in the region.

Current ICRISAT groundnut research and integrated projects to 2002.

Donor	Project title	Project scientist	Grant amount (ICRISAT budget in US$ '000)	Duration
ACIAR, Australia	More efficient breeding of drought resistant peanuts in India and Australia	S N Nigam	0.033	Oct 1998–Jun 2001
DFID, UK	Safe to eat or why chickens die? Developing low-cost and simple technologies for aflatoxin estimation in foods and feeds	D V R Reddy	0.140	Apr 1998–Mar 2001
Indian Institute of Science, Bangalore (Grant from START, USA)	Climate prediction for rainfed groundnut production in the dry tropics	S M Virmani	0.011	1998/1999
PLAN International	Groundnut project in Malawi	P Subrahmanyam	0.131	Nov 1998– Dec 2001
QDPI, Australia (Grant from ACIAR)	Management of white grubs in peanut cropping systems in Asia and Australia	R J K Myers	0.041	1998–2002
UNDP/IAEG	Impacts of ICRISAT/NARS germplasm research for sorghum, groundnut, and pearl millet	M C S Bantilan	0.080	Oct 1998–Sep 2000
CABI/DFID	Principal pod-boring pests of tropical legume crops: economic importance, taxonomy, natural enemies and control	E Minja	0.006	Oct 1998–Sep 2000
OPEC Fund	Increase groundnut productivity for rural prosperity in Asia	S N Nigam	0.070	Jul 1999 to Jun 2000
ADB	Legume-based technologies for rice and wheat production systems in South and Southeast Asia	C Johansen	0.600	Apr 1997–Apr 2000
Belgium	Integrated control of *Polymyxa graminis*, a vector of peanut clump virus	D V R Reddy	0.610	Jan 1992–Jun 1996 (Phase I) Jul 1996–Dec 1999 (Phase II)
CFC and World Bank	Preservation of wild species of *Arachis*	P J Bramel-Cox	0.396	Jun 1996–Dec 2000
CFC	Conservation, evaluation and dissemination of groundnut germplasm, and foundation seed production and distribution for the West African region	P J Bramel-Cox	1.425	May 1996–Dec 2001
BMZ/GTZ	Promotion of legume cultivation (Phase IV)	P J van der Merwe	1.734	Dec 1997–Jun 2000
Targetted project approved for funding				
USAID	Rural prosperity is nation's economic stability: a partnership approach to attain sustainable production of groundnut and pigeonpea in smallholder agriculture for quality diet, household food security, and poverty alleviation in Malawi	P Subrahmanyam	0.677	1999–2001

Source: Office of Donor Relations, ICRISAT, Patancheru, Andhra Pradesh, India.

Genetics and Plant Breeding

A Case of 2n Pollen in an Accession of an Annual Diploid Groundnut Wild Species, *Arachis duranensis*

P Vindhiyavarman, K N Ganesan, A Mothilal, and S E Naina Mohammed (Regional Research Station, Vridhachalam 606 001, Tamil Nadu, India)

The occurrence of 2n pollen was confirmed in several species by seed set following tetraploid x diploid crosses. It is a common phenomenon in potato species (Hanneman and Peloquin 1968, Mok and Peloquin 1975). Such sexual polyploidization should be regarded as a most potent evolutionary mechanism when compared with somatic doubling. Even though both achieve polyploidization, the former is creative in that it provides novel variability and gene combinations avoiding significant inbreeding. On the other hand, in somatic doubling the genotype produced will be at most balanced diallelic in the tetraploid and considerably inbred. These different genetic consequences will be reflected in the vigor, fertility, and competitive ability of the founder polyploid population.

Arachis duranensis Krapov & W.C Gregory (GKBSPSC 30067; ICG 8200) is a native of Argentina. It is an annual diploid (2n=20) species with procumbent growth habit. The pods and seeds are small. The pollen of *A. duranensis* was utilized for hybridization with the cultivar VRI 4 of *Arachis hypogaea* (2n=40) during the rainy season commencing June 1997. The resultant hybrid seeds were planted during the postrainy season (Jan 1998). Two hybrids that had set seeds profusely indicated the pollination by 2n pollen of *A. duranensis.* Many workers in potato have demonstrated similar mechanisms. Dyads

Table 1. Description of fertile hybrids between *A. hypogaea* cv VRI 4 x *A. duranensis.*

Descriptor	Female parent cv VRI 4 of *A. hypogaea*	Male parent *A. duranensis*	Hybrids VRI 4 x *A. duranensis*
Growth habit	erect	procumbent 1	decumbent 1
No. of n+1 branches	5	5	4
No. of n+2 branches	10	15	10
No. of n+3 branches	5	18	12
Length of main axis(n) (cm)	45.5	24.2	26.0
Length of n+1 branches	51.5	85.0	53.8
Length of n+2 branches	18.4	44.8	34.2
Length of n+3 branches	12.0	18.7	13.6
Branching pattern	irregular	irregular	irregular
Flowers on the main axis	absent	absent	absent
Type of inflorescence	compound	compound	compound
Leaf color	dark green	light green	light green
Pubescence on the stem	sparse	dense	moderate
No. of pods plant^{-1}	18.0	28.0	60.0
100 seed mass (g)	40.8	7.6	19.7
Shelling percentage	72.1	78.3	77.5
Seed size	medium	very small	small
Seed shape	round to flat	oblong	oblong
Seed color	tan	rose	rose
Days to maturity	105.0	120.0	110.0

have been reported in many cultivars of potato and Bleier (1931) observed fusion of both metaphase plates in the second division frequently. Oppenheimer (1933) and Stelzner (1943) both detected parallel spindles and dyads in interspecific hybrids in *Solarium chacoense.*

The fertile hybrids between *Arachis hypogaea* cv VRI 4 and *A. duranensis* were decumbent I in growth habit, without flowers on the main stem and the branching pattern was irregular. There were few n+2 branches and the plants matured in 105 days (Table 1). Hence they combined the characters of both the subspecies i.e., *fastigiata* and *hypogaea.* The pod-setting was profuse and three or two pegs were observed per node. The pod size was intermediate between the two parents. The seeds of VRI 4 were round to flat either on one or both sides, whereas the seeds of *A. duranensis* were oblong. The seeds of the hybrids were intermediate between the two parents.

The F_2 plants were studied during the rainy season (June 1998). There was segregation for five different types based on plant morphology and pod characters in the F_2.The study of F_3 plants is in progress. The present material will be a useful donor for further introgression without tedious ploidy manipulation.

Acknowledgments

The supply of *A. duranensis* (ICG 8200) by the Genetic Resources Unit of ICRISAT, Patancheru, is gratefully acknowledged. Thanks are also due to ICAR for rendering financial support for this program.

References

Bleier, H. 1931. Untersuchungen iiber die sterilitat der kartoffel Arch. Pflanzenbau 5:545-560.

Hanneman, R.E., and Peloquin, S.J. 1968. Ploidy levels of progeny from diploid-tetraploid crosses in the potato. American Potato Journal 45:255-261.

Mok, D.W.S., and Peloquin, S.J. 1975. Breeding value of 2n pollen (diplandroids) in tetraploid x diploid crosses in potatoes. Theoretical and Applied Genetics 46:307-314.

Oppenheimer, H.C.H. 1933. Cytogenetische Untersuchungen an Bastarden Knollen tragender *Solanum-Arten.* I *Solanum chacoense* BITT x *Solanum tuberosum* L.s. Str. Z indukt. Abstamm - U. vereblehre 65:72-98.

Stelzner, G. 1943. Wage zur zuchterischen Nutzung des *Solanum chacoense* BITT. In Hinblick die zuchtung Kafer - resistenter Kartoffel - Sorten. Zuchter 15:33-38.

Synthetic Amphidiploids in the Genus *Arachis*

P Vindhiyavarman, K N Ganesan, A Mothilal, and S E Naina Mohammed (Regional Research Station. Vriddhachalam 606 001, Tamil Nadu, India)

The amphidiploids in the genus *Arachis* represent an important gene pool for groundnut improvement as they incorporate genes from two species. Further, amphidiploidy makes it possible to establish a bridge between a crop species and a directly incompatible species by crossing the latter with a mutually compatible third species. The present study was conducted with a view to understanding the breeding behavior of some amphidiploids.

The diploid (2n=20) wild species belonging to section *Arachis* was selected for the study. *A batizocoi,* the only species belonging to 'B' genome, and the 'A' genome species *A. viilosa, A. stenosperma, A. duranensis, A. cardenasii, A. kempff-mercadoi, A. correntina,* and *A. helodes* were utilized for the development of eight different amphidiploids.

The amphidiploids were planted in the field during the rainy season in June, 1998. The pollen stainability data were recorded by sampling on two different days with a count of 300 pollen grains per plant. The results are presented in Table 1. The morphology of the individual amphidiploids is furnished in the text. F_2 plants were obtained by in situ germination in all the combinations except *A. villosa* x *A. batizocoi.* These F_2 plants were transplanted in separate plots for further study. The F, plants obtained so far are briefly described for purposes of comparison.

A. viilosa* x *A. stenosperma. The standard petal color of *A. stenosperma* is lemon yellow. This trait was expressed in the amphidiploid while the leaves resembled *A. viilosa.* Seed setting was rare. Fourteen F_2 plants were obtained. Of these, six plants exhibited the standard petal color of lemon yellow and the others were orange yellow.

A. duranensis* x *A. viilosa. The traits of *A. duranensis* i.e., smaller sized leaflets and flowers, were expressed in the amphidiploid. Six F_2 plants were obtained with three plants exhibiting a larger standard petal resembling *A. viilosa* and three plants with the smaller sized standard petal and leaflets resembling *A. duranensis.*

A. viilosa* x *A. batizocoi. The characters *of A. batizocoi,* such as less intense branching, longer lateral branches, roundish leaflets and a lemon yellow standard petal color were expressed in the amphidiploid. The size of the standard petal was intermediate between the two. The pollen fertility was only 1.5%. No F_2 plants have been produced so far.

***A. cardenasii* x *A. villosa*.** The standard petal of *A. villosa* is larger than that of *A. cardenasii,* whereas the reverse is true for leaflet size. The amphidiploid was intermediate between the two. Of the 40 plants obtained in F_2, 28 plants resembled *A. cardenasii* and 12 plants resembled *A. villosa* in gross morphology especially in respect of the sizes of the standard petal and leaflets.

***A. correntina* x *A. helodes*.** The characters of *A. helodes,* i.e., deep orange standard petal color, dark green leaves and pinkish pigmentation in the stem dominated in the amphidiploid. Only five F_2 plants were obtained and they had slightly narrower leaflets, light green leaves, and the standard petal size smaller than both the parents.

A. stenosperma* x *A. cardenasii The main axis was taller than both the parents. The standard petal color was lemon yellow resembling *A. stenosperma*, and the pod size was intermediate between the two parents. The F, plants segregated for lemon yellow (19 plants) and orange yellow color (21 plants) standard petals and also for leaf morphology.

***A. stenosperma* x *A. kempff-mercadoi*.** The amphidiploid expressed the larger sized standard petal similar to *A. kempff-mercadoi.* However, the color of the standard petal was lemon yellow. It was vigorous and the seed setting was profuse. The F_2 plants segregated for lemon yellow (18 plants) and orange yellow color (9 plants) standard petal. The leaf shape of eight plants resembled *A. stenosperma.* However, nineteen plants had narrow (linear) leaflets.

Table 1. Pollen stainability of selected diploid species of the section *Arachis* and their *hybrids*.

Species	Mean % of stainec1 pollen
Arachis villosa	97.40 ± 1.28
A. stenosperma	98.10 ± 0.80
A. duranensis	96.23 ± 0.60
A. batizocoi	88.35 ± 1.30
A. cardenasii	98.35 ± 0.75
A. correntina	84.13 ± 0.90
A. helodes	95.60 ± 1.30
A. kempff-mercadoi	96.20 ± 1.00
A. villosa x A. stenosperma	43.10 ± 4.50
A. duranensis x A. villosa	34.12 ± 8.52
A. villosa x A. hatizocoi	1.57 ± 0.10
A. cardenasii ' A. villosa	45.95 ± 7.53
A. correntina 'A. helodes	39.84 ± 1.50
A. stenosperma 'A. cardenasii	56.93 ± 3.40
A. stenosperma ' A. kempff-mercadoi	67.01 ± 5.20

The cytological analysis of the amphidiploid *A. duranensis* x *A. villosa* revealed the formation of 8.9 bivalents and 2.2 univalents. Resslar and Gregory (1979) observed in hybrids between 'A' genome species of section Arachis, the absence of quadrivalents, anaphase bridges, and heteromorphic bivalents. Further, the differences resulting in the formation of univalents were cryptic differences rather than structural rearrangements between homeologues. The pollen stainability studies revealed that the hybrids between species having 'A' genome were fertile, however, that involving *A. batizocoi* ('B' genome) was sterile. Smartt et al. (1978a, 1978b) reported the hybrids between *A. batizocoi* and other members of section Arachis exhibited structural heterozygotes, as well as disturbed reduction division and irregular segregation of chromosomes.

Triploids of amphidiploids

The pollen of four amphidiploids, i.e., *A. cardenasii* x *A. villosa, A. correntina* x *A. helodes, A. stenosperma* x *A. cardenasii, and A. stenosperma* x *A. kempff-mercadoi* was utilized for hybridization with an *A. hypogaea* parent (cv VR 14) and triploids (2n=30) were obtained. They will be utilized in further backcrosses.

Acknowledgments

The authors wish to thank ICRISAT for supplying the wild species of *Arachis.* Thanks are also due to the Indian Council of Agricultural Research for financial support for this program.

References

Resslar, P.M., and Gregory, W.C. 1979. A cytological study of three diploid species of the genus *Arachis L.* Journal of Heredity 70:13-16.

Smartt, J., Gregory, W.C, and Pfluge Gregory, M. 1978a. The genomes of *Arachis hypogaea.* I. Cytogenetic studies of putative genome donors. Euphytica 27:665-675.

Smartt, J., Gregory, W.C, and Pfluge Gregory, M. 1978b. The genomes of *Arachis hypogaea.* 2. The implications in interspecific breeding. Euphytica 27:677-680.

Groundnut Variety, TAG 24, With Potential for Wider Adaptability

D M Kale, A M Badigannavar, and G S Murty
(Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, Maharashtra, India)

Groundnut variety, TAG 24, was originally released for the Vidarbha region of Maharashtra in 1991 and notified by the Ministry of Agriculture, Government of India, during 1992 (Patil et al. 1995). Subsequently, this variety performed equally well in other states such as Andhra Pradesh, Gujarat, Orissa, North Eastern Hill States, Pondicherry, Rajasthan, Tamil Nadu, and West Bengal. This prompted a reexamination of the yield performance of TAG 24 in the All India Coordinated Research Project on Oilseeds (AICORPO) rabi/summer varietal trials. In this report, the data on TAG 24 as a test entry (between 1987 and 1990), as well as an additional control cultivar (between 1991 and 1997) from AICORPO trials are compiled and presented.

TAG 24 was yield tested between 1987 and 1997 in 146 trials in various stages of AICORPO testing in Zones 1 to IV. These trials included national, zonal, local, and minikit checks which consisted of 11 cultivars spread all over the four zones. TAG 24 gave a higher pod yield than the respective best control in 70 out of 146 and seed yield in 70 out of 139 trials. (The seed yield was reported only in 139 trials). The yield increase in TAG 24 for pods ranged between 1% and 65%, and for seed between 1% and 73% in these trials.

Each time when a trial was conducted in a zone, mean yields of TAG 24 and the best control variety (irrespective of its identity) over all locations in the zone were compared. The mean pod yield of TAG 24 was higher than the best control in 4 out of 4 evaluations in zone 1,4 out of 7 evaluations in zone II, 5 out of 8 evaluations in zone III, and 4 out of 12 evaluations in Zone IV. Similarly, the mean seed yield of TAG 24 was superior to the best control in 4 out of 4 evaluations in zone I, 5 out of 7 evaluations in zone II, 5 out of 8 evaluations in zone III, and 6 out of 12 evaluations in zone IV. The mean yield of TAG 24 and the best control in each evaluation were pooled to arrive at the zonal mean for all evaluations (Table 1). The pod yield superiority in TAG 24 ranged between 3.5% and 20.6% in zones, I, II, and III. In zone IV, the pod yield of TAG 24 was 2.7% less than the mean pod yield of the best control. However, the superiority in seed yield of TAG 24 ranged from 1.4% to 24.9% in all the zones. All India mean pod and seed yields of TAG 24 were 2.58 and 1.83 t ha^{-1}, respectively (Table 1).

All the control cultivars in the four zones were also compared with TAG 24 individually. TAG 24 showed 31% superiority in pod yield in 87 out of 113 trials and 30% superiority in seed yield in 91 out of 105 trails over the most popular cultivar, JL 24. Similarly, TAG 24 out-yielded other prominent control cultivars also in more than 50% of the trials (Table 2).

These results from coordinated trials suggest that TAG 24 has wider adaptability than the recommended area of its cultivation. This could be due to a combination of several desirable agronomic and physiological traits such as semidwarf habit, high harvest index, tolerance

Table 1. Zone-wise mean yields of TAG 24 in All India Coordinated rabi/summer varietal trials (1987/88 to 1996/97).

		Number of		Yield (kg ha^{-1})				Increase (%)	
				Best control		TAG 24			
Zone[1]	Years	Evaluations	Trials	Pod	Seed	Pod	Seed	Pod	Seed
I	1994-97	4	4	1374	948	1658	1184	20.6	24.9
11	1987-97	7	29	2492	1648	2714	1836	8.8	11.4
III	1987-94	8	86	2451	1709	2536	1813	3.5	6.1
IV	1990-97	11	27	2780	1922	2706	1949	-2.7	1.4
Pooled mean		-	-	2498	1716	2582	1826	3.4	6.4

1. Zone I = Uttar Pradesh, Punjab, Haryana, North Rajasthan.
Zone II = Gujarat, North Maharashtra, Madhya Pradesh.
Zone III = Western and Southern Maharashtra, Andhra Pradesh, Orissa, Tamil Nadu, Karnataka. Kerala.
Zone IV = Bihar, West Bengal, Tripura, Assam, Andaman.

Table 2. Comparative yields of TAG 24 against 11 control cultivars in All India Coordinated rabi/summer varietal trails (1987/88 to 1996/97).

	Mean yield (kg ha^{-1})				Superiority of TAG 24 over control			
	Pod1		Seed		% increase		No. of trials	
Control	TAG 24	Control	TAG 24	Control	Pod	Seed	Pod	Seed[1]
JL24	2665	2032	1843	1423	31	30	87/113	91/105
ICGS 11	2565	2558	1845	1754	3	5	31/75	37/71
TMV2	2785	2000	1814	1421	39	28	38/54	37/53
ICGS 44	2811	2616	1993	1828	7	9	32/54	32/50
SB XI	2588	1849	1833	1265	40	45	47/53	44/50
J 11	2507	2244	1805	1632	12	11	25/44	25/40
ICGV 86590	2412	2270	1710	1496	6	14	21/38	25/37
GG2	2420	2260	1747	1577	7	11	12/16	11/13
ICGS 37	2836	2704	1944	1761	5	10	9/16	9/16
VRI3	3046	2844	2277	2176	7	5	8/14	6/13
ICGS 1	1100	800	745	496	38	50	3/3	3/3

1. Number of trials with superior yield/total number of trials.

to late leaf spot, and bud necrosis (Patil et al. 1995), and acid soils (Basu 1997), and better water-use efficiency (AC1AR 1995).

References

Australian Centre for International Agricultural Research (ACIAR). 1995. Selection for water-use efficiency in grain legumes. (ACIAR PN 9216) Annual Report. Canberra, Australia: Australian Centre for International Agricultural Research. 10 pp.

Basu, M.S. 1997. Rabi/summer groundnut research under the All India Coordinated Project: Summary-cum-Project Coordinator's Report, page II in Progress Report 1996-97. Rabi/summer Groundnut Workshop. 6-7 Oct 1997, National Research Centre for Groundnut (NRCG), Junagadh. Junagadh, India: Project Coordinating Unit, Groundnut (ICAR), NRCG.

Patil, S.H., Kale, D.M., Deshmukh, S.N., Fulzele, G.R., and Weginwar, B.G. 1995. Semi dwarf, early maturing and high yielding new groundnut variety, TAG-24. Journal of Oilseeds Research 12:254-257.

Evaluation of Groundnut Genotypes for Rainfed Conditions in the Northern Coastal Zone of Andhra Pradesh, India

V Raja Rajeswari (Regional Agricultural Research Station, Acharya N G Ranga Agricultural University, Anakapalle 531 001, Andhra Pradesh, India)

Groundnut is grown in about 0.12 m ha in the northern coastal districts (Srikakulam, Vizianagaram, and Visakhapatnam) of Andhra Pradesh. However, the average yields are low (0.8 t ha^{-1}). Excessive vegetative growth due to high humidity and soil moisture conditions, and cloudy weather during the rainy season (kharif) result in poor pod yields. In addition, lack of seed dormancy is a major constraint in groundnut cultivation in these districts. The present study was undertaken to identify genotypes that can give higher yields than the currently grown popular varieties, such as TMV 2, JL 24, and Kadiri 3 in spite of the above constraints.

Eleven genotypes of groundnut including TMV 2, JL 24, and Kadiri which were regarded as controls, were raised in a randomized block design with three replications during the 1998 rainy season at the Regional Agricultural Research Station, Anakapalle. The soils were sandy

Table 1. Comparison of developmental and morphological characters in different groundnut genotypes during the rainy season, 1998, Anakapalle, Andhra Pradesh, India.

Genotype	Days to 50% flowering	Days to maturity	Plant height (cm) at 30 DAS	60 DAS	90 DAS	Harvest	Leaf dry mass (g) at DAS	60 DAS	90 DAS	Stem dry mass (g) at 30 DAS	60 DAS	90 DAS
TG26	27	98	10.7	56.7	57.6	77.6	0.8	13.4	10.5	0.9	9.5	19.4
K 150	25	108	18.0	45.3	58.8	71.2	1.2	9.5	15.6	1.5	9.2	23.9
ICGS 44	31	103	13.0	38.9	41.1	54.1	1.2	10.2	9.4	1.2	8.6	16.3
K 134	25	109	16.0	45.5	58.3	79.7	1.1	12.3	14.6	1.0	10.6	27.1
YLG3	32	104	13.2	40.4	45.2	51.6	1.2	11.2	11.5	0.9	9.7	14.9
ICGS 65	32	105	12.2	35.6	38.5	45.4	1.2	9.5	10.6	0.9	8.0	18.4
K 1128	29	109	18.5	50.7	54.9	87.0	1.5	14.6	7.1	1.3	11.8	19.1
K 153	27	109	18.2	55.8	72.3	91.7	1.5	12.2	6.7	1.4	10.9	17.5
Controls												
JL24	30	100	15.8	46.6	60.9	68.1	1.4	13.2	9.8	1.3	10.5	17.9
Kadiri 3	30	100	11.8	34.8	38.9	51.8	1.2	10.0	9.6	1.1	9.3	21.3
TMV2	28	104	16.0	45.2	55.8	83.9	1.0	11.4	10.1	0.9	11.5	19.3
Mean	29.0	104.5	14.9	45.0	52.9	69.3	1.2	11.6	10.5	1.1	10.0	19.5
SE	±1.15	±0.89	±1.65	±1.29	±1.73	±3.96	±0.17	±0.68	±0.41	±0.11	±0.58	±0.79
CD (P = 0.05)	3.40	2.70	4.88	3.81	5.11	11.68	0.51	2.01	1.20	0.34	1.71	2.35
CV (%)	7.0	2.4	19.3	5.0	5.7	9.9	25.0	10.2	6.7	17.7	10.1	7.1

loam, low in nitrogen (250 kg ha^{-1}), but medium to high in available phosphorus (11-13 kg ha^{-1}), and potassium (115-210 kg ha^{-1}). The soil pH ranged between 6.5 and 7.8. Each genotype was grown in six rows 3 m long with a spacing of 30 cm between rows and 10 cm between plants within the rows. The recommended dose of fertilizers (20 kg N + 21.85 kg P + 33.35 kg K ha^{-1}) and standard practices were adopted in raising the crop. A total rainfall of 1070.3 mm was received during the crop growth period (Jul-Oct). The average rainfall over the past 10 years has been 748.3 mm.

Data on developmental and morphological characters are presented in Table 1.K 134 and K 150 were early in flowering but matured later than other test genotypes. TG 26, JL 24, and Kadiri 3 matured early. Plant height increased progressively from 30 days after sowing (DAS) to harvest in all the genotypes. K 153, K 1128, TMV 2, K 134, and TG 26 had a tall growth habit while ICGS 65, YLG 3, ICGS 44, and Kadiri 3 were shorter at harvest. Leaf dry mass peaked at 60 DAS for most of the genotypes except for K 150, K 134, YLG 3, and ICGS 65. The more vigorous genotypes continued to put on leaf mass even up to 90 DAS. Like plant height, stem dry mass increased progressively and was maximum at 90 DAS in all genotypes.

The number of pods $plant^{-1}$ varied from 16.8 (TMV 2) to 22.8 (ICGS 65). Of the genotypes ICGS 65, K 134, ICGS 44, and K 153 produced significantly more pods $plant^{-1}$ than the best control, JL 24 (Table 2). However, pod yield $plant^{-1}$ was significantly higher only in ICGS 44 and ICGS 65. Hundred pod mass varied from 63.3 g (K 153) to 83.7 g (JL 24) with a mean value of 73.7 g. None of the genotypes was superior to JL 24 in 100 pod mass. No genotype had a significantly greater shelling percentage than TMV 2, which was the best control for this trait.

ICGS 65 (1.5 t ha^{-1}), and K 134 (1.4 t ha^{-1}) produced a significantly higher pod yield than the best control, Kadiri 3 (12 t ha^{-1}) (Table 2). These genotypes also recorded more pods $plant^{-1}$. The present study suggests that

Table 2. Performance of groundnut genotypes at Anakapalle, Andhra Pradesh, India, rainy season, 1998.

Genotype	Number of pods plant^{-1}	Pod yield plant^{-1} (g)	Hundred pod mass (g)	Shelling percentage	Pod yield (t ha^{-1})
TG26	18.4	10.9	68.0	62.0	1.2
K150	20.6	13.8	71.3	68.0	1.1
ICGS44	21.7	16.9	76.3	67.7	1.3
K 134	22.0	16.6	83.3	66.3	1.4
YLG3	18.0	15.1	69.3	63.5	1.2
ICGS 65	22.8	17.0	74.3	66.6	1.5
K 1128	19.2	13.1	74.3	61.1	0.8
K153	20.9	8.5	63.3	62.9	0.8
Controls					
JL24	18.5	14.5	83.7	64.7	0.9
Kadiri 3	17.9	10.9	80.3	63.3	1.2
TMV2	16.8	12.5	66.3	66.5	0.9
Mean	19.77	13.62	73.70	64.74	1.09
SE	±0.76	±0.81	±1.29	±0.68	±0.06
CD (P = 0.05)	2.24	2.39	3.81	2.00	0.16
CV (%)	7.60	10.30	3.03	1.82	8.82

K 134, ICGS 65, and ICGS 44 are likely to be more adapted to rainfed conditions in this northern coastal zone characterized by low light, high rainfall, and high humidity because of their limited vegetative growth, shorter internodal length, and high pod yield.

Release of Cultivars of Yueyou 5 and Yueyou 79 in Guangdong, China

Liang Xuanqiang, Li Shaoxiong, Li Yicong, and Zhou Guiyuan (Crops Research Institute, Guangdong Academy of Agricultural Sciences, Wushan 510640, Guangzhou, China)

Yueyou 5 and Yueyou 79, Spanish type groundnut cultivars, were developed in 1998 by the Crops Research Institute, Guangdong Academy of Agricultural Sciences, and released by the Guangdong Provincial Crops Approval Committee in 1999. Yueyou 5 was derived from [(Yueyou 116 x PI 381622) F_1 x Yueyou 116] F_1 x (Giuyou 28 x ICG 8641) F_2 using the modified pedigree method. The PI 381622 and ICG 8641 were introduced from ICRISAT. In the Guangdong Provincial New Groundnut Varieties Trial from 1995 to 1997, Yueyou 5 outyielded the local control cultivar by 9.8%. Plant characteristics of Yueyou 5 are shown in Table 1. Yueyou 5 matures 6-7 days earlier than the local control cultivar. Under natural conditions it showed high resistance to rust (scoring 3.5 on a 1-9 scale) and moderate resistance to early leaf spot. It is recommended

Table 1. Characteristics of groundnut cultivars Yueyou 5 and Yueyou 79.

Characteristics	Yueyou 5[1]	Yueyou 79
Days to maturity	115	122
Pods plant^{-1}	14	16
100-pod mass (g)	180	185
100-seed mass(g)	72.5	73
mature pod (%)	85.8	84.1
Pod yield (t ha^{-1})	4.1	4.5
Seed yield (t ha^{-1})	2.86	2.92
Shelling percentage	72.0	71.7
Oil content (%)	52.2	52.0
Protein content (N x 6.25) (%)	26.5	32.5
O/L value[2]	0.97	1.67

1. Mean of data from Guangdong New Groundnut Varieties Trials. 1995-1997.
2. O/L value=oleic/linoleic acid ratio.

for general cultivation in Guangdong Province and other parts of South China. Yueyou 5 also performed well in the northern part of Vietnam.

Yueyou 79 was derived from (Yinduhuapi x Yueyou 116) F_{10} x Yueyou 116 using the modified pedigree method. Yinduhuapi (Chinese name) was introduced from ICR1SAT (exact name unknown) with high resistance to rust, bacterial wilt, and root rot, and with good seed quality. The traits of Yueyou 79 are shown in Table 1. In the Guangdong Provincial New Groundnut Varieties Trial from 1995 to 1997, the mean yield of Yueyou 79 was 4.5 t^{-1} and it outyielded the local control variety by 11%. It showed high resistance to rust (scoring 3.5), to bacterial wilt under artificial inoculation (wilt incidence 15%), and high resistance to root rot under field conditions. Yueyou 79 has a high protein content (32.5%), which is the highest protein content of the cultivars developed in China so far. It is adapted to various cropping systems and is gradually replacing the old cultivars in southern China.

Swat Phalli-96: A High-Yielding, Short Season Groundnut Variety for North West Frontier Province, Pakistan

A Khan (Agricultural Research Station, Mingora, Swat, Pakistan)

Groundnut is an important oilseed crop of rainfed areas of Pakistan. It is consumed mostly as roasted nuts. North West Frontier Province (NWFP) contributes about 11% to the total national groundnut production. In the NWFP, 57% of the total cultivable area remains fallow in the kharif (rainy) season due to low and unreliable rainfall. Sometimes high intensity rains cause soil erosion and other related calamities. To conserve soil deterioration and maintain the eco-soil environmental balance for sustainable crop production, it is preferable to grow safer, economical and more remunerative crops like groundnut. For this purpose there is scope to increase the groundnut area, production, and productivity in NWFP by cultivating high-yielding, short season groundnut varieties in the kharif season (Apr-Nov/Dec). The Provincial Seed Council on October 20,1996, released a Virginia bunch variety 'Swat Phalli-96' for commercial cultivation in NWFP. It is a pure line selection from a US Virginia bunch variety made at the Agriculture Research Station, Mingora (Swat). It is a semierect type, maturing in 130-135 days. It has a pod yield (mean of 6 years) of 2.99 t ha^{-1} and haulm yield (also mean of 6 years) of 4.26 t ha^{-1}. The average height of the main axis of the plant is 22 cm. It has dark green foliage with medium-sized leaflets. The pod is medium in size and has moderate to prominent reticulation with a parrot-like pod beak. Pod constriction is medium. Pods are mostly 2-3 seeded and clustered around the main tap root in the soil. The average shelling percentage is 70% with pinkish-colored seeds that are bold in size (100 seed mass is 70 g). They contain 46% oil and 29% protein. It is tolerant of the common diseases of groundnut like root rot (caused by *Macrophomina phaseolina)* and *Cercospora* leafspots. It also possesses fresh seed dormancy of about 3 months.

Yueyou 223: A High-Yielding Chinese Cultivar with Good Resistance to Rust

Liang Xuanqiang, Li Yicong, Li Shaoxiong, and Zhou Guiyuan (Crops Research Institute, Guangdong Academy of Agricultural Sciences, Wushan 510640, Guangzhou, China)

Rust *(Puccinia arachidis)* is the most widely distributed and economically important groundnut disease in southern China causing annual yield losses of 20-30%. It was essential to develop high-yielding cultivars with good resistance to rust to improve groundnut productivity in China.

The groundnut cultivar Yueyou 223, a Spanish type, was developed by the Crops Research Institute, Guangdong Academy of Agricultural Sciences, and released by the Guangdong Provincial Crops Approval Committee in 1993, and by the National Crops Varieties Approval Committee in 1998 as a national groundnut variety.

Yueyou 223 was derived from multicross Shanyou 27 x [Ec76446 (292) x Yueyou 431] F_4 using the modified pedigree method. Shanyou 27 was one of the popular cultivars with high yield but low resistance to rust in South China in the 1980s. Ec76446 (292) was introduced from ICR1SAT and was evaluated as excellent germplasm with good resistance to rust in China. Yueyou 431 was an advanced breeding line with big pods. From 1988 to 1990, in National Groundnut New Varieties Trials (Southern Part), the dry pod yield of Yueyou 223 averaged 3.72 t ha^{-1} over 14 locations outyielding the control, Yueyou 116, by 12.5%. In a field demonstration test

(3 ha), Yueyou 223 gave 3.6 t ha^{-1} and 14.3% more yield than the control cultivar. Reaction of Yueyou 223 to rust was evaluated from 1990 to 1992. It showed good resistance (score 3.0) under artificial inoculation.

Yueyou 223 matures in 115 days in the spring season and 110 days in the autumn season. It has an erect growth habit. The main stem is 50.2 cm high. Two-seeded pods account for 79% of all pods. The 100-pod mass is 210 g, and 100-seed mass is 80 g. Its shelling percentage is 72.5% and the seeds contain 51.3% oil and 28.6% protein. Since Yueyou 223 has desirable characteristics of yield, improved pod and seed quality, and good resistance to rust it was recommended for cultivation in the south and central part of China and it has covered about 60 million ha in these regions.

Participatory Evaluation of Groundnut Cultivars in Northern Nigeria

R Tabo[1], A O Ogungbile[2], B R Ntare[1], P E Olorunju[2], and O Ajayi[3] (1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), BP 320, Bamako, Mali; 2. Institute for Agricultural Research/Ahmadu Bello University, PMB 1044, Zaria, Nigeria; 3. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), PMB 3491, Kano, Nigeria)

Groundnut *(Arachis hypogaea L.)* is the most important cash and food legume crop in the Sudan Savanna agroecological zone of Nigeria, but its production has been adversely affected by drought and rosette disease (Yayock et al. 1976, Olorunju et al. 1992). Recent collaborative research efforts by ICRISAT, the Institute for Agricultural Research (IAR), Samaru, Nigeria, and other national agricultural research systems have resulted in the development of some promising groundnut cultivars tolerant to drought and rosette disease. These promising varieties were evaluated in farmers' fields in northern Nigeria during 1996 in collaboration with IAR, with the objectives of assessing their performance, acceptability by farmers and costs of production.

The improved varieties tested, ICGV 86015 and Fleur 11, which were nominated by ICRISAT, are early maturing (90-100 days to maturity) and can therefore escape terminal drought, a common occurrence in this region. Also tested was UGA 2, a medium maturing line (110-120 days to maturity) developed by IAR and resistant to groundnut rosette virus disease. These three were compared with a local variety. The study was carried out in Jigawa, Kano, and Katsina states in northern Nigeria. Three villages were chosen in each state on the basis of rainfall gradient. Table 1 shows the biophysical details of the nine study villages. There were 14 participating farmers in Jigawa, 19 in Kano, and 14 in Katsina states. These farmers were selected based on their previous interaction with extension agents and on their willingness to collaborate in this work. Plot sizes were about 0.1 ha.

Table 2 shows the mean pod yields in the nine villages of the three states. There was no significant difference among yields of varieties across the nine villages. ICGV 86015 performed relatively better than the other varieties in all the states. All the improved varieties maintained stable yields across the states, but ICGV 86015 and

Table 1. Location and bio-physical details of nine selected villages in northern Nigeria.

State	Village name	Agroecological zone[1]	Coordinates		Soil type	Mean annual total rainfall (mm)
			Latitude	Longitude		
Kano	Kofa	S. Sudan	11° 34'	8° 17	Loamy	898
	Panda	S. Sudan	n ° 3 r	8° 04'	Loamy	875
	Badume	N. Sudan	12° 12'	8° 19'	Sandy	704
Jigawa	Kantoga	S. Sudan	11° 30'	9° 23'	S. Loam[2]	850
	Dalari	N. Sudan	12° 36'	9° 48'	Sandy	639
	Gijigami	N. Sudan	12° 34'	9° 25'	Sandy	673
Katsina	Gora	S. Sudan	11° 55'	7° 43'	Loamy	1050
	Rimaye	N. Sudan	12° 19'	7° 54'	Loamy	728
	Barhim	N. Sudan	12° 58'	704,.	Sandy	734

1. S.Sudan = South Sudan; N. Sudan - North Sudan.
2. S. Loam = Sandy loam.

UGA 2 performed better in the drier North. Rainfall was adequate and reasonably well distributed in all the states, and did not, therefore, constitute a major constraint to crop performance during the year of the study (Table 1). Yield levels were not as high as expected probably due to other factors such as poor crop management by farmers, poor soil fertility, and biotic stresses.

Labor costs constituted about 80% of the total production costs while the costs of inputs made up only a small proportion of the total costs of production (Table 3).

Table 2. Mean yields (t ha^{-1}) of groundnut cultivars in nine villages in Kano, Jigawa and Katsina states in northern Nigeria.

State/village	ICGV 86015	Fleur 11	UGA 2	Local
Kano state				
Kofa	1.16	0.98	0.97	1.10
Panda	1.11	0.96	0.96	0.96
Badume	1.19	0.99	1.00	1.00
Jigawa state				
Kantoga	1.05	1.11	1.02	1.25
Dalari	1.25	1.05	1.11	0.92
Gijigami	1.13	0.90	1.13	1.11
Katsina state				
Gora	0.99	0.93	0.93	0.91
Rimaye	0.99	0.92	1.16	1.00
Barhim	0.96	0.93	0.92	0.92
Mean	1.09	0.97	1.02	1.02
SE	±0.100	±0.069	±0.088	±0.114

The variety ICGV 86015 yielded the highest net return per ha (N 13 360) followed by UGA 2 (N 12 160), the local variety (N 11 988) and Fleur (N 10 980) (Table 3). The positive returns per hour indicate that more labor could still be used profitably for producing these varieties. All the farmers obtained pod yields above the average yield of 0.40 t ha^{-1} required to cover the costs of production.

The characteristics of the varieties which farmers considered as desirable included high pod and reasonable haulm yields, large seed size, early maturity, and tolerance to drought and rosette disease. Most farmers, particularly in the villages of Dalari, Panda, Kantoga, and Gora preferred ICGV 86015 because crop establishment was satisfactory under drought conditions and it was early maturing. The seed size was acceptable and the pods were well filled. The haulm yields were also satisfactory. Farmers, however, reported problems of damage due to termite attack. Fleur 11 was liked by farmers because of its early maturity and good pod yield. The quantity and quality of haulms were, however, adversely affected by late leaf spot (*Phaeoisariopsis per sonata)* disease. UGA 2 had good quality haulms. It was later maturing and tolerant to aphid attack. It also had acceptable pod yield and the seeds were large.

Participating and nonparticipating farmers were excited about the performance of the cultivars tested. At the end of the cropping season the farmers exchanged seeds among themselves for sowing in the next cropping season. During two separate agricultural shows that were organized by the Local Government Areas (LGAs) of Kano and Jigawa states, farmers displayed, on their own initiative, samples of the three varieties, ICGV 86015, Fleur 11, and UGA 2.

Table 3. Costs and returns of producing different groundnut cultivars in northern Nigeria.

	ICGV 86015	Fleur 11	UGA 2	Local
Output (t ha^{-1})	1.09	0.97	1.02	1.02
Gross revenue (N ha^{-1})	21 880	19 480	20 500	20 400
Labor cost (N ha^{-1})	6220	6200	6040	6120
Other costs (N ha^{-1})				
Seeds	1000	1000	1000	1000
Fertilizer	800	800	800	800
Depreciation	500	500	500	500
Total cost (N ha^{-1})	8520	8500	8340	8420
Net income (N ha^{-1})	13 360	10 980	12 160	11 988
Returns (N ha^{-1})	63.00	55.42	41.71	59.15
Yield required to cover cost (t ha^{-1})	0.43	0.42	0.42	0.42

1. 1$ US = N 80.

This participatory on-farm evaluation of groundnut cultivars, which was a part of a larger diagnostic study, facilitated the characterization of production systems and the selection of benchmark sites in the study area. The study exposed farmers to new groundnut varieties from research and they were enthusiastic about growing them. This should further enhance the release process.

References

Olorunju, P.E., Kuhn, C.W., Demski, J.W., Misari, S.M., and Ansa, O.A. 1992. Inheritance of resistance in peanut to mixed infection of groundnut rosette virus (GRV) and groundnut rosette assistor virus and single infection of GRV. Plant Disease 76:95-100.

Yayock, J.Y., Rossel, H.W., and Harkness, C. 1976. A review of the 1975 groundnut rosette epidemic in Nigeria. Samaru Conference Paper 9. Institute for Agricultural Research (Samaru). Ahmadu Bello University, Zaria, Nigeria, 12 pp.

Development of Spanish Groundnut Genotypes with Fresh Seed Dormancy

P Manivel, R K Mathur, A Bandyopadhyay, and T G K Murthy (National Research Centre for Groundnut, PO Box 5, Junagadh 362 001, Gujarat, India)

Lack of fresh seed dormancy in the Spanish groundnut (*Arachis hypogaea L.* subsp *fastigiata* var *vulgaris*) is one of the major problems limiting its productivity. Hence, evolving Spanish groundnut varieties with genetically built-in dormancy is desirable. This paper reports on some dormant Spanish genotypes bred at the National Research Centre for Groundnut, Junagadh, Gujarat, India.

Both direct and reciprocal crosses were made between GG 2, a high-yielding but nondormant Spanish groundnut cultivar and GAUG 10, a Virginia bunch (*Arachis hypogaea L.* subsp *hypogaea* var *hypogaea*) cultivar with a fresh seed dormancy period of up to 35 days, to incorporate dormancy (Wadia et al. 1987). Twenty-three advanced breeding lines of bunch growth habit were derived by pedigree selection and tested for fresh seed dormancy in summer, 1998. Sound mature fresh seeds collected from these cultures were tested for germination following International Seed Testing Association (ISTA) rules, 1985. The germination test was conducted immediately after harvest and at 5-day intervals up to 35 days. Those cultures showing more than 10% germination immediately after harvest were discarded as they lacked dormancy. Two promising advanced breeding lines with fresh seed dormancy, PBS 16004 and PBS 16005, were identified (Table 1).

Table 1. Promising fresh seed dormant advanced breeding lines of groundnut.

Genotype	Pedigree	Pod yield (kg ha^{-1})	Fresh seed dormancy period (days)
PBS 16004	GAUG 10 x GG 2	3538	15-20
PBS 16005	GAUG 10 x GG2	2275	10-15

References

International Seed Testing Association. 1985. International rules for seed testing. Seed Science and Technology 13:300-520.

Wadia, K.D.R., Nageswara Rao, R.C., and Williams, J.H. 1987. An improved method for identification of dormant sequentially branched progenies from populations derived from crosses between non dormant (subspecies *fastigiata*) and dormant (subspecies *hypogaea*) groundnuts (*Arachis hypogaea L.*). Oleagineux 42:75-82.

Evaluation of Advanced Breeding Lines of Groundnut for Resistance to Thrips and Aphids

M Y Samdur, V Nandagopal, R K Mathur, and P Manivel (National Research Centre for Groundnut, PO Box 5, Junagadh 362 001, Gujarat, India)

In groundnut the Sesbania thrips (*Caliothrips indicus* Bagnall) and aphid *(Aphis craccivora* Koch) are the major sucking pests. They occur in almost all the groundnut-growing areas of India and particularly in the Saurashtra region of Gujarat where the infestations warrant the application of synthetic pesticides (Upadhyay and Vyas

1986, Acharya and Koshiya 1993). The foliar damage due to thrips ranged from 29 to 30% (Nandagopal and Vasantha 1991). Both these insects occur during the early period of vegetative growth. The infestation of thrips is generally noticed in groundnut around 20 days after sowing (DAS). Though the yield loss due to aphid feeding may not be significant, its role as a vector of peanut stripe virus (PStV) disease cannot be overlooked (Singh et al. 1993). Hence identification of resistant/tolerant groundnut varieties would be useful in breeding for resistance to these insects.

Table 1. Number of thrips eggs per leaf, aphid visual scores, and yield per plant in advanced breeding cultures of groundnut[1].

Culture	No. of eggs per leaf (thrips)	Visual scores (aphids)	Pod yield per plant (g)
PBS 11023	5.1	2.7	5.2
PBS 11046	5.7	2.4	10.6
PBS 12067	5.1	3.1	7.6
PBS 12102	13.2	2.8	11.2
PBS 14021	5.5	3.1	12,4
PBS 20026	6.0	3.9	4.9
PBS 20055	10.7	2.9	8.7
PBS 21020	2.6	2.0	12.6
PBS 23031	3.6	2.4	17.2
PBS 21063	7.8	1.8	5.9
PBS 22017	5.1	4.0	17.5
PBS 22023	15.1	3.0	6.4
PBS 22028	8.4	2.0	3.6
PBS 23003	1.4	1.8	7.9
PBS 23007	6.1	2.8	3.9
PBS 24002	9.0	2.4	7.1
PBS 24004	7.1	3.5	14.3
PBS 24005	0.5	2.1	3.5
PBS 24006	1.0	2.1	9.5
PBS 24030	1.0	2.5	5.3
PBS 24040	2.0	4.0	14.8
PBS 29022	6.8	3.4	9.5
PBS 29030	14.7	3.8	3.0
Code 5	5.1	2.8	7.0
Code 26	8.7	2.8	8.7
GG2	5.2	3.5	17.2
Gimar 1	2.1	3.0	10.5
JL24	8.9	4.0	11.0
SE	±2.96	±0.31	±1.80
CD (P = 0.05)	8.19	0.87	4.97

1. Mean of 3 replications.

Under net house conditions 28 cultures comprising 25 advanced breeding lines and three released varieties were sown in a complete randomized block design with three replications, each with 45 cm spacing between rows and 10 cm between plants within a row. Between 20 and 25 days after emergence these plants were infected with adult thrips and eggs. These thrips had been reared in the laboratory by multiplying adult thrips netted in the field by placing them on 20-day old seedlings in individual trays covered by net so that the thrips population could build up over 7-10 days. These trays, with 250-300 thrips per tray, were placed between the rows of advanced breeding lines and left undisturbed for infestation of the foliage of the cultures. The sampling of leaves was done 50 DAS by collecting 10 leaves at random (4th leaf from the top) per culture per replication and these were stored in plastic bottles containing 100 ml dimethyl sulphoxide (DMSO) solution to remove the chlorophyll pigments. The leaves were later stained with 0.5% acid fuchsin and thrips eggs were counted under a dissection microscope following Nandagopal and Soni (1994). The data on aphid infestation were recorded by visual scoring on 0-4 scale similar to Bhakhetia (1980).

The results indicated that the number of eggs laid per leaf varied from 0.5 to 15.1 (Table 1). The lowest number of eggs was recorded in the culture PBS 24005 (0.5) followed by PBS 23003 (1.4), PBS 24006 (1.0), 24030 (1.0), PBS 24040 (2.0), Girnar 1 (2.1), PBS 21020 (2.6), and PBS 21031 (3.6) and these were considered to be resistant. The remaining cultures recorded more than 5 eggs per leaf. The cultures PBS 20055, PBS 29030, and PBS 22023 recorded the highest number of eggs ranging from 10 to 15.1 and were categorized as susceptible.

Less aphid infestation was observed in the cultures of PBS 24005, PBS 24006, PBS 24030, Girnar 1, PBS 21031 and PBS 21020 and these were categorized as moderately resistant. The culture PBS 23003 possessed resistance against both the sucking insects (Table 1). In spite of the higher number of thrips and aphid damage the culture PBS 22017 recorded higher yield (17.5 g) and GG 2 had a yield of 17.2 g, so they were considered to be tolerant. As the evaluation was carried out under heavy population pressure, the genotypes showing resistance may therefore be further utilized in breeding programs.

Acknowledgment

The authors wish to thank Dr A Bandyopadhyay, Director NRCG, for encouragement and facilities.

References

Acharya, M.F., and Koshiya, D.J. 1993. Bionomics of groundnut thrips, *Caliothrips indica,* Bagnall (Thysanoptera: thripidae). Gujarat Agricultural University Research Journal 18:144 -119.

Bakhetia, D.R.C. 1980. Screening of breeding material for insect-pests resistance in oilseeds crops. Pages 155-174 *in* Breeding for oilseed crops (Gill, K.S., ed.). Ludhiana, Punjab, India: Punjab Agricultural University.

Nandagopal, V., and Soni, V.C. 1994. A simple method to determine feeding and oviposition behaviour of groundnut jassids (*Balcluthe hortensis* Lindb.). Journal of Oilseeds Research 11:31-33.

Nandagopal, V., and Vasantha, S. 1991. Influence of plant growth regulator on the population of thrips, *Caliothrips indica* (Bagnall) and damage in groundnut. Entomon 16:87-89.

Singh, V., Ghewande, M.P., and Reddy, P.S. 1993. Peanut stripe virus disease - present status and its management. International Journal of Pest Management 39:422-430.

Upadhyay, V.R., and Vyas, H.N. 1986. Comparative toxicity of certain insecticides to predatory coccinellids associated with sucking pests of groundnut in Saurashtra. Indian Journal of Plant Protection 13:91-93.

Screening Groundnut Breeding Lines for Resistance to Aphids, Aphis craccivora Koch

E M Minja[1], P J A van der Merwe[1], F M Kimmins[2], and P Subrahmanyam[1] (1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), PO Box 1096, Lilongwe, Malawi; 2. NRI/University of Greenwich, Chatham, Kent ME4 4TB, UK)

Aphis craccivora Koch is a major pest of groundnut (*Arachis hypogaea L.*) causing yield losses by feeding on phloem sap and through transmission of virus diseases (Padgham et al. 1990, Feakin 1973). It is a vector of at least seven viruses that attack groundnuts, the most important of which are groundnut rosette virus (GRV) in Africa and peanut stripe virus in Asia.

Host-plant resistance to *A. craccivora* in groundnut is recognized as the most effective, economic and sustainable method of limiting both the spread of the aphid and the viruses (Padgham et al. 1990). Evans (1954) demonstrated that host-plant resistance restricted the spread of GRV in Tanzania and subsequent studies confirmed this in Malawi (ICR1SAT 1988). Amin (1985) suggested that resistance mechanisms in groundnut could deter colonization by immigrant alatae and could also reduce their fecundity. Screening of germplasm from various regions by ICRISAT has led to the identification of aphid-resistant groundnut genotypes (ICRISAT 1988). Through the global groundnut breeding activities of the ICRISAT Chitedze Research Station near Lilongwe, Malawi, breeding lines and elite groundnut varieties were screened for aphid resistance after demonstrating field resistance to rosette virus infections during the 1998/99 cropping season.

Thirty-seven breeding populations (F_6) were compared to four standard controls (CG7, a rosette-susceptible but high-yielding medium-duration groundnut variety released in Malawi, Zambia, and Uganda; JL 24, a rosette-susceptible short-duration groundnut variety originating from India and released in Malawi and Zambia; ICG 12991, a short-duration rosette-resistant variety at final evaluation; and EC 36892, a medium-duration groundnut aphid resistant variety from ICRISAT Genetic Resources Unit) in a screenhouse experiment.

The F_6 populations were selected from four crossing combinations. The variety EC 36892 was the female parent and the source of resistance to A. craccivora. The male parents and the progenies expressed host-plant resistance to rosette virus under high disease pressure conditions in Malawi. The objective of the crosses was to combine rosette virus resistance with resistance to the vector (*A. craccivora*). The details of pedigrees are presented in Table 1.

Table 1. Pedigree of the groundnut varieties derived from crosses involving a female aphid-resistant parent and rosette virus-resistant male parents.

	Pedigree	
Identity	Female	Male
ICGX-SM 94101	EC36892	ICG 6428
ICGX-SM 94104	EC36892	ICGV-SM 90704
ICGX-SM 94108	EC36892	ICG 7457
ICGX-SM 94110	EC36892	ICG 9540

In the screenhouse, three seeds of each genotype were sown in plastic pots (13 cm top diameter, 13 cm high) containing a local Alfisol. There were ten replicates in a randomized complete block design. The soil in the pots was constantly kept moist. Six days after sowing (DAS) the seedlings were inspected and thinned to one per pot. Eight days after sowing, single first instar aphid nymphs from a culture maintained on a susceptible groundnut variety, Malimba, were introduced onto the tender leaf of each seedling. After confirming that each nymph was moving about on the area of placement, each pot was covered by a crisp bag and secured in place. Aphids were left to move freely along plants and feed. Daily observations were maintained on the development of nymphs to adults and reproductive life. New first instar nymphs were observed on some of the lines six days after first instar infestation (DAFI) on plants. The adults were left to reproduce for five days after which the first colony count was made (10 DAFI) on each plant. The plants were secured in place for the colonies to develop further for another five days and care was taken to avoid disturbance. A second colony count was made at 15 DAFI to get an overview of any further population growth over time.

The results indicated that first instar aphid nymphs established on all genotypes tested (Table 2). The rate of nymphal growth and time taken to produce new offspring nymphs varied between genotypes. There were highly significant differences ($P<0.001$) of offspring population counts between the 41 genotypes at the two counting dates. Among the genotypes selected from previous field trials, aphid fecundity at 10 and 15 DAFI showed that ICG 12991 had the lowest rate of nymph development, low fecundity, and relatively smaller-sized aphids compared with EC 36892, CG 7, and JL 24.

The aphid population counts on eight breeding lines among the F_6 populations and the controls are shown in Table 2. The results indicated that the genotypes tested showed varying degrees of resistance to A. craccivora by reduced aphid growth and fecundity. The level of resistance in ICG 12991 was significantly higher ($P<0.001$) than the other control varieties. JL 24 was most susceptible, with all its plants supporting the highest aphid reproductive rate compared with the other genotypes. Among the breeding populations, the majority showed higher levels of resistance compared with EC 36892 at both 10 DAFI and 15 DAFI.

Although screening was only conducted during the first month of groundnut plant establishment (up to 30 DAS), this period covers most of the stage when groundnut plants are vulnerable to rosette virus infections in the field. If the aphids land on the plant and delay in maturity which leads to low offspring populations, it would imply that there could probably be delayed disease spread to other plants. It is also probable that there are various factors in the plants which deter the aphids from settling and developing normally. These preliminary results, therefore, support the suggestion by Amin (1985) and Kimmins (F M Kimmins, NRI/University of Greenwich, Chatham, Kent, UK, personal communication, 1999) that resistance mechanisms in groundnut could deter colonization and reduce fecundity. Field experiments to further assess the populations under natural/artificial aphid populations and screenhouse trials to establish the mechanisms of resistance in these genotypes should be considered as a priority area for immediate research work.

Table. 2 Mean aphid population counts on F_6 groundnut lines and controls.

Identity	Count at 10 DAFI[1]	Count at 15 DAFI
ICGX-SM 94101/P1	14.3[2]	92.7[2]
ICGX-SM94101/P7	19.7	49.4
ICGX-SM 94104/P5	19.5	72.2
ICGX-SM 94104/P10	18.6	93.0
ICGX-SM 94108/P1	15.0	46.1
ICGX-SM 94108/P3	18.2	69.9
ICGX-SM 94109/P2	20.3	43.0
ICGX-SM 94109/P3	16.8	66.1
Control		
JL24	42.8	265.6
EC 36892	29.2	209.2
CG7	32.0	294.7
ICG 12991	9.0	14.8
Mean	25.2	105.7
SE	±4.26	±22.01
LSD (P = 0.05)	11.85	61.28

1. DAFI = Days after first instar infestation.
2. Mean of 10 replications.

References

Amin, P.W. 1985. Resistance of wild species of groundnut to insect and mite pests. In Cytogenetics of Arachis. Proceedings of the International Workshop, 31 Oct-2 Nov 1983, ICRISAT Center, India. Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

ICRISAT. (International Crops Research Institute for the Semi-Arid Tropics). 1988. Annual report 1987. Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 390 pp.

Evans, A.C. 1954. Groundnut rosette disease in Tanganyika. I. Field studies. Annals of Applied Biology 41:189-206.

Feakin, S.D. 1973. (ed.). Pest control in groundnuts. 3rd edn. Page 123 *in* PANS manual no. 2, London, UK: Centre for Overseas Pest Research.

Padgham, D.E., Kimmins, F.M., and Ranga Rao, G.V. 1990. Resistance in groundnut (*Arachis hypogaea L.*) to *Aphis craccivora* (Koch). Annals of Applied Biology 117:285-294.

Evaluation of Advanced Breeding Genotypes of Groundnut for Resistance to Major Foliar Fungal Diseases

M Y Samdur, R K Mathur, P Manivel, M P Ghewande, and A Bandyopadhyay (National Research Centre for Groundnut, PO Box 5, Junagadh 362 001, Gujarat, India)

Early leafspot (*Cercospora arachidicola*), late leafspot (Phaeoisariopsis personata), and rust (*Puccinia arachidis*) are important foliar diseases of groundnut (*Arachis hypogaea L.*) causing severe damage to the crop (McDonald et al. 1985, Kokalis-Burelle et al. 1997). These foliar diseases both reduce the yield and render the fodder unsuitable as animal feed by causing deterioration in quality of the plant biomass. Control of these diseases through application of fungicides not only increases the cost of cultivation, but also leads to environmental and health hazards. Therefore, the development of resistant cultivars is one of the best alternatives to reduce the incidence of these diseases. Attempts have been made at the National Research Centre for Groundnut (NRCG) to develop such cultivars/genotypes with the major emphasis on foliar disease resistance. Materials developed in this breeding program have been evaluated for their resistance to early and late leafspots, and rust.

The trial included 29 promising advanced breeding Virginia genotypes *(A. hypogaea* subsp *hypogaea* var *hypogaea*) along with two control varieties. It was laid out in a randomized complete block design with three replications during the rainy seasons of 1996 and 1997 at the NRCG, Junagadh, Gujarat. The plots were of 5 rows, each of 5 m length, with interrow spacing of 60 cm and plant-to-plant distance of 10 cm. The recommended agronomic practices were followed. Disease severity of early leafspot (ELS), late leafspot (LLS) and rust were recorded by adopting a modified 1-9 scale under field conditions (Subrahmanyam et al. 1995).

The genotypes PBS 20026, PBS 21063, PBS 22028, CS 19 (TMV 2 x *A. chacoense*), and Code 7 (J11 x *A. cardenasii*) were consistently resistant or moderately resistant to ELS during both the seasons (Table 1). Genotypes PBS 20026, PBS 21063, PBS 23007, and CS 19 recorded scores from 2.7 to 5.0 during both seasons, and were, therefore, categorized as resistant/moderately resistant to LLS. Four genotypes, PBS 20026, PBS 21063, PBS 23007, and CS 19 showed consistently moderate resistance to ELS, LLS, and rust. The genotype PBS 21063 was also equivalent to the best control, ICGS 44, for pod yield. The cultivar PBS 23007 also combined a high level of resistance to all three diseases and good yield level. High yield potential and a high degree of resistance do not generally go together (Nigam et al. 1991). Lower dry matter partitioning in rust- and LLS-resistant genotypes have been reported by Williams et al. (1984). Hence, a good strategy for resistance breeding would be the development of genotypes with high yield potential and a moderate level of resistance. Some of the resistant genotypes reported in this paper may be recommended for testing their performance under different agroclimatic conditions and/or further use as donor parents in breeding programs.

Acknowledgment

The authors wish to thank Dr P Paria, Senior Scientist (Cytogenetics), NRCG, for providing some of the interspecific advanced breeding genotypes.

References

Kokalis-Burelle, N., Porter, D.M., Rodrignez-Kabana, R., Smith, D.H., and Subrahmanyam, P. (eds.) 1997. Compendium of Peanut Diseases, 2nd edn. St. Paul, Minnesota, USA: APS Press. 94 pp.

McDonald, D., Subrahmanyam, P., Gibbons, R.W., and Smith, DM. 1985. Early and late leafspots of groundnut. Information Bulletin no. 21, Patancheru 502 324, Andhra Pradesh, India: International Crop Research Institute for the Semi-Arid Tropics. 24 pp.

Table 1. Disease scores for early leafspot (ELS), late leaf spat (LLS) and rust diseases, and yield and yield-contributing traits in advanced breeding genotypes of Virginia groundnut during rainy seasons 1996 and 1997, Junagadh, Gujarat, India.

Genotype	ELS 1996	ELS 1997	ELS Mean[1]	LLS 1996	LLS 1997	LLS Mean[1]	Rust 1996	Rust 1997	Rust Mean[1]	Yield plant^{-1} (g)	100-seed mass (g)	Selling percent
PBS 11023	5.4	5.6	5.5	7.5	7.0	7.25	7.0	4.8	5.90	11.26	32.23	68.46
PBS 11046	5.3	5.6	5.4	7.9	7.3	7.60	6.5	4.6	5.55	16.15	37.32	69.22
PBS 20026	3.6	3.8	3.7	4.2	4.3	4.25	4.3	5.2	4.75	10.11	32.36	64.87
PBS 20055	5.0	7.4	6.2	6.2	8.2	7.20	5.8	6.1	5.95	12.40	29.15	71.28
PBS 21020	6.6	5.4	6.0	7.8	8.3	8.05	8.0	5.8	6.90	17.55	29.05	61.41
PBS 21031	6.5	6.2	6.3	8.2	8.1	8.15	7.6	5.5	6.55	16.89	31.41	66.43
PBS 21050	6.9	5.2	6.0	7.5	7.5	7.50	7.4	5.2	6.30	17.56	30.25	64.91
PBS 21063	3.1	3.0	3.0	2.8	4.2	3.50	4.7	4.7	4.70	16.68	36.57	66.97
PBS 22028	4.3	3.6	3.9	5.4	4.1	4.75	5.2	5.2	5.20	18.79	38.56	65.50
PBS 23007	5.1	3.7	4.4	5.0	4.1	4.55	5.4	4.5	4.95	13.09	29.29	57.30
PBS 24001	5.6	6.0	5.8	6.7	7.4	7.05	7.8	5.6	6.70	12.67	29.28	69.35
PBS 24002	4.6	5.3	4.9	5.4	6.8	6.10	6.9	5.9	6.40	13.06	30.20	71.06
PBS 24003	5.7	4.3	5.0	7.3	5.2	6.25	7.6	4.7	6.15	18.89	31.47	71.65
PBS 24004	5.8	5.9	5.8	6.7	6.9	6.80	4.1	5.2	4.65	14.30	27.70	63.70
PBS 24005	4.6	5.3	4.9	5.1	6.8	5.95	5.7	5.3	5.50	17.32	33.83	68.35
PBS 24006	5.2	4.1	4.6	6.5	5.0	5.75	5.9	3.7	4.80	15.40	35.74	70.86
PBS 24030	5.6	5.9	5.7	6.3	7.0	6.65	6.0	5.3	5.65	14.89	35.75	69.35
PBS 24040	4.8	5.5	5.1	6.2	7.3	6.75	7.0	5.8	6.40	13.63	28.26	62.25
PBS 24041	6.6	5.50	6.0	7.5	8.4	7.95	7.7	5.4	6.55	11.07	38.63	66.48
PBS 29022	5.8	6.0	5.9	7.3	7.8	7.55	8.3	5.6	6.95	17.25	30.86	67.34
PBS 29030	6.4	4.6	5.5	6.6	5.7	6.15	7.5	5.3	6.40	15.66	40.78	66.07
CS 19	3.9	1.6	2.7	4.2	2.8	3.50	4.4	2.7	3.55	7.51	29.26	65.74
CS 21	5.8	5.8	5.8	5.7	7.3	6.50	6.4	5.4	5.90	13.94	33.47	70.83
Code 7	5.0	2.7	3.8	5.4	6.0	5.70	5.3	3.1	4.20	11.82	28.00	72.64
Code 11	4.9	4.6	4.7	6.8	5.2	6.00	6.6	4.8	5.70	13.74	29.53	62.94
Code 12	5.4	5.4	5.4	6.3	8.0	7.15	6.2	5.9	6.05	12.25	24.34	64.99
Code 13	5.8	5.7	5.7	7.3	7.2	7.25	6.8	5.6	6.20	12.15	28.72	67.14
Code 30	5.9	3.6	4.7	7.7	6.9	5.80	6.9	3.8	5.35	17.88	37.12	68.18
1CGS 44	6.1	6.1	6.1	7.2	7.8	7.50	7.3	7.4	7.35	16.62	31.97	69.19
Kadiri 3	5.8	6.2	6.0	6.8	7.4	7.10	7.8	4.9	5.85	15.41	31.19	70.13
SE	±0.20	±0.25	±0.2	±0.28	±0.27	±0.28	±0.27	±0.23	±0.24	±1.23	±2.12	±1.62
CD (P - 0.05)	0.55	0.69	0.5	0.77	0.75	0.77	0.74	0.63	0.66	3.40	5.85	4.47
CV (%)	6.39	8.78	7.0	7.49	7.45	7.60	7.50	7.89	7.20	23.82	10.97	4.20

1. The means pooled over two rainy seasons.

Nigam, S.N., Dwivedi, S.L., and Gibbons, R.W. 1991. Groundnut breeding: constraints, achievements and future possibilities. Plant Breeding Abstracts 61:1127-1136.

Subrahmanyam, P., Reddy, L.J., Nigam, S.N., Gibbons, R.W., Rao, V.R., Singh, A.K., Pande, S., Reddy, P.M., and Subba Rao, P.V. 1995. Screening methods and sources of resistance to rust and late leafspots of groundnut. Information Bulletin no. 47. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 24 pp.

Williams, J.H., Ramraj, V.M., and Pal, M. 1984. Physiological studies on foliar diseases: varietal differences in response to use of fungicides. Pages 49-53 in Groundnut Rust Disease: Proceedings of a Discussion Group Meeting, 24-28 Sep 1984, ICRISAT Center, India. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Aflatoxin Contamination of Groundnuts in Mozambique

P S van Wyk[1], P J A van der Merwe[2], P Subrahmanyam[2], and D Boughton[3] (1. Oil and Protein Seed Centre, Grain Crops Institute, Private Bag X1251, Potchefstroom, 2520, South Africa; 2. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), PO Box 1096, Lilongwe, Malawi; 3. Department of Agricultural Economics, Michigan State University, East Lansing, MI 48824-1039, USA)

Contamination of groundnut (*Arachis hypogaea L.*) with aflatoxins, the secondary toxic metabolites produced by fungi of the *Aspergillus flavus* Link ex Fries group, is a serious quality problem (Mehan et al. 1991). The fungi invade groundnut seeds before harvest, during postharvest drying/curing, and during storage. Preharvest aflatoxin contamination is important during the pod development under drought conditions while postharvest contamination is significant under wet and humid conditions (Mehan 1987).

Mozambique is the largest producer of groundnut in southern Africa. The crop is grown almost throughout the country, with the largest concentration in Nampula Province in the northern region. Groundnut plays an important role both as a food and cash crop for smallholder farmers in the country. It is an important component of rural diet and provides supplementary cash income to women farmers in Mozambique. The crop is grown and managed mostly by resource-poor farmers, especially women.

Aflatoxin contamination is a serious quality problem in Nampula Province. Loss of international and regional markets is attributed to poor quality of nuts due to aflatoxin contamination. South African companies, which are the major contacts for the international export market for Mozambique, discontinued buying groundnuts from Nampula because of high levels of aflatoxin contamination (G A de Wit, South African Peanut Co., PO Box 172, Pretoria 0020, personal communication). Hence, there is a need for systematic evaluation of the incidence and extent of aflatoxin contamination at the farm level and at buying points and warehouses. This information will permit the identification of appropriate methods of management suitable to smallholder fanners, traders, and exporters.

This paper reports the incidence of fungal infection and levels of aflatoxin contamination in groundnut samples collected from farmers at lifting and after drying/curing, and from traders at buying points.

Soil and climate characteristics and groundnut cultivation

Groundnut-producing areas in Nampula are predominantly deep, sandy soils. Soils in the western part, in Malema and Ribawe districts, are heavier and consist of light textured, brownish-red clay loams and sandy clay loams. Nampula falls in one of the agroclimatic regions with high rainfall (700-800 mm annum^{-1}), but it is unevenly distributed. The highest rainfall usually occurs from mid-November to early April. Severe dry spells are usually experienced from mid-December to late January. Warm winters and hot summers with temperatures rising above 30°C are experienced. Groundnut sowing proceeds from late-November to mid-January and harvesting begins in mid-April. Both short-duration (110 days) and long-duration (140 days) varieties are grown.

Groundnut sampling and analysis

Thirty-four groundnut samples were collected from farmers at the time of lifting in 10 districts, and 30 samples after drying/curing in five districts in Nampula Province. Ten samples were also collected from traders at two different buying points. In each case, approximately 200 g of pods were collected, dried in paper bags, and the samples were sent to South Africa for mycological examination and aflatoxin analysis.

Seeds were examined at the Oil and Protein Seed Centre, Potchefstroom, South Africa, and the percentage of moldy seed was determined. Each seed sample (50 g) was analyzed for the occurrence of aflatoxins at the Quality Assurance Laboratory, Perishable Products Exports Control Board, PO Box 40863, Arcadia 0007, South Africa.

Results

The percentage of seed with visible mold growth and the levels of aflatoxin contamination (ug kg^{-1}) in groundnut samples are presented in Table 1. Of 34 samples collected at lifting, 13 were contaminated with aflatoxins and eight recorded aflatoxin levels in excess of 30 ug kg^{-1}. Samples from Mecubury, Muabassa, Nampula, Nacaroa, and Malema were free of aflatoxins. Fifteen samples showed visible mold growth, but were free of aflatoxins. Two samples from Erati had heavy mold growth but were free of aflatoxins. Samples from Mugovola and Murrupuia showed the highest levels of aflatoxin contamination (620 to 1320 ug kg^{-1}). Out of 30 samples collected from farmers after drying/curing, 10 recorded the presence of aflatoxins and four had in excess of 30 ug kg^{-1}. Two samples from Amendo, and one each from Mugovola and Erati, showed very high levels of aflatoxin contamination. Several samples from Erati were highly moldy (mean 25.1%) but with little or no aflatoxin contamination. Of 10 samples collected from traders, only two showed aflatoxin contamination. All the samples collected from Nakala had very severe mold growth (mean 54%), but only two contained aflatoxins (Table 1). The high incidence of mold growth and the low levels of aflatoxin content in some samples are probably due to high temperatures during pod development and drying/curing phases.

Four samples collected from farmers at lifting and from traders at buying points were also examined to determine the aflatoxin composition (B1, B2, G1, and G2) and the results are presented in Table 2. Aflatoxin G1 was predominant in samples collected at lifting and aflatoxin B1 in samples collected from traders. Predominance of aflatoxin G1 in samples collected at harvest suggests that A. parasiticus is probably the major colonizer (Klich and Pitt 1988, van Wyk 1998).

Conclusions

The results of this study show that aflatoxin contamination is a serious problem in Nampula Province and the contamination occurs in both preharvest and postharvest phases. Some of the locations showed extremely high levels of aflatoxin content (2740 ug kg^{-1}) and the produce is unfit both for human and animal consumption. Further investigations are required to understand the factors

Table 1. Percentage of moldy seed and aflatoxin content in groundnut samples collected from farmers' fields at lifting (10 locations), after drying/curing (five locations), and from traders at buying points (two locations) in Nampula Province, Mozambique, during the 1997/98 crop season.

Location	No. of samples tested	Moldy seed (%)[1]		Aflatoxin content (ug kg^{-1})	
		Range	Mean	Range	Mean
Samples collected at lifting					
Mugovola	7	0-19	5.0	0-620	167.9
Mecubury	3	1-7	4.7	0	0
Muabassa	1	4	4.0	0	0
Erati	4	0-19	9.3	0-24	5.9
Muecate	4	0-15	4.8	0-97	24.3
Murrupuia	5	3-13	7.6	0-1320	750.8
Nampula	2	1-4	2.5	0	0
Ribawe	2	0-4	2.0	0-2	0.8
Nacaroa	5	0-4	2.2	0	0
Maletna	1	0	0	0	0
Samples collected after drying/curing					
Amendo	8	0-8	4.1	0-2740	362.2
Mugovola	6	1-4	1.8	0-1382	230.7
Mecubury	1	4	4	0	0
Erati	9	6-48	25.1	0-167	20.5
Murrupuia	6	4-10	7.0	0	0
Samples collected from buying points					
Mugovola	5	0-6	2.4	0	0
Nakala	5	32-64	54.0	0-31	10.9

1. Percentage of seeds showing visible moldiness due to infection by A.flavus and Macrophomina phaseolina (Tassi) Ooid.

Table 2. Aflatoxin composition in four groundnut samples collected from farmers at lifting and in two samples collected from traders at buying points in Nampula Province, Mozambique, in 1998.

Sample	Aflatoxin content (ug kg^{-1})				Total aflatoxin
	B1	B2	G1	G2	(ug kg^{-1})
At lifting					
1	1041	63	1126	510	2740.1
2	54	8	90	3	154.6
3	476	142	652	112	1381.5
4	55	21	55	36	166.9
At buying point					
1	20	2	2	0	23.4
2	22	5	4	1	31.0

contributing to aflatoxin contamination. Drought and temperature stress during the pod development and damage to pods by soil pests and diseases (preharvest phase), and the practices of lifting, drying/curing, and storage (postharvest phase) need to be critically examined before interventions are suggested to farmers, traders, processors, and exporters. Experience gained in other countries on the management of aflatoxin contamination should be utilized to educate farmers and other stakeholders in Mozambique.

References

Klich, M.A., and Pitt, J.I. 1988. Differentiation of *Aspergillus flavus* from A. parasiticus and other closely related species. Transactions of the British Mycological Society 91:99-108.

Mehan, V.K., McDonald, D., Haravu, L.J., and Jayanthi, S. 1991. The groundnut aflatoxin problem: review and literature database. International Crops Research Institute for the Semi-Arid Tropics (ICR1SAT), Patancheru 502 324, Andhra Pradesh, India. 387 pp.

Mehan, V.K. 1987. The aflatoxin contamination problem in groundnut: control with emphasis on host plant resistance. Pages 63-92 in Proceedings of the First Regional Groundnut Plant Protection Group Meeting and Tour, 15-21 Feb 1987, Harare, Zimbabwe. Chitedze Research Station, Lilongwe, Malawi: ICRISAT Regional Groundnut Program for Southern Africa.

van Wyk, P.S., Cillier, A.J., and Labuschagne, C.L.E. 1998. Occurrence of aflatoxin-producing isolates within the *Aspergillus flavus*-group fungi in South African groundnut seed. African Plant Protection 4:129-132.

Response of Spanish Groundnuts to Stem and Pod Rots Caused by *Sclerotium rolfsii* Sacc.

A Krishnakanth, M V C Gowda, and B N Motagi
(Department of Plant Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad 580 005, Karnataka, India)

Stem and pod rots, caused by *Sclerotium rolfsii* Sacc. are a major constraint to production in most of the groundnut-growing areas in India (Mehan et al. 1995a). Various cultural, chemical, and biocontrol practices have been recommended for control of these diseases, but individually they are not effective. Hence, integrated disease management incorporating different approaches has been suggested for effective control (Sherwood et al. 1995). Host-plant resistance is an important component of such an approach. But there is no information about the reaction to this disease of Spanish bunch cultivars currently grown in India. Screening for resistance in the field is complicated by the nonuniform spatial distribution of sclerotial inoculum, and as a result consistent and reliable data are difficult to obtain.

In the present study, 10 Spanish bunch cultivars along with already known resistant (ICGV 87165 and ICGV 86590) and susceptible (TMV 2) controls (Mehan et al. 1995b) were evaluated in 3.38 m^2 plots with four replications in a randomized block design by artificial inoculation over two seasons. The recommended package of practices for groundnut cultivation was adopted. Harvesting was done according to the maturity of different entries.

S. rolfsii was isolated from diseased groundnut plants grown in Vertisols. Sand-corn meal medium (Abeygunawardena and Wood 1957) was used to prepare the culture of *S. rolfsii.* Inoculum containing mycelia and sclerotia along with corn meal and sand was applied to the soil surface around the base of groundnut plants at approximately 125 g per 2.5 m in row, 50-60 days after sowing. Sorghum stubble (3-4 cm pieces) was scattered along the rows to enhance the fungal growth. After two weeks the inoculation was repeated. Plants showing symptoms of stem rot, pod rot, or both stem and pod rots were counted at harvest and the incidence was expressed as a percentage of the total number of plants in each plot. The data was subjected to AMOVA in each season and over seasons using pooled analysis. Genotypes exhibited significant variation in both the seasons and pooled analysis revealed significant genotype x season interactions.

Two known resistant genotypes (ICGV 87165 and ICGV 8650) showed significantly low incidence compared with the susceptible control (TMV 2) thus confirming their reaction (Table 1). Most Spanish bunch cultivars of Karnataka State (TMV 2, JL 24, Dh 40, KRG 1, R 8808) and germplasm lines (ICG 5125 and ICG 5247) were susceptible (>57.2%) as they recorded significantly more disease than the resistant controls. Dh 8, a Spanish bunch cultivar was, however, comparable or superior to resistant controls. Foliar disease-resistant Spanish bunch mutants, such as VL 1-28-2, VL 1-45, and VL 1-110 also exhibited susceptible reactions to *S. rolfsii.* Among them, VL 1-45 (81.4%), was extremely susceptible to the disease. The genotype R 8808 recorded lower disease incidence in the postrainy (49.6%) than in the rainy season (83.0%) indicating a need for multiple evaluations for confirming the resistance and its stability. The resistant sources identified in the present study could be used in future breeding programs.

Table 1. Response of groundnut genotypes to Sclerotium rolfsii inoculation.

	Disease incidence (%)		
Genotype	Postrainy season	Rainy season	Pooled
Dh8	22.3a[1]	22.9ab	22.6a
KRG I	50.6cd	65.3ef	57.9c
JL24	50.2cd	64.3e	57.2c
R8808	49.6cd	83.0i	66.3f
ICG 5125	50.1 ed	78.2hi	64.1def
ICG 5247	61.8 ef	52.3d	57.0c
Dh 40	67.2f	65.1e	66.1ef
VL 1-45	76.9g	85.7j	81.4g
VL 1-28-2	55.9e	65.0e	60.5cde
VL 1-110	50.2cd	67.1efg	58.7cd
Resistant controls			
ICGV 86590	32.2b	22.5a	27.4a
ICGV 87165	43.4c	30.6c	37.0b
Susceptible control			
TMV 2	57.1de	72.1fgh	64.6ef
Mean	51.36	59.56	55.46
SE	±3.28	±2.40	±2.03
CD (P = 0.05)	9.41	6.88	5.70
CV (%)	9.03	5.70	7.33

1. Figures with same letters are not significantly different at (P = 0.0 5).

References

Abeygunawardena, D.V.W., and Wood, R.K.S. 1957. Factors affecting the germination of sclerotia and mycelial growth of *Sclerotium rolfsii* Sacc. Transactions of the British Mycological Society 40:221-230.

Mehan, V.K., Mayee, C.D., Benneman, T.B., and McDonald, D. 1995a. Stem and pod rots of groundnut. Information Bulletin no. 44. Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 19 pp.

Mehan, V.K., Mayee, C.D., McDonald, D., Ramakrishna, N., and Jayanthi, S. 1995b. Resistance in groundnut to *Sclerotium rolfsii* caused stem and pod rots. International Journal of Pest Management 41:79-83.

Sherwood, J.L., Beute, M.K., Dickson, D.W., Elliott, V.J., Nelson, R.S., Opperman, CH., and Shew, B.B. 1995. Biological and biotechnological control advances in *Arachis* diseases. Pages 160-206 *in* Advances in peanut science (Patte, E.H., and Stalker, H.T., eds.). Stillwater, USA: American Peanut Research and Education Society, Inc.

Screening of Groundnut Genotypes for Resistance to Kalahasti Malady and Late Leaf Spot Diseases

P Harinath Naidu[1], A Sudhakar Rao[1], and S B Sharma[2]
(1. Regional Agricultural Research Station, Acharya N G Ranga Agricultural University, Tirupati 517 502, Andhra Pradesh, India; 2. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India)

Kalahasti malady, a pod disease caused by a stunt nematode (*Tylenchorhynchus brevilineatus*), was first reported during the 1975/76 postrainy season on groundnut in the Srikalahasti area in Chittoor district, Andhra Pradesh (Reddy et al. 1984). Yield losses of 20-50% are common in severely infected fields. Sources of resistance to this disease have been identified (Siva Rao et al. 1986, Mehan and Reddy 1988, Harinath Naidu 1996). The late leaf spot disease (LLS) caused by *Phaeoisariopsis personata* is an important constraint to groundnut production and sources of resistance have been identified (Subrahmanyam et al. 1982, Harinath Naidu 1997). This paper reports results of screening of 42 groundnut genotypes for resistance to kalahasti malady and late leaf spot.

Experiments were conducted during the 1995-97 postrainy seasons in kalahasti malady-infected soils at a farm of Andhra Pradesh State Seed Development Corporation (APSSDC), Srikalahasti, Andhra Pradesh. A randomized block design (RBD) was followed with two replications. Each genotype was sown in two 5 m-long rows. The test genotypes were sandwiched by rows of a susceptible control, JL 24. The rows were 30 cm apart with a plant-to-plant distance of 10 cm. All the genotypes were screened for late leaf spot severity at the Regional Agricultural Research Station (RARS) farm, Tirupati, during the rainy seasons of 1995 and 1996 in addition to testing them in the postrainy seasons at APSSDC farm, Srikalahasti. The late leaf spot severity was recorded at 90 days after sowing on a a 1-9 scale (Subrahmanyam et al. 1982). The genotypes were harvested at maturity and 25 randomly-selected plants of each genotype were scored for kalahasti malady severity on a 1-5 scale (Reddy et al. 1984). The observations on number of pods and pod yield were recorded (Table 1).

Of the 42 genotypes screened for kalahasti malady, 29 showed a significantly lower disease score than the control, JL 24. Three genotypes, ICGV 92195, ICGV 92268, and ICGV 92269 produced a significantly greater number of pods (12.2 to 12.5) and higher pod yield (9.9 to 10.6 g $plant^{-1}$) than the control. Among the 10 moderately-resistant genotypes (2.0-3.0 disease score) ICGV 93370 and ICGV 92196 produced a significantly greater number of pods (11.8 to 12.4) and higher pod yield (9.1 to 10.6 g $plant^{-1}$).

All the 42 genotypes screened against LLS were found susceptible to LLS with a disease score of 7.5 to 9.0.

The three resistant genotypes, ICGV 92195, ICGV 92268, and ICGV 92269, which gave significantly better pod yields, may be considered for recommendation to farmers in the nematode affected areas.

Table 1. Reaction of 42 short-duration groundnut genotypes to kalahasti malady and late leaf spot diseases.

Genotype	Kalahasti malady severity (1-5 scale)[1]	LLS severity (1-9 scale)	Number of pods $plant^{-1}$ (g)	Pod yield $plant^{-1}$ (g)
ICGV 93370	2.6	8.8	12.4	10.6
ICGV 93373	3.3	9.0	9.4	7.6
ICGV 93379	3.1	9.0	8.0	11.5
ICGV 93383	3.0	9.0	7.5	6.5
ICGV 93407	2.9	8.8	8.1	7.1
ICGV 93411	3.9	8.0	10.0	6.2
ICGV 93420	2.8	9.0	9.1	7.3
ICGV 93433	3.4	7.8	7.4	6.2
ICGV 93433	3.9	8.7	7.0	6.5
ICGV 93436	3.0	9.0	7.4	6.0
ICGV 93437	3.0	8.7	8.1	6.2
ICGV 93438	3.2	8.8	11.4	6.7
ICGV 92195	2.0	9.0	10.0	9.1
ICGV 92196	2.8	8.7	11.8	9.1
ICGV 92199	4.0	7.7	12.6	7.4
ICGV 92209	3.3	7.5	9.7	6.9
ICGV 92212	3.3	8.8	8.7	5.7
ICGV 92216	2.9	6.8	10.8	8.2
ICGV 92218	4.0	7.8	9.0	7.0
ICGV 92222	2.6	8.3	7.0	6.5
ICGV 92224	2.8	9.0	6.7	6.2
ICGV 92229	4.5	9.0	7.4	7.4
ICGV 92242	2.4	7.8	6.1	5.9
ICGV 92243	2.7	9.0	8.0	6.3
ICGV 92247	2.9	8.8	10.9	7.4
ICGV 92255	4.6	9.0	12.1	8.9
ICGV 92261	3.8	8.5	9.1	6.8
ICGV 92268	2.0	8.8	12.5	9.9
ICGV 92269	2.0	8.8	12.2	10.6
ICGV 91109	3.2	8.8	10.4	7.6
ICGV 91112	4.4	9.0	10.4	7.4
ICGV 91114	3.4	9.0	10.1	6.6
ICGV 91116	3.8	9.0	10.7	7.4
ICGV 91117	3.1	8.8	9.8	7.9
ICGV 91118	3.2	8.7	8.9	5.1
ICGV 91123	3.2	8.0	10.4	5.2
ICGV 91124	3.6	8.0	8.5	5.0
ICGV 91151	3.9	8.8	4.9	4.5
ICGV 91155	3.7	9.0	6.6	5.6
ICGV 89023	3.5	8.7	8.6	5.9
ICGV CHICO	4.3	8.7	7.1	4.8
JL 24 (Control)	4.5	9.0	8.2	6.2
CD (P = 0.05)	0.8	0.5	2.8	2.3
CV (%)	12.6	3.7	15.8	17.1

1. Disease scale (1 = No disease symptoms, 2 = Pods normal in size with a few small dark brown to black lesions covering 1-25% of pod surface, 3 = Pods normal in size with lesions covering 25-50% of pod surface, 4 = Pods smaller in size with lesions covering 50-75% of pod surface, 5 = Pods much smaller in size with lesions covering more than 75% of pod surface).

References

Harinath Naidu, P. 1996. Etiology and management of Kalahasti malady in groundnut. Ph.D. thesis, Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad 500 030, Andhra Pradesh, India. 272 pp.

Harinath Naidu, P., Vasanthi, R.P., Rajagopal, N., Sudhakar Rao, A., and Papa Rao, A. 1997. Screening of groundnut genotypes to late leaf spot. The Andhra Agricultural Journal 44:94-98.

Mehan, V.K., and Reddy, D.D.R. 1988. Investigations on a nematode disease of groundnut caused by *Tylenchorhynchus brevilineatus*. Groundnut Pathology Progress Report no. 19, Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 160 pp.

Reddy, D.D.R., Subrahmanyam, P., Sankara Reddy, G.H., Raja Reddy, C., and Siva Rao, D.V. 1984. A nematode disease of peanut caused by *Tylenchorkynchus brevilineatus*. Plant Disease 68:526-529.

Siva Rao, D.V., Srinivasan, S., and Raja Reddy, C. 1986. Reaction of selected groundnut cultivars to nematode infection *(Tylenchorhynchus brevilineatus)* under field conditions. Tropical Pest Management 32:167-170.

Subrahmanyam, P., McDonald, D., Gibbons, R.W., Nigam, S.N., and Neviil, D.S. 1982. Resistance to rust and late leaf spot diseases in some genotypes of *Arachis hypogaea*. Peanut Science 9:6-10.

Effects of Some Chinese Strains of Peanut Stripe Virus (PStV) on Groundnut Cultivars and Other Plants

Chen Kunrong[1], Zhang Zongyi[1], Xu Zeyong[1], R G Dietzgen[2], and D V R Reddy[3] (1. Oil Crops Research Institute, CAAS, Wuhan 430062, China; 2. Queensland Agricultural Biotechnology Centre, Brisbane 4072, Australia; 3. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India)

Peanut stripe virus (PStV) is an economically important virus infecting groundnut *(Arachis hypogaea)* in Southeast Asia. It is widely distributed in all groundnut production areas in China (Xu et al. 1984). Peanut stripe virus has assumed economic importance because of its potential to cause significant reductions to crop yields and in quarantine because of its relatively high frequency of transmission through groundnut seed. The virus has been reported to occur as distinct strains on the basis of symptoms in groundnut and host reaction (Wongkaew and Dollet 1990). During surveys in China wide variation in symptoms was noticed in PStV-infected groundnut. In this paper symptoms, seed transmission frequency, and pod losses due to some PStV isolates occurring in China are reported.

Symptomatology. Five isolates of PStV were collected from groundnut in Wuhan (PStV-W1, W2, N), Guangzhou (PStV-G) and Tansan (PStV-T). They were maintained on groundnut cv Honghua No. 1 in a glasshouse. Extracts from each isolate were mechanically sap inoculated on to different groundnut genotypes and on to a range of indicator plants (Table 1). On the basis of symptoms produced on various groundnut genotypes they were divided into three groups. Isolates included in group I caused mild mottling symptoms and very little stunting (PStV-WI and T). Isolates in group II (PstV-W2 and G) caused blotches and relatively more stunting than the isolates in group 1. Isolates in group III (N) were distinguished on the basis of necrosis of veins, severe mosaic symptoms, and stunting. All isolates in the three groups caused systemic mosaic on *Glycine max, Cassia occidentalis* (PStV-N not tested) and *Nicotiana benthamiana;* local lesions on Chenopodium *amaranticolor*, Cassia tora (PStV-N not tested), and cowpea. All isolates failed to infect *Sesbania exalta* and Phaseolus vulgaris cv Topcrop. None of the diagnostic hosts was suitable for distinguishing the isolates.

Effect on plant growth and pod yield. Two widely-distributed isolates in China (W1 and G) were chosen to study their effect on growth and yield of groundnut cultivars Zhonghua Nos. 1, 3, and 4 and Luhua No. 11, under glasshouse conditions. PStV-WI caused 1.4% to 6.4% reduction in height and G caused 9.2% to 16.3% reduction. Losses in pod yields due to PStV-WI ranged from 20.8% to 36.6% and decrease in pod yields due to PStV-G ranged from 29.8% to 55%. The cultivars Zhonghua Nos. 3 and 4 suffered maximum losses in pod yields by both the PStV isolates.

Seed transmission frequency. Nearly 1000 seeds were used to determine the rate of transmission to seed. PStV-WI was transmitted to 20.9% and PStV-G to 6.1% of seed of cv Zhonghua No. 3. However in cv Zhoughua No. 4 seed transmission rate was lower than that observed for Zhonghua No. 3 (6.1% for WI and none for G).

Aphid transmission. All five PStV isolates were transmitted by *Aphis craccivora* from groundnut to groundnut. The efficiency of transmission was 4.2% (1/24) for PStV-N, 12.0% (3/25) for PStV-G, 20.0% (5/25) for PStV-WI, 22.2% (6/27) for PStV-W2, and 44.0% (11/25) for PStV-T.

Conclusions

Five PStV isolates collected from various parts of China could be classified into three distinct groups on the basis

Table 1. Reactions to five PStV isolates following their transmission to host plants by mechanical sap inoculation.

Host plant	Group I PStV-WI,T	Group II PStV-W2, G	Group III PStV-N
Arachis hypogaea	Inoc./Systemic	Inoc./Systemic	Inoc./Systemic
cv Zhonghua No. 4	None/MMot.Str[1]	None/Blo,Str[1]	None/LN,Stu[1]
Yuhua No. 1	MMot/MMot	None/Bio	None/LN,Stu
Luhua No. 1	None/MMot,Str	None/Blo	None/LN,Stu
93904	MMot/MMot	None/Blo,Str	None/LN,Stu
79266	MMot/Str	None/Bio	None/LN,Stu
Glycine max cv 84-87	None/Mo	None/Mo	None/Mo
Zhangziwu	LLn/Mo,Cri	LLn/Mo	LLn/Mo,Cri
Zhongdu-24	None/Mo	None/Mo	None/Mo
Chenopodium amaranticolor	LLc/None	LLc/None	LLc/None
Cassia occidentalis	None/Mo	None/Mo	-[2]
Cassia tora	LLn/None	LLn/None	
Sesbania exalta	None/None	None/None	
Phaseolus vulgaris cv Topcrop	None/None	None/None	None/None
Cowpea	LLn/None	LLn/None	LLn/None
Nicotiana benthamiana	None/Mo	None/Mo	None/Mo

1. Blo = blotch, Cri = crinkle, LLc =local chlorotic lesions, LLn = local necrotic lesions, LN =leaf necrosis, Mmot = mild mottle, Mo = mosaic; Str = stripe, Stu - stunt.
2. Not tested.

of symptoms produced on different groundnut cultivars. Isolates in group I, which produced mild mottling symptoms, were found to be widely distributed. An isolate in group I (PStV-WI) showed relatively higher seed transmission frequency than an isolate in group II (PStV-G). In glasshouse tests PStV-G caused more reduction to pod yield than PStV-WI.

Acknowledgments

This work was supported by Australian Centre for International Agricultural Research (ACIAR) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

References

Xu, Z., Cai, Z., Yu, Z., and Qin, W. 1984. The types of peanut virus diseases and serological diagnosis of the viruses in northern China. Oil Crops of China 3:48-54.

Wongkaew, S., and Dollet, M. 1990. Comparison of peanut stripe virus isolates using symptomatology on particular host and serology. Oleagineaux 45:267-278.

Entomology

Additional Aphid Vectors of Groundnut Rosette Virus in Nigeria

M D Alegbejo (Department of Crop Protection, Institute for Agricultural Research, Ahmadu Bello University, PMB 1044, Zaria, Nigeria)

Groundnut rosette virus (GRV) is a widespread disease of groundnut in Africa especially Nigeria (Storey and Bottomley 1928, Alegbejo 1997). Two main types, green (GRV-G) and chlorotic (GRV-C), are common in Nigeria. The virus is transmitted persistently by *Aphis craccivora* Koch (Storey and Reyland 1955). All stages of *A. craccivora* transmit the disease but the nymphs are more efficient than adults. The minimum inoculation feeding period is at least 5-10 minutes (Dubern 1980, Misari et al. 1988). *A. gossypii* Glover has been reported as an additional vector of GRV in Malawi by Adams (1966), and in the United States *Myzus persicae* Sulzer has been recorded (Todd et al. 1993). This study was conducted to determine whether these aphids are vectors of GRV in Nigeria.

GRV-G and GRV-C and their assistor virus, GRAV, were obtained from field-infected plants at the Institute for Agricultural Research farm at Samaru, northern Nigeria. The viruses were maintained in a highly susceptible groundnut genotype, 48-115 B. They were periodically transmitted to young seedlings using *A. craccivora*. Seedlings were obtained by raising seeds sown directly into 12.5 cm-diameter plastic pots containing sterilized soil. Seedlings were inoculated within 1 week of germination. Ten test plants were used per treatment in each experiment. This was repeated four times. The same number of uninoculated plants was used as the control in each test.

Stock cultures of the different species of aphids were obtained from adult apterae as follows: *A. craccivora* from cowpea, Ife brown (*Vigna unguiculata* (L.) Walp), *A. gossypii* Glover from cotton, Samcot 8 (*Gossypium* sp), and M. persicae from sorghum cv SK 5912 (*Sorghum bicolor* (L.) Moench). The three species of aphids were identified by taxonomist Dr M C Dike of the Department of Crop Protection, Ahmadu Bello University, Zaria, Nigeria. Apterae were placed on petri dishes lined with filter paper moistened with water. Nymphs deposited overnight were placed on the healthy seedlings of their respective hosts and allowed to develop to adults. Aphid stocks were maintained by serial transfers of the larvipositing apterae at 24-h intervals to seedlings of their respective hosts.

Batches of 80-100 first to second - instar nonviruliferous aphids (about 30-36 h old) were allowed to feed separately on similar groundnut plants infected with either GRV-G or GRV-C for periods ranging from 0.25 to 48 h. After each acquisition access feeding period, single aphids from each group and each species were transferred to individual healthy groundnut plants and allowed an inoculation access feeding period of 24 h.

Three days old aphids from the stock culture were allowed an acquisition access feeding period of 2-3 days on infected groundnut plants. The aphids were then confined singly or in groups of 5 or 10 per plant. After an inoculation access feeding period of 0.25 to 48 h, they were sprayed with dimethoate (Rogor®) at the rate of 1.30 g a.i. L^{-1}.

A. craccivora was significantly ($P = 0.05$) more efficient in transmitting both the GRV-G and GRV-C than *A. gossypii* and *M. persicae. A. craccivora* transmitted GRV-G and GRV-C to the same extent. The latter was also true of both *A. gossypii* and *M. persicae.* Single aphids of all the species acquired the viruses after 4 h acquisition access feeding. Ten viruliferous aphids per test plant were more efficient in transmitting both GRV-G and GRV-C than one or five viruliferous aphids per test plant. *A. craccivora* was again the most efficient followed by *A. gossypii* and *M. persicae.* Each of the species of aphids transmitted GRV-G and GRV-C to the same extent. Single aphids of A. craccivora were able to transmit both GRV-G and GRV-C after 0.25 h inoculation access feeding while single aphids of *A. gossypii* and *M. persicae* were only able to transmit both viruses after 0.5 h inoculation access feeding period. This investigation shows that *A. gossypii* and *M. persicae* are additional vectors of GRV in northern Nigeria. They are, however, relatively inefficient compared with *A. craccivora.*

A field trial conducted on the epidemiology of GRV at Samaru, Nigeria, in 1998, showed that 70% of the aphids trapped were *A. craccivora,* 15% were A. fabae Blanchad, while 9% were *A. gossypii* and 6% M. persicae.

Three trials conducted in separate locations at Samaru and its environs using a highly susceptible groundnut genotype, 48-115B, as the infector row and either *A. craccivora, A. gossypii* or *M. persicae* as vector, indicated that *A. craccivora* was a highly efficient vector while *A. gossypii* and *M. persicae* were relatively inefficient field vectors. However, both *A. gossypii* and *M. persicae* could contribute substantially to the spread of GRV in the field.

References

Adams, A.N. 1966. Groundnut rosette virus - Another vector. The Rhodesia, Zambia and Malawi Journal of Agricultural Research 4:125.

Alegbejo, M.D. 1997. Effect of intercropping groundnut with tall cereals on the incidence of groundnut rosette virus. International *Arachis* Newsletter 17:39-40.

Dubern, J. 1980. Mechanical and aphid transmission of the Ivory Coast strain of groundnut rosette virus. Phytopathologische Zeitschrift 99:318-326.

Misari, S.M., Abraham, J.M., Demski, J.W., Ansa, O.A., Kuhn, C.W., Casper, R., and Breyel, E. 1988. Aphid transmission of viruses causing chlorotic rosette and green rosette diseases of peanut in Nigeria. Plant Disease 72:250-253.

Storey, H.H., and Bottom ley, A.M. 1928. Rosette disease of the peanut (*Arachis hypogaea L.*). Annals of Applied Biology 15:26-45.

Storey, H.H., and Reyland, A.K. 1955. Transmission of groundnut rosette virus. Annals of Applied Biology 43:423-432.

Todd, J.W., Culbre, A.K., and Demski, J.W. 1993. Insect vectors of groundnut viruses. Page 81 in Working together on groundnut virus diseases (Reddy, D.V.R., McDonald, D., and Moss, J.P., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Effect of Climatic Factors and Aphid Population on the Incidence of Groundnut Rosette Virus in Nigeria

M D Alegbejo, E Egwurube, and B D Kashina (Institute for Agricultural Research, Ahmadu Bello University, PMB 1044, Zaria, Nigeria)

Groundnut rosette virus (GRV) is the most important factor limiting the production of groundnut (*Arachis hypogaea L.*) in Nigeria. It is transmitted persistently by *Aphis craccivora* Koch (Storey and Reyland 1955). An epidemic of the disease occurred in 1975 and destroyed an estimated 0.7 million ha of groundnut (Yayock et al. 1976). Another epidemic occurred in 1985 with a nearly total loss of yield in some parts of northern Nigeria (Misari et al. 1988). These epidemics were associated with outbreaks of A. craccivora. This study was conducted to determine the effect of climatic factors and aphid population on the incidence of GRV.

The trial was set up in June 1997 at Samaru using three groundnut genotypes, 48-115B (highly susceptible to GRV), RRB (moderately susceptible), and RMP 91 (resistant). The experiment was laid out as a randomized complete block design with four replicates. Each plot consisted of one hundred plants on five ridges. A plastic tray (40 x 20 x 10 cm) with the inside painted yellow to attract aphid vectors of GRV, was set up in each plot. Each trap was held 46 cm above ground level on cement blocks against a contrasting background of bare soil. The trays were two-thirds filled with a solution containing 98% water, 1.5% teepol detergent, and 0.5% formalin preservative. Trapped aphids were collected once each week and identified. Aphid species were related to disease incidence and climatic factors. The liquid in the water trap was changed after each week's collection of aphids. Counts of GRV-infected plants were made at 8-day intervals throughout the wet season. The severity of symptoms on individual plants was ranked according to a scale of 1-5 where 1 = no symptoms; 2 = leaf symptoms, but no stunting; and 3-5 = leaf symptoms with stunting varying from slight to more than 70%.

The masses of pods and haulms harvested from each plot were recorded. Serological tests were carried out between the test virus and monoclonal antibodies of potato leaf roll virus (ScR6), obtained from the Scottish Crops Research Institute, UK, using the Triple Antibody Sandwiched Enzyme Linked Immunosorbent Assay (TAS-ELISA). The Duncan's Multiple Range Test (DMRT) was used to separate means based on F values at the 5% level of significance. Correlation analysis was carried out between weather factors and the number of aphids trapped per week, number of infected plants per week, and age of plants.

Seventy percent of the aphids trapped were *A. craccivora,* 15% were *A. fabae* Blanchard, while 9% were *A. gossypii* Glover and 6% were *Myzus persicae* Sulzer. There was a significant positive correlation between the following factors: incidence of GRV and number of alate aphids trapped; temperature and age of plants; temperature and number of alate aphids trapped; relative humidity and incidence of GRV (Table 1). A significant negative correlation was, however, observed between age of plants and number of alate aphids trapped; sunshine hours and number of alate aphids trapped; relative humidity and number of alate aphids trapped; and relative humidity and sunshine hours. Periods of high rainfall and relative

Table 1. Correlation coefficients of the relationship between groundnut rosette virus (GRV) in groundnuts number of alate aphids trapped and variations in the weather at Samaru in 1997[1].

	Correlation coefficients						
Variables	VI	V2	V3	V4	V5	V6	V7
VI = Number of alate aphids trapped week^{-1}	+1.00						
V2 = Incidence of GRV week^{-1}	+0.56	+ 1.00					
V3 = Age of plants (in weeks)	-0.55	+0.32	+1.00				
V4 = Mean temperature (°C)	+0.74	-0.70	+0.75	+1.00			
V5 = Mean sunshine (hours)	-0.56	+0.50	+0.83	+0.88	+1.00		
V6 = Mean rainfall (mm)	-0.58	-0.66	-0.31	-0.45	-0.46	+1.00	
V7 = Mean relative humidity (%)	-0.56	-0.80	-0.69	-0.88	-0.89	+0.56	+1.00

1. Values are correlation coefficients: correlation coefficient at 5% level of significance = 0.54.

Table 2. Epidemiology of groundnut rosette virus at Samaru, Nigeria, in 1997.

Groundnut genotype	Mass of pod plot^{-1} (kg)	Mass of haulm plot^{-1} (kg)	Mean of aphids trapped in each plot week^{-1}	Cumulative percentage of GRV-infected plants in the trial period	Disease index value
RMP91	1.03a	16.30a	38.50c	4.50c	1.20c
RRB	0.60b	2.12b	158.50b	30.00b	3.40b
48-115B	0.50b	2.84b	192.30a	62.50a	4.00a

In each column numbers followed by the same letter are not significantly different from each other at P = 0.05 using the Duncan's Multiple Range Test.

humidity coincided with periods of low incidence of alate aphids trapped and vice versa (Table 1). Heavy and consistent rainfall washed off aphids from the groundnut and kept down the population before the groundnut became infected with GRV. Therefore, in years of intermittent dry and wet spells, massive build up, and an early dispersal and survival of aphids is likely to occur giving rise to an epidemic of GRV disease. This may be contained by early destruction of the weed hosts of the virus and vector and of the vector itself. There were significant groundnut genotype differences in the number of aphids trapped and GRV-infected plants (Table 2). The susceptible groundnut genotype, 48-115B, had the highest incidence of aphids and GRV disease, followed in descending order by the moderately resistant RRB and the resistant RMP91 genotypes. It is therefore advisable to sow resistant genotypes to reduce the incidence of GRV disease and alate aphids landing on the crop.

Acknowledgments

The financial assistance from the Institute for Agricultural Research, Samaru, and the Legumes and Oilseeds Research Program is greatly appreciated. Thanks to Mr Abdulmalik Zubairu and Mr I F Wayo for technical assistance, and Dr M C Dike for aphid identification.

References

Misari, S.M., Abraham, J.M., Demski, J.W., Ansa, O.A., Kuhn, C.W., Casper, R, and Breyel, E. 1988. Aphid transmission of the viruses causing chlorotic rosette and green rosette diseases of peanut in Nigeria. Plant Disease 72:250-253.

Storey, H.H., and Reyland, A.K. 1955. Transmission of groundnut rosette virus. Annals of Applied Biology 43:423-432.

Yayock, J.Y., Rossel, H.W., and Harkness, C. 1976. A review of the 1975 groundnut rosette epidemic in Nigeria. Samaru Miscellaneous Papers no. 71.

A Note on Host Plants for the Groundnut Plant Hopper, *Hilda patruelis,* in Southern Africa

E Minja[1], E Zitsanza[2], P Mviha[3], and P Sohati[4]
(1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), PO Box 1096, Lilongwe, Malawi; 2. Plant Protection Research Institute (PPRI), PO Box 8100, Causeway, Harare, Zimbabwe; 3. Chitedze Research Station, PO Box 158, Lilongwe, Malawi; 4. Mochipapa Research Station, PO Box 630090, Choma, Zambia)

The groundnut hopper, *Hilda patruelis* Stal (Homoptera: Tettigometridae), is a polyphagous sucking bug found in Africa south of the Sahara (Weaving 1980, Bohlen 1978, NRI 1996). Although *Hilda* is reported as a minor pest on cashew nuts, pigeonpea, citrus, soybean, maize, potato, okra, sunflower, cowpea, *Phaseolus* bean, and mung bean, the extent of damage to groundnut can often be of economic importance.

An adult hopper is from 3 to 5 mm in length, and brown or green in colour with white markings. Nymphs resemble the adults but without fully developed wings. Plants are attacked below the soil surface at the base of the stem and on the roots. On groundnuts the hoppers are also found feeding on pegs and pods and they tend to jump off when disturbed. Breeding occurs throughout the year and clusters (usually 10-50) of small, silvery-blue, elongate eggs are laid on the stems, roots, and in the case of groundnuts, on pegs and pods as well. Eggs hatch in 10-15 days. Each generation takes about 37-42 days with 5 nymphal instars to the adult. These hoppers survive the dry season on the roots of weeds or volunteer groundnut plants and later move into groundnut fields shortly after germination.

Infested plants turn yellow, wilt, and die due to sap-sucking by the hoppers. The vascular system of the plants turns brown, probably as a result of toxins in the saliva of Hilda or secondary infection by plant pathogens and the hoppers move from dying to adjacent healthy plants. *Hilda* has an obligate symbiotic relationship with several species of ants which protect it from predators and maintain the tunnels around the root zone in return for the honeydew excreted by the hopper. Common ant species include *Anoplolepis* spp and *Pheidole* spp (Bohlen 1978, NRI 1996). The presence of these ants at the base and along stems, branches, and pods on plants is a useful diagnostic feature.

Additional host plants in Malawi and Zimbabwe. During the course of field studies in Malawi in 1997/98, four additional host plants for Hilda were observed. They were sorghum, Hibiscus bushes, fish bean plant (*Tephrosia vogelii*), and a common Asteraceae weed (*Veronia poskeana*) locally known in Malawi's Chichewa language as Mbilizongwe. In Zimbabwe, Hilda was reported on *Hibiscus* bushes and Mexican marigold plants, Tagetes spp (PPRI 1982).

Incidence and damage levels on groundnut in Malawi, South Africa, Zambia, and Zimbabwe. Reports from Malawi (Rose 1962, Wightman and Wightman 1994), South Africa (Van Eeden 1993), and Zimbabwe (Weaving 1980, PPRI 1986) indicate extensive damage to groundnut crops particularly in dry seasons. The pest is always found at low densities on many farms (2-5% of plants) in most countries in southern Africa during normal growing seasons.

H. patruelis is generally considered as a minor pest of groundnuts and control is not cost effective. However, sporadic heavy infestations may occur in periods of drought or on an off-season crop. For example, during the 1997/98 growing season, groundnut field surveys at full podding phase indicated that 1-5% (mean 3.5%) of plants were infested in Malawi, eastern Zambia, and parts of Zimbabwe. Southern Zambia (Gwembe valley) had infestations ranging from 20-80% (mean 46%). The high infestation in southern Zambia was associated with very low and unevenly distributed rainfall. A small off-season groundnut seed multiplication crop at Chitedze Research Station had to be abandoned in 1997 due to an unexpected heavy infestation by *Hilda* (over 75% of plants). Isolated and very early or late sown farmers' crops often suffer severely from *Hilda* damage in many locations in Malawi, Zambia, and Zimbabwe. Heavy and continuous rains, however, destroy the tunnels maintained by the ants and reduce hopper populations.

References

E. Bohlen. 1978. Crop pests in Tanzania and their control. German Agency for Technical Cooperation, Ltd. (GTZ). 2nd edn. Berlin and Hamburg, Germany: Verlag Paul Parey. 142 pp.

NRI (Natural Resources Institute). 1996. Groundnuts. Pest Control Series, PANS2 (2nd edn). Chatham, UK: Natural Resources Institute. 348 pp.

PPRI (Plant Protection Research Institute). 1982. Control of *Hilda patruelis.* Pages 12-14 in Annual Report 1980/81.

Harare, Zimbabwe: Department of Research and Specialist Services, Ministry of Lands, Agriculture and Water Development.

PPRI (Plant Protection Research Institute). 1986. National surveys of insect pests of crops in communal areas. Pages 23-31 *in* Annual Report 1985/86. Harare, Zimbabwe: Department of Research and Specialist Services, Ministry of Lands, Agriculture and Water Development.

Rose, D.J.W. 1962. Pests of groundnuts. Rhodesian Agricultural Journal 59:197-298.

Van Eeden, C.F. 1993. The ecology and injuriousness of the insect pest complex of groundnuts *(Arachis hypogaea)* in the South African highveld region. Ph.D. thesis, University of Orange Free State, South Africa. 144 pp.

Weaving, A.J.S. 1980. Observations on *Hilda patruelis* Stal (Homoptera: Tettigometridae) and its infestation of the groundnut crop in Rhodesia. Journal of the Entomological Society of South Africa 43:151-167.

Wightman, J.A., and Wightman, A.S. 1994. An insect, agronomic and sociological survey of groundnut fields in southern Africa. Agriculture, Ecosystems and Environment 51:3.11-331.

Efficacy of Plant Products Against Thrips (Scirtothrips dorsalis Hood) in Groundnut

T Senguttuvan (National Pulses Research Centre, Tamil Nadu Agricultural University, Vamban 622 303, Pudukkottai, Tamil Nadu, India)

Several species of thrips attack groundnut, but only a few such as Scirtothrips *dorsalis* Hood, *Frankliniella schultzei* (Trybom), and *Caliothrips indicus* (Bagnall) are of economic importance. Among different thrips, S. dorsalis is an important species causing crinkling and distortion of leaves. Prolonged and heavy infestation may cause stunting of plants resulting in 40% reduction in yield of groundnut Systemic insecticides were found to be effective against thrips in groundnut (Thimmaiah and Panchabhavi 1973, Senapathi and Patnaik 1980). However, control of thrips by botanical products would be less expensive with fewer adverse effects on natural enemies, and fewer environmental and operational hazards. Thus, the present study was conducted to find an effective plant product against *S. dorsalis.*

Scirtothrips dorsalis was a serious pest in the early crop growth of groundnut at Pudukkottai, Tamil Nadu. Field trials were conducted for two rainy seasons and one dry season namely, kharif 1995, winter 1995/96, and kharif 1996 in red lateritic soils at the National Pulses Research Centre, Vamban, Pudukkottai, Tamil Nadu, India, using the groundnut variety TMV 7 under irrigated conditions. Two separate trials, one for neem products, and one for indigenous plant extracts, were laid out in a randomized block design with three replications and a plot size of 5 m x 4 m. The plant extracts (50 g L^{-1}) other than the neem formulations, neem oil and neem seed kernel (NSK), were made into paste by grinding a few hours before spraying. The required quantity of water combined with teepol (1 ml L^{-1}) and the plant extract were then mixed thoroughly and filtered through muslin cloth. The plant products in both the trials were sprayed twice at 25 and 40 days after sowing using a manual knapsack sprayer. Water alone was sprayed in control plots and 0.05% monocrotophos used as a chemical insecticide control. Observations were made on 25 partially opened terminal leaves of five randomly-selected plants for the number of thrips prior to spraying and 3, 7, and 14 days after each treatment.

Significant differences were noted among the treatments of thrips population per leaf in all seasons. In both the trials, the monocrotophos was more effective than the plant products in controlling *S. dorsalis.* It recorded 45-50% reduction in population over the water control. All the neem products resulted in significantly lower thrips population than the control. Neem Gold® in kharif 1995 (2.44 thrips $leaf^{-1}$), neem leaf extract in winter 1995/96 (1.54 thrips $leaf^{-1}$), and neem oil in kharif 1996 (1.90 thrips $leaf^{-1}$) recorded low thrips population. The overall mean of three seasons indicated that the neem products namely, Achook®, Neem Gold® and neem oil (3%) had 29, 29 and 28% lower populations than the control (3.02 thrips $leaf^{-1}$) (Table 1). Mohan (1989) reported that application of NSK (5%) caused high mortality of thrips and mites within a week after application in rice. The neem-based formulations such as RD-9 Repelin and Neem Guard® were most effective in controlling groundnut leaf miner (Prabakar et al. 1994).

Among the indigenous plant products, Vitex leaf extract (LE) during kharif 1995 (1.95 thrips $leaf^{-1}$), *Achorus* root extract (RE) during winter 1995/96 and kharif 1996 recorded low (1.71 and 1.80 thrips leaf respectively) population of thrips. The mean data showed that Vitex LE and *Eucalyptus* LE were the best treatments in controlling *S. dorsalis,* as they recorded 30 and 29% lower populations than the control (Table 2). The other plant extracts were less effective. Sahayaraj and Sekar (1996) reported *Vitex negundo* leaf extract was effective in controlling *Spodoptera* in groundnut.

The lower population of thrips during the winter season compared with the kharif seasons in both the trials may have been due to the cool climate that prevailed during January and February, and low rainfall during the southwest monsoon in the kharif seasons.

The present study concluded that Achook®, Neem Gold®, and neem oil, among neem formulations, and *Vitex* LE and *Eucalyptus* LE among indigenous plant extracts were effective against S. dorsalis in groundnut crops.

Table 1. Effect of neem products on *Scirtothrlps dorsalis* in groundnut

	Mean population of thrips				
Treatment	Kharif 1995	Winter 1995/96	Kharif 1996	Mean	Difference from control (%)
NSK 5%[1]	3.03	1.69	2.20	2.31	-23.5
NO 3%[2]	3.01	1.59	1.90	2.17	-28.1
Neem leaf extract 5%	3.14	1.54	2.00	2.23	-26.2
Nimbecidine® 3 ml L^{-1}	2.97	1.79	2.00	2.24	-25.3
Neem Gold® 3 ml L^{-1}	2.44	1.71	2.30	2.15	-28.8
Neem Azal® 2 ml L^{-1}	3.33	1.57	2.00	2.30	-23.8
Achook® 3 g L^{-1}	2.71	1.71	2.00	2.14	-29.1
Monocrotophos 0.05%	1.59	1.27	1.50	1.54	-49.0
Control	4.07	2.70	2.30	3.02	-
SE	±0.36	±0.15	±0.14		
CD (P = 0.05)	0.75	0.31	0.30		

1. NSK = neem seed kernel
2. NO = neem oil.

Table 2. Effect of indigenous plant products on *Scirtothrlps dorsalis* in groundnut

	Mean population of thrips				
Treatment	Kharif 1995	Winter 1995/96	Kharif 1996	Mean	Difference from control (%)
Eucalyptus tereticornis LE[1] 5%	1.90	1.74	2.20	1.95	-29.3
Tribulus terrestris PE 5%	2.59	1.88	2.20	2.22	-19.7
Vitex negundo LE 5%	1.95	1.85	2.00	1.93	-30.1
Achorus calamus RE 5%	3.23	1.71	1.80	2.25	-18.5
Croton sparsiflorus PE 5%	3.07	1.86	2.30	2.41	-12.7
Ipomaea carnea LE 5%	2.75	1.87	2.30	2.49	-9.8
Jatropa tanjorensis LE 5%	3.14	1.91	2.40	2.48	-10.1
Datura stramonium LE 5%	3.28	1.84	2.10	2.41	-12.7
Lucas aspera PE 5%	3.05	1.93	2.00	2.33	-15.6
Monocrotophos 0.05%	1.87	1.31	1.40	1.53	-44.6
Control	3.50	2.39	2.40	2.76	
SE	±0.35	±0.17	±0.11		
CD (*P* = 0.05)	0.74	0.38	0.23		

1. LE = leaf extract, RE = rhizome extract, PE = plant extract.

References

Mohan, K. 1989. Studies on the effect of neem products and vegetable oils against major pests of rice and safety to natural enemies. M.Sc.(Ag.) thesis, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

Prabhakar, M., and Rao, P.K. 1994. Relative toxicity of botanical pesticides against groundnut leafminer, *Aproaerema modicella* (Dev.). Journal of Insect Science 7:177.

Sahayaraj, K., and Sekar, K. 1996. Efficacy of plant extracts against tobacco caterpillar larvae in groundnut. International *Arachis Newsletter* 16:38-39.

Thimmiah, G., and Panchabhavi, K.S., 1973. Insecticidal control of thrips (*Megalurothrips indicus* Bagnail) on groundnut. Mysore Agricultural Journal 7:334-335.

Senapathi, B., and Patnaik, N.C. 1980. Studies of ecology of Scirtothrips dorsalis Hood on groundnut. Journal of Research, Orissa University of Agriculture and Technology 10:17-20.

Seasonal Occurrence of Groundnut Leaf Miner in Relation to Weather Factors

T Senguttuvan (National Pulses Research Centre, Tamil Nadu Agricultural University, Vamban 622 303, Pudukkottai, Tamil Nadu, India)

Groundnut leaf miner (GLM) is an important pest of groundnut and soybean in South and Southeast Asia. In India, although it attacks groundnut throughout the year, it is more severe under moisture stress conditions (Wightman and Ranga Rao 1994). The populations fluctuate from year to year and season to season. During a season, it fluctuates between different generations of the pest (Logiswaran and Mohanasundaram 1986). Weather factors influence the GLM population abundance (Lewin et al. 1979, Logiswaran et al. 1982), but the key factors regulating its population have not been identified. The present studies were conducted to assess the influence of weather factors on the population dynamics of GLM at Vamban, Tamil Nadu, India.

Fortnightly (FN) sowings at the National Pulses Research Centre, Vamban, were begun from the first fortnight of August 1994, and continued for one year, of the commonly grown groundnut variety, TMV 7. The crop was raised in 40 m^2 plots under irrigation, and normal agronomic practices were followed. Observations were recorded on 50 randomly-selected plants in each sowing for the number of larvae per plant and percent infested leaflets at 45 days after sowing (DAS). Data on maximum temperature, minimum temperature, relative humidity, sunshine hours, number of rainy days, and rainfall were recorded daily at the weather station of the research farm. Fortnightly means were computed for each parameter (except rainy days and rainfall, for which the number of rainy days and total rainfall were calculated). The percent infested leaflets and number of larvae per plant were considered as dependent variables (Y), and correlated with the corresponding fortnightly means of weather factors (X) at the time of observation.

Leaf miner damage was observed in all months, except during the September II FN to November II FN. This may have been due to continuous and widespread rainfall during this period. However, the crops sown during February II FN, March I FN, June 1 and II FN, and July I FN (observations recorded in March II FN, April I FN,

Table 1. Seasonal occurrence of groundnut leaf miner at Vamban, Tamil Nadu, India.

Year	Month	Fortnight	Leaflets damaged (%)	Larvae plant*[1]
1994	August	I	76.4	12.8
		II	38.7	8.2
	September	I	12.6	4.8
		II	0.0	0.0
	October	I	0.0	0.0
		II	0.0	0.0
	November	I	0.0	0.0
		II	0.0	0.0
	December	I	3.7	0.4
		II	6.5	1.0
1995	January	I	8.0	0.7
		II	29.6	2.8
	February	1	47.6	5.8
		II	40.8	4.8
	March	I	33.7	4.6
		II	59.4	12.9
	April	I	69.2	18.6
		II	37.7	9.9
	May	I	11.3	1.2
		II	3.5	0.8
	June	I	29.0	3.2
		II	31.5	4.9
	July	I	64.3	12.5
		II	47.9	14.5

Table 2. Correlation of weather parameters (X) with GLM incidence (Y).

Weather parameter	Correlation coefficient (r) for larvae plant[1]	Leaflets damaged (%)
XI Maximum temperature (°C)	0.58*	0.66**
X2 Minimum temperature (°C)	0.14	0.04
X3 Relative humidity (%)	-0.28	-0.36
X4 Sunshine hours	0.13	0.33
X5.No. of rainy days	0.05	-0.15
X6 Total rainfall (mm)	0.07	-0.05

1. * = P<0.05;** = P<0.01.

July I FN, July II FN, and August I FN) showed high GLM damage and larval abundance (Table 1). GLM incidence has been observed to be maximum during July and August and from February to May in South India (Nair 1975).

Correlation studies showed significant and positive associations of damage and larval population with maximum temperature, but the influence of other parameters was not significant (Table 2). Lewin et al. (1979) reported that temperature was associated positively, and rainfall negatively with leaf miner incidence, while Logiswaran et al. (1982) observed significant negative correlations of maximum and minimum temperature with leaf miner infestation. No correlation was observed with rainfall.

References

Lewin, H.D., Saroja, R.S., Sundararaju, D., and Padmanabhan, M.D. 1979. Influence of sowing time and weather on the incidence of groundnut leaf miner. Indian Journal of Agricultural Sciences 49:886-891.

Logiswaran, G., and Mohanasundaram, M. 1986. Influence of weather factors on the catches of moths of groundnut leaf miner Aproaerema modicella Deventer in the light trap. Entomon 12:147-150.

Logiswaran, G., Modhava Rao, S., Vasudevan, G., and Kannan, V. 1982. Influence of time of sowing and weather factors on the infestation of leaf miner *Aproaerema modicella* Deventer and yield in rainfed groundnut. Madras Agricultural Journal 69:359-363.

Nair, M.R.G.K. 1975. Insects and mites of crops in India. New Delhi, India: Indian Council of Agricultural Research. 404 pp.

Wightman, J.A., and Ranga Rao, G.V. 1994. Groundnut pests. Pages 395-479 *in* The Groundnut Crop (Smart, J., ed.). London, UK: Chapman and Hall.

Effect of Prey and Their Ages on the Feeding Preference of *Rhynocoris marginatus* (Fab.)

K. Sahayaraj (Dept. of Zoology, St. Xavier's College, Palayankottai 627 002, Tamil Nadu, India)

Rhynocoris marginatus (Heteroptera : Reduviidae) is a generalist predator found in agroecosystems such as groundnut, cotton, soybean (Sahayaraj 1995), and also in the semi-arid zone, scrub jungle, and forest. It was reported to be a predator on 20 insect pests of various crops (Sahayaraj 1998). For groundnut *Amsacta albistriga* Walk., *Aproaerema modicella* Deventer, *Helicoverpa armigera* (Hub.) and *Spodoptera litura* Fab. are the major pests and cause considerable losses in production (Wightman and Rao 1993). Different life stages of this predator have been observed in groundnut in the field. The present investigation was undertaken to study the acceptance of these pests and their stages by the different life stages of this reduviid predator under laboratory conditions.

Adults of *R. marginatus* were collected from groundnut fields in Trichy district, Tamil Nadu, and reared on different groundnut lepidopteran pests under laboratory conditions (30 ± 2°C; 75 ± 5% RH) in 120 ml plastic containers. Laboratory emerged fourth and fifth nymphal instars and adults were used in these studies. A glass olfactometer was used to find the prey and their stage acceptance. An olfactometer consists of a central tube (2.3 cm diameter) from which project outwards 6 equally-spaced tubes (21 cm length, 2.3 cm diameter). The pest stage acceptance of *R. marginatus* of the different larval instars of *A. modicella, A. albistriga, H. armigera,* and *S. litura* was evaluated by a choice experiment. Day old fourth and fifth instars, and adults of *R. marginatus* were tested against different larval instars of the pests. Different larval stages of the prey were introduced into the terminal openings of each arm, and immediately the openings were covered with muslin cloth and the prey larvae allowed to move undisturbed for 10 minutes. Fourth instars of *R. marginatus* were then introduced into the central tube and the feeding events recorded continuously for six hours. Successful predation and stage of the prey preferred were recorded. The same procedure was adopted for the fifth nymphal instars and adults of *R. marginatus.*

A choice test was also conducted to assess the prey acceptance of *R. marginatus* to these four groundnut lepidopteran pests. Preferred stages of the prey species (confirmed from the stage acceptance study) were introduced into the terminal arm openings and these covered with muslin cloth. The pests were allowed to move undisturbed for 10 minutes. Predators were then introduced into the central tube of the olfactometer and the feeding events recorded continuously for six hours. Prey acceptance was assessed in terms of the first prey that was encountered, killed and consumed by the predator. All the groundnut pests were maintained in the laboratory on groundnut leaves (TMV 7 variety). Each experiment was replicated twenty times with different life stages of predators, pests and their life cycle stages.

Stage acceptances of *R. marginatus* on four different groundnut pests are presented in Table 1. When the nymphs and adults of *R. marginatus* were provided with different larval stages of the four groundnut pests, the fourth instar predator accepted the smaller prey whereas the fifth instar and adult predator accepted larger prey. This suggested that the final instar and the adult predator were more successful in encountering the largest (oldest prey) size of these groundnut pests. Moreover, large prey obviously provided more food per individual than did small ones and younger nymphal predators needed less food than older nymphal instars and adult predators. The stage of *R. marginatus* could be attributed to the dynamics of prey-predator interaction which is principally governed by the size (Sahayaraj and Ambrose 1994). It is clear from this study that during release programs, it is necessary to release different life stages of this predator at the same time.

Although reduviids are generalized predators, they exhibit a certain degree of host specificity. The results revealed that different life stages of this predator preferred *S. litura followed* by *H. armigera, A. modicella,* and *A. albistriga.* Thus in the choice test, the reduviid accepted different groundnut pests under test differentially (Table 2). Among the groundnut pests tested in this study, the least-preferred pest was a red hairy caterpillar. Presence of a hard exoskeleton with hairs, and some sort of odour may have deterred the predator from feeding on *A. albistrica.* Disagreeable odours and tastes, morphological characters, and behaviours of the pests might decide the differential attack and feeding strategies of this predator. The ability of predatory insects to choose between prey types has an important bearing on the outcome of a biocontrol program (Hattingh and Samways 1992) suggesting the biocontrol utility of *R. marginatus.* This study revealed a particular life cycle stage of *R. marginatus* accepted a particular stage of the pest and this predator mainly accepted *S. litura* followed by *H. armigera.* These results indicate that the larger predator accepted the larger-sized prey and the smaller predator accepted the smaller size prey and so the timely release of a predator is very important in biocontrol programs.

Table 1. Pest life cycle stage acceptance by different stages of the predator, *Rhynocoris marginatus.*

Predator life stage	% acceptance of groundnut pests			
	A. albistrica	*A. modicella*	*H. armigera*	*S. litura*
Fourth instar	Second (16.73)	Fifth (40.68)	Fourth (38.70)	Fourth (43.76)
Fifth instar	Third (17.15)	Fifth (51.30)	Fifth (38.70)	Fifth (48.14)
Adult	Fourth (18.65)	Fifth (70.25)	Fifth (46.63)	Sixth (50.13)

Table 2. *Rhynocoris marginatus* preference (%) for different pests of groundnut

Predator life stage	Larval stage of the pest			
	A. albistrica	*A. modicella*	*H. armigera*	*S. litura*
Fourth instar	3.33	15.00	30.66	51.00
Fifth instar	5.00	15.00	30.00	50.00
Adult	5.00	10.00	40.00	45.00

Acknowledgments

This work is entirely supported by the Department of Science and Technology (DST), New Delhi, under the Young Scientist Project. The author wishes to thank Rev Dr S J Britto, S J, Principal, St. Joseph's College, Trichy, and Rev Dr A Pappuraj, S J, Principal, and Prof M T Punithan, Head, Department of Zoology, St. Xavier's College, Palayamkottai.

References

Hattingh, V., and Sam ways, M.J. 1992. Prey choice and substitution in *Chilocorus* spp. (Coleoptera: Coccinnelidae). Bulletin of Entomological Research 82:327-334.

Sahayaraj, K. 1995. Bio-efficacy and development of a reduviid predator, *Rhynocoris marginatus* on *Spodoptera litura*. International *Arachis* "Newsletter 15:56-57.

Sahayaraj, K. In press. Biocontrol potential of forest dwelling reduviids with special reference to *Rhynocoris marginatus* (Fab). Save Forest and Wild Life.

Sahayaraj, K., and Ambrose, D.P. 1994. Stage and host preference and functional response of a reduviid predator *Acanthaspis pedestris* Stal from cotton pests. Journal of Biological Control 8:23-26.

Wightman, J.A., and Rao, G.V.R. 1993. A groundnut insect identification handbook for India. ICRISAT Information Bulletin no. 39. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 60 pp.

Field Evaluation of the Predator, *Rhynocoris marginatus* (Fab.), on Two Groundnut Defoliators

K Sahayaraj (Department of Zoology, St. Xavier's College, Palayankottai 627 002, Tamil Nadu, India)

The groundnut crop is attacked by many defoliators in India of which the most important and widely distributed are *Helicoverpa armigera* Hubner and *Spodoptera litura* (Fab.) (Wightman and Rao 1993). These pests have developed resistance to many insecticides (Venugopal Rao et al. 1993). As a result of the harmful effect of indiscriminate use of insecticides and particularly their role in eliminating beneficial fauna, the emphasis in plant protection is shifting towards development and implementation of IPM approaches in controlling these insect pests. Although studies on many natural enemies including the predator *Chrysoperla* carnea (Banks) (Kalyana Sundaram et al. 1994) have been reported on groundnut, reduviids have not been utilized at the field level. Thus the predation efficiency of the native reduviid predator, *Rhynocoris marginatus* (Fab), against *Helicoverpa armigera* and *Spodoptera litura* was studied under field conditions.

Two plots sown to groundnut cultivar TMV 7, each measuring 0.405 ha, were selected at a distance of 0.2 km apart at Elathegiri village, Dharmapuri district, Tamil Nadu. In both fields, transplanting was done in the first week of August, 1997. In one field releases of the predator, *R. marginatus, were made* from 4 September to 3 October, 1997, at 15-day intervals (5,000 predators ha^{-1}) while the second plot without releases was kept as a control. Each plot was divided into three subplots and in each about 670 predators were released late in the evening (111 each of egg and first, second, third, fourth, and fifth instars). The predator eggs on card pieces (1 x 1 cm) were stapled to the lower sides of leaves whereas the nymphal instars were released on the lower side of the plant. The incidence of *H. armigera* and *S. litura* were observed 26,34, 49, and 64 days after sowing (DAS). Observations were recorded from 10 randomly-selected plants from each subplot. Analysis of variance technique was followed to determine the treatment effect and the means were compared using DMRT at P = 0.05.

The results of the study showed that the incidence of *H. armigera* varied from 6.55 to 0.77 per plant and for S. *litura* variation was 5.66 to 0.88 per plant, in the plot where *R. marginatus* releases were made (Table. 1). The comparison between the population of these defoliators before and the after predator release was statistically significant (P<0.05). The corresponding figures for the control plot varied from 6.44 to 14.55 and 5.44 to 12.11 per plant. This showed that the predator played a role in checking the incidence of both the defoliators. The pod yield was also the highest in the reduviid released plot (1867.77 kg ha^{-1}). The control plot produced 1022.82 kg pods ha^{-1}. *Rhynocoris* spp have an advantage over other predators, as they are tolerant of many insecticides (George 1996). Thus, they can also be integrated into an IPM program that includes conventional or synthetic insecticides.

Table 1. Efficacy of *R. marginatus* in controlling defoliators in groundnut.

Day of observation after sowing	Pest population plant^{-1}			
	Spodoptera litura		*Helicoverpa armigera*	
	Control	Predator released	Control	Predator released
26	6.44^{aA}	6.55^{aA}	5.44^{aA}	5.66^{aA}
34	7.22^{aA}	4.33^{aB}	7.00^{aA}	4.33^{aB}
49	9.66^{bA}	1.88^{bB}	7.55^{bA}	1.11^{bB}
64	14.55^{cA}	0.77^{cB}	12.11^{cA}	0.88^{cB}

Values carrying the same lower case letter in a column and upper case letter in a row are not statistically significant at P = 0.05 using the Duncan's Multiple Range Test.

Acknowledgments

The author is grateful to the Department of Science and Technology (DST), Government of India, for financial assistance. He also wishes to thank Rev Dr A A Pappuraj, S J, Principal, and Professor M T Punithan, Head, Department of Zoology, St. Xavier's College, Palayankottai, for their encouragement.

References

George, J.E. 1996. Impact of chosen insecticides on the non-target reduviid biocontrol agents (Insecta: Heteroptera: Reduviidae) Ph.D. thesis, Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu, India. 117 pp.

Kalyana Sundaram, K., Dhandapani, N., Swamiappan, M., Sundarababu, P.C., and Jayaraj, S. 1994. A study on the management of some pests of groundnut. (*Arachis hypogaea L.*) with biocontrol agents. Journal of Biological Control 8:1-4.

Venugopal Rao, N., Raja Sekhar, P., and Venkataiah, M. 1993. Insecticide resistance management in relation to *Helicoverpa armigera* (Hubner) in Andhra Pradesh. Journal of Insect Science 6:210-214.

Wightman, J.A., and Rang Rao, G.V. 1993. A groundnut insect identification hand book for India. Information Bulletin no. 39. Patancheru 502 324, A.P., India. International Crops Research Institute for the Semi-Arid Trooics. 60 pp.

Production and Management

Groundnut Production Constraints and Research Needs in Mozambique

P Subrahmanyam[1], P J A van der Merwe[1], and M A mane[2] (1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), PO Box 1096, Lilongwe, Malawi; 2. Instituto Nacional de Investigacao Agronomica (INIA), CP 3658, Maputo, Mozambique)

Groundnut (*Arachis hypogaea L.*) plays an important role both as a food and cash crop for smallholder farmers in Mozambique. It is an important component of rural diet; groundnut oil is a popular cooking medium and the flour is used to enrich the relish/Roasted and boiled nuts are eaten as snack food. Groundnut provides supplementary cash income to women farmers in Mozambique who support their families, especially children's education and health.

Mozambique is the largest groundnut producer in southern Africa, with 950 000 ha cultivated in 1996. Nampula Province is the largest producer of groundnut in the country, although it is grown almost throughout, with the highest concentration in the northern region.

in March 1998 and 1999, ICRISAT and INIA scientists visited northern Mozambique to assess the situation of groundnut production and identify the major constraints that limit crop production. Discussions were held with various stakeholders including farmers, extension agents, and NGOs during these trips to identify the future research requirements in the country. The findings are briefly presented in this report.

Groundnut production and constraints

The current average yield of groundnut is very low, with a nation-wide mean of about 200 kg ha^{-1}, which is one of the lowest in the world. Production constraints are many and diverse due to contrasting agroecologies and include nonavailability of improved varieties adapted to various production systems, lack of organized seed production and delivery mechanisms, poor soil fertility and cultural practices, insect pests, and diseases.

Groundnut is grown by smallholder farmers, especially women farmers, under very low input conditions, without any fertilizers and pesticides, largely as a mixed crop with bambara groundnut, phaseolus bean, cowpea, cassava, maize, sorghum, and with vegetables such as cucumber, squash, okra, and tomato, sown on flat land. Most of the groundnut fields visited in March 1998 and 1999 were at pod-filling to maturity stages and the size of the fields varied from 0.25 ha to over 1.00 ha per household. Plant populations were low in a majority of the fields. In some villages, farmers were harvesting the crop.

Early-maturing Spanish varieties ('Natal Common' type) were observed in most of the fields. The majority of fields had a mixture of two to five groundnut varieties including Spanish, Valencia, and long-duration Virginia types. It was not possible to determine the identity of all the varieties, several of which appeared to be traditional land races. The Virginia types which were found in farmers' fields were very prostrate runner types. RMP 12, a long-duration rosette-resistant Virginia bunch variety, was observed in some fields. Although RMP 12 has low yield potential, farmers grow this variety because of its resistance to rosette virus.

During meetings with the farmers, they said they maintain their own seed for sowing in the following year. Storing of seed material in gunny sacks hung over the fire-place in the kitchen appears to be a common practice. Seed stored in this way will be covered with black soot. This practice is believed to protect the seed from storage pests. Maintenance of seed by the farmers over many years seems to be one of the reasons why there is such a diversity of land races in farmers' fields. During the period of civil war in Mozambique, several of the areas in Nampula Province were not accessible. Farmers in these areas continued to grow groundnut with whatever seed they had for cultivation.

In recent years, several NGOs based in Mozambique have imported groundnut seed from Zimbabwe and South Africa and distributed it to farmers as a relief measure after the war. There is a great need to collect the local land races from these areas before the introduced varieties take over the traditional varieties. It is noteworthy that two such land races, ICG 9549 (RPM 134) and ICG 9558 (RPM 167) collected in Mozambique in 1977 proved to be resistant to rosette when tested at ICRISAT-Lilongwe in recent years (1993 to 1998) (Subrahmanyam et al. 1998). From discussions with the farmers and extension personnel, it was clear that there are no organized seed production and delivery systems operating in Nampula Province.

Rosette virus was the most serious and destructive disease of groundnut in almost all fields visited in 1998 and 1999. Both chlorotic and green rosette were observed in most of the fields, however, green rosette was most predominant. The disease was especially serious in late-sown groundnuts often leading to 100% disease incidence. Early-sown crops showed less damage from the disease. It is interesting to note that rosette occurs in epidemic proportions every year in Nampula Province, unlike in other parts of the country, and the reasons for these epidemics have not been fully elucidated. All groundnut varieties, except RMP 12, grown by the farmers are susceptible to rosette. It appears to be the major factor causing low average yields (200 kg ha^{-1}) in Nampula Province. Foliar diseases were also serious in most fields visited, especially in the coastal districts (Nakala area) which are warm and humid. Rust and leaf spots (both early and late) were very severe and destructive, causing extensive defoliation especially on crops nearing maturity. Unfortunately, information on the extent of yield losses due to these diseases was not available. Wilting of plants due to termite infestation was observed in some areas. However, the incidence was very low and sporadic.

Groundnuts are harvested at maturity, the pods are stripped manually, and dried in homesteads. In some parts of Nampula, groundnuts are stacked along with the pods soon after the harvest because of labor shortages and stripped at a later stage when other crops have been harvested. Improper staking of groundnut predisposes the pods to *Aspergillus flavus* Link ex Fries infection and aflatoxin contamination thus reduces the quality of the produce. A systematic survey is required to examine the preharvest methods and determine the extent of the aflatoxin contamination problem in Mozambique.

Research requirements

During the pre-civil war era, research on groundnut was carried out at the Instituto Nacional de Investigacao Agronomica (INIA). Research efforts at INIA resulted in development of some improved groundnut production technologies in the country (Ramanaiah et al. 1988). During the prolonged civil war, much of the country's infrastructure and expertise in research and extension was debilitated to a great extent. As a result, valuable genetic resources, including several improved groundnut varieties, and human resources were lost for ever. In view of these constraints and the enormous potential for improving groundnut productivity in Mozambique, INIA should emphasize capacity building, collection of local land races, introduction of improved varieties, and market development. Over the past 25 years, ICRISAT has generated a wealth of improved technologies which can be utilized to achieve this goal through supply of improved seed material for on-farm evaluation and subsequent adaptation, development of sustainable seed production and delivery systems, and marketing. ICRISAT has recently initiated collaboration with World Vision International, TechnoServe, CARE, and OXFAM, and provided improved breeding materials for on-station/on-farm testing and verification. However, this requires more coordination on a national basis.

Rosette disease is the most important constraint to groundnut production in Nampula Province. At present, RMP 12 is the only resistant variety on the national variety list. RMP 12 has not performed well in variety trials conducted to date, perhaps because of its long duration. Given farmers' preference for small-seeded, short-duration Spanish varieties because of the ready market, short-duration varieties with resistance to rosette and foliar diseases should be included in future trials as a matter of priority.

Variety release procedures are under development in Mozambique. These procedures should allow the use of supporting data on varietal performance under similar agro-ecological conditions in neighboring countries in order to accelerate the release of badly needed rosette-resistant cultivars.

Farmers grow a wide range of traditional land races and their mixtures in Nampula Province. There is a danger of losing these valuable resources over a period of time with the introduction of improved groundnut varieties. Hence, collection of land races from farmers' fields should receive high priority.

Aflatoxin contamination is believed to be a serious quality problem of groundnut in Mozambique. Loss of international/regional export markets is attributed to low quality of nuts due to aflatoxin contamination. There is a need for systematic evaluation of the incidence and extent of aflatoxin contamination at the farm level (pre- and postharvest) and at buying points and warehouses. This information will permit the identification of appropriate methods of management suitable to smallholder farmers, traders, processors, and exporters.

Domestic and international marketing possibilities should be explored in order to broaden the range of varieties for which there is market acceptance. The current situation whereby only the small-seeded, short-duration varieties gain ready market acceptance could hinder the introduction of more productive medium- or long-duration cultivars appropriate for some agroecologies.

Training of scientists, technicians, and extension workers and reconstruction of infrastructure in INIA is urgently required to address the issues pertaining to groundnut research and development in Mozambique.

References

Ramanaiah, K.V., Freire, M.J., Chilengue, B.S., and Munguambe, A.V. 1989. Pages 157-161 in Proceedings of the Third Regional Groundnut Workshop for Southern Africa, 13-18 Mar 1988, Lilongwe, Malawi (Bock, K.R., Cole, D.L., Hildebrand, G.H., Nigam, S.N., and Wightman, J.A., eds.). Patancheru, Andhra Pradesh 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Subrahmanyam, P., Hildebrand, G.L., Naidu, R.A., Reddy, L.J., and Singh, A.K. 1998. Sources of resistance to groundnut rosette disease in global groundnut germplasm. Annals of Applied Biology 132:473-485.

A Simple, Rapid, and Nondestructive Method for Screening Aluminum Tolerance in Groundnut

K K Pal and Rinku Dey (National Research Centre for Groundnut, PO Box 5, Junagadh 362 001,Gujarat, India)

Aluminum (Al) toxicity is a major constraint limiting the growth of groundnut in acid soils. Therefore, selection and breeding of groundnut for increased aluminum tolerance/resistance could be a useful approach for increasing the production of the crop in acid soils particularly in the eastern and north-eastern states of India. A simple and rapid technique is required to assess the sensitivity/tolerance/resistance of the genotypes of groundnut to Al-stress. Two main methods, soil culture and nutrient solution culture, have been employed for screening Al tolerance in other crops (Ma et al. 1997). The nutrient solution technique is preferred as the roots are easily visible. However, the presence of interfering ions, particularly phosphate, Ca, and other metals, may be a shortcoming of this method. In an attempt to overcome these problems, a rapid and nondestructive seedling assay has been developed to screen the groundnut genotypes for Al-toxicity tolerance.

In a preliminary screening, nine cultivars representing various habit groups i.e., Virginia (bunch and runner), Spanish, and Valencia were selected. Seeds were washed with deionized water (MilliQ) and germinated in acid-washed petri dishes containing water agar (0.5% agar in

Table 1. Seedling assay: root length of groundnut seedlings after 7 days of incubation at 28±2°C.

	Concentration of Al in uM												
Cultivar	0	25		50		100		200		400		SE	Rank
JL24	16.76[1]	16.53	(01.37)[2]	14.27	(14.86)	13.46	(19.69)	13.53	(19.27)	11.13	(35.38)	±0.95	T[3]
ICGV89211	9.97	6.83	(31.43)	5.27	(47.19)	4.37	(56.22)	3.07	(69.28)	2.07	(79.32)	±0.74	HS
TG26	8.87	7.53	(15.10)	4.60	(48.14)	3.70	(58.29)	2.03	(77.11)	1.30	(85.34)	±0.78	HS
TMV2	8.63	5.57	(35.46)	3.30	(61.76)	2.67	(69.06)	1.53	(82.27)	1.40	(83.77)	±0.60	HS
Gangapuri	11.73	12.00	(-1.95)	11.80	(-0.26)	11.10	(05.69)	9.23	(21.58)	6.13	(47.92)	±0.84	I
Ak 12-24	8.90	8.60	(03.37)	6.63	(25.50)	5.47	(38.54)	2.83	(68.20)	1.63	(81.68)	±0.57	HS
M 13	12.97	12.30	(05.09)	8.20	(36.73)	7.33	(43.44)	5.43	(58.10)	3.80	(70.68)	±0.99	HS
Girnar 1	11.40	9.73	(14.65)	10.13	(11.14)	9.07	(20.53)	6.53	(42.72)	4.57	(59.91)	±0.73	I
Kadiri 3	13.27	11.63	(12.29)	11.17	(15.76)	4.80	(64.33)	3.63	(72.62)	2.87	(78.35)	±1.10	HS
SE	±1.15	±0.85		±0.86		±0.65		±0.83		±0.48			

1. Root length as mean of five seedlings replicated three times in cm.
2. Data in parentheses represent percent reduction in root length compared with control.
3. T= tolerant; HS= highly sensitive; I- intermediate.

deionized water), at 28°C. After 48 h, the seedlings with radicle length of 1 cm were separated into petri dishes containing 15 ml of deionized water with different concentrations (0, 25, 50, 100, 200, and 400 uM) of Al ($A1C1_3.6H_2O$) with 0 concentration as the control. The pH of the medium was adjusted to 4.5. In each petri dish, five germinated seedlings of each cultivar were placed (replicated three times) and incubated at 28±2°C for seven days in an incubator. The solution in each petri dish was replaced with fresh solution of $AlCl_3$ every day. After seven days of growth, the seedlings were taken out and washed with deionized water several times. The root length of each seedling was measured. Then the roots were stained with a 0.1% aqueous solution of erichrome cyanine R and 0.1% hematoxylin in 0.01% KIO_3 for 15 min. The excess dye was removed by washing the seedlings in deionized water. Stained roots reflect the sensitivity to Al-toxicity (Polle et al. 1978). The staining patterns were observed to ascertain the results obtained in the root inhibition studies. Cultivars which were not stained with either of the stains at any Al level and which did not show more than 40% reduction in root growth at the highest concentration (400 uM) of Al were ranked as tolerant whereas those which stained at all the levels and where the reduction in root growth was more than 60% at the highest concentration were ranked as highly sensitive. Intermediate rank was given to those cultivars in which the reduction in root growth was between 40-60% at the highest concentration and staining of the roots was obtained with 100 uM of Al concentration onwards. In erichrome cyanine R staining, pink coloration and in hematoxylin staining, greyish-brown coloration along the entire root were the indicators of Al sensitivity.

In this method, more emphasis has been given to the comparison of root length of Al-affected plants with control plants grown in absence of Al and the percent reduction in the root length. In the tolerant cultivar, JL 24, the root growth was reduced by 35.38% at even 400 uM concentration of Al whereas in the highly sensitive cultivars like ICGV 89211, TG 26, TMV 2, Ak 12-24, M 13 and Kadiri 3, the inhibition of root elongation ranged from 70-85% at the same concentration (Table 1). Analysis of slope vs root length of control also confirmed the tolerance of JL 24 to Al-toxicity as it had the lowest value for b (0.06) among the cultivars studied. For Gangapuri the reduction at 400 uM was 47.92% and for Gimar 1 59.91%. However, the data appear anomalous in these two cultivars, particularly in Gangapuri. In the sensitive cultivars (ICGV 89211, TG 26, TMV 2, and M 13), drastic reduction in the root length was observed even at a concentration of 50 uM of Al whereas in the tolerant cultivar like JL 24, the tolerance was obvious. Although there is considerable variation in the root length in the different concentrations of Al-toxicity across the cultivars, the method is simple as percent reduction of root length has been considered for assessment. The result was more or less consistent with the staining pattern (Table 2). Staining may be used in this method

Table 2. Staining patterns of groundnut roots with erichrome cyanine R and hematoxylin.

	Al concentration (uM)					
Cultivar	0[1]	25	50	100	200	400
JL24	-	-	-	-	-	-
ICGV 89211	-	+	+	+	+	+
TG26	-	+	+	+	+	+
TMV2	-	+	+	+	+	+
Gangapuri	-	-	-	-	+	+
Ak 12-24	-	-	+	+	+	+
M13	-	-	+	+	+	+
Girnar 1	-	-	-	+	+	+
Kadiri 3	-	+	+	+	+	+

1. Control.

as a confirmatory test. It is nondestructive as the seedling showing tolerance can immediately be transferred to the normal growth medium and subsequently grown for multiplication. This method requires only 10 days and is suitable for screening large numbers of plants. Since no interfering ions like phosphate, Ca or other metals were present, the results obtained in this method are reliable as far as Al-toxicity is concerned. At present, the method is being refined and the effects of seed size being examined as seed reserves are the sole source of nutrition. Identification of the possible mechanism(s) involved in Al-toxicity tolerance after identifying the source of resistance/tolerance is being investigated.

References

Ma, J.F., Zheng, S.J., Li, X.F., Takeda, K., and Matssumoto, H. 1997. A rapid hydroponic screening for aluminium tolerance in barley. Plant and Soil 191:133-137.

Polle, E., Konzac, C.F., and Kittrick, J.A. 1978. Visual detection of aluminium tolerance levels in wheat by hematoxylin staining of seedling roots. Crop Science 18:823-827.

Response to Sulfur of Rainfed Groundnut Genotypes on Lateritic Sandy Loam (Aeric Haplustalf) in Orissa, India

S K Sahu, S C Nayak, J K Dhal, and R K Nayak (Orissa University of Agriculture and Technology, Bhubaneswar 751 003, Orissa, India)

Groundnut is a major oilseed crop in Orissa contributing nearly 57% of the total oilseed production of the state. Lateritic uplands in Orissa are suitable for growing kharif (rainfed) groundnut crops which are mostly used for seed purposes during the rabi (dry) season. Of many constraints for sustaining groundnut productivity in the wet season, deficiency of sulfur in red and lateritic (Aeric Haplustalf) soils is considered most important. Investigations on the status of sulfur in soils of Orissa showed that nearly 50-60% of the above soils were deficient in this nutrient (ICAR 1997). Sahu and Das (1997) showed a 10-25% increase in yield when groundnut was grown in lateritic soils with added sulfur. Different genotypes of groundnut show variations in their sulfur requirements but information on sulfur requirements of major groundnut genotypes cultivated during wet seasons on lateritic soils in Orissa is meagre.

In order to find out suitable doses of sulfur for five genotypes (Smruti, AK 12-24, ICGS 11, TAG 24, and TG 3) field trials were carried out with 4 levels of S (0, 15,30, and 45 kg S ha^{-1}) during 1996 and 1997 wet seasons on lateritic soil at the Central Research Station, Orissa University of Agriculture and Technology. Altogether 20 treatments were replicated three times in a factorial complete block design. Phosphogypsum containing 15% sulfur was the source of sulfur.

The soil of the experimental sites was sandy loam (Aeric Haplustalf) with pH 5.5 to 5.6, organic carbon 0.3-0.35%, and 0.15% $CaCl_2$-extractable S between 8.5 to 9.0 mg kg^{-1}. The crops received 20 kg N, 17.5 kg P, and 33.2 kg K ha^{-1}. Diammonium phosphate, urea, and muriate of potash were the sources of N, P, and K as needed. The crops received NPK along with S in full at the time of sowing.

The data (Table 1) showed that application of S significantly increased the pod yields, shelling turnover, and uptake of sulfur by groundnut. Maximum pod yields, shelling turnover and uptake of S were recorded following application of S at 45 kg ha^{1}. The genotypes of ICGS 11

Table 1. Response of groundnut genotypes to sulfur during wet seasons in Orissa, India.

	Pod yield (kg ha^{-1})			Shelling percentage			S uptake (kg ha-')		
Treatments	1996	1997	Mean	1996	1997	Mean	1996	1997	Mean
Genotype									
Smruti	942	681	811	69.5	69.2	69.3	3.13	2.10	2.67
AK 12-24	793	587	690	67.5	69.4	68.4	2.62	2.17	2.39
ICGS 11	920	751	836	69.2	69.3	69.2	2.50	2.62	2.60
TAG 24	852	598	724	69.0	66.4	67.7	2.60	2.24	2.42
TG3	900	575	737	68.0	67.6	67.8	2.66	1.79	2.23
CD (P = 0.05)	22.1	37.0	-	NS	2.1	-	0.05	0.42	-
Level of S (kg ha^{-1})									
0 (control)	804	558	681	65.3	64.1	64.7	2.28	1.50	1.95
15	848	601	724	67.3	66.9	67.1	2.56	1.85	2.22
30	925	661	793	70.2	70.6	70.4	2.70	2.48	2.59
45	955	732	843	71.2	71.9	71.5	2.81	2.80	2.80
CD (P = 0.05)	13.2	74.7	-	0.91	1.5	-	0.02	0.15	-

Table 2. Response of groundnut genotypes to different levels of sulfur during two wet seasons in Orissa, India.

	Pod yield (kg ha^{-1}), mean of two seasons				
	S_0[1]	S_{15}	S_{30}	S_{45}	Mean
Genotype					
Smruti	714	751 (5.2)[2]	827 (15.0)	952 (33.3)	811
AK 12-24	619	664 (7.3)	742 (19.8)	737 (19.1)	690
ICGS 11	721	795 (10.3)	875 (21.3)	967 (34.1)	836
TAG 24	686	708 (3.2)	743 (8.3)	760 (10.8)	724
TG3	667	704 (5.5)	781 (17.1)	797 (19.4)	737
Mean	681	724 (6.3)	793 (16.4)	843 (23.8)	
		Genotypes	Levels of S		
CD (P = 0.05)		29.5	66.1		

1. For levels of sulfur, see Table 1.
2. Figures in parentheses indicate percentage increase over control, S_0, of the same variety.

and Smruti produced the maximum pod yields, shelling turnover, and uptake of S. This may be due to genotypic effects. Application of S at 30-45 kg ha^{-1} is considered adequate for wet season groundnut genotypes for growing in lateritic, sandy loam.

The interaction data averaged for two years (Table 2) showed that genotypes ICGS 11 and Smruti had higher responses to sulfur application. For application of 45 kg S ha^{-1} the maximum pod yield of 967 kg ha^{-1} was obtained for the genotype ICGS 11, and 952 kg ha^{-1} for Smruti. The corresponding yield increases over the control at this level of S were 34.1% for ICGS 11 and 33.3% for Smruti. Other genotypes showed a lower response to S. The relative susceptibility for groundnut genotypes to sulphur stress were ICGS 11 > Smruti > TG-3 > AK 12-24 > TAG 24.

References

All India Co-ordinated Project on Micro and Secondary Nutrients and Pollutant Elements in Soil and Plants (ICAR). 1997. Annual Progress Report. Bhopal, Madhya Pradesh, India: Indian Institute of Soil Science.

Sahu, S.K., and Das, B.B. 1997. Effect of sources, dose, time and mode of sulfur application to groundnut on lateritic soils. International *Arachis* Newsletter 17:62-63.

Deleterious Rhizobacteria Associated with Groundnut

Rinku Dey, K K Pal, S Chauhan, and D M Bhatt
(National Research Centre for Groundnut, PO Box 5, Junagadh 362 001, Gujarat, India)

A myriad of microorganisms is commonly present in the rhizosphere of a growing plant. The nature of these microorganisms depends on the types of root exudates and substrate availability. Several categories of rhizosphere bacteria are currently recognized (Chanway et al. 1991) including disease-causing pathogens, deleterious rhizobacteria (DRB), plant growth-promoting rhizobacteria (PGPR) and symbiotic/asymbiotic bacteria. Evidence is increasing that the saprophytic/free living microflora of the rhizosphere have the potential to influence plant growth and crop yield substantially.

Initially, to study rhizobacteria associated with groundnut, about 400 different rhizobacterial isolates were obtained from the rhizotic zones of groundnut. These were tested for different plant growth-promoting/inhibiting attributes such as production of indole acetic acid (IAA) (Sarwar and Kremer 1995), siderophores (Schwyn and Neilands 1987), and hydrocyanic acid (HCN) (Bakker and Schippers 1987). Most of the cyanogenic strains were fluorescent pseudomonads (Table 1). The attributes were determined following the standard procedures of the authors mentioned above. During this study on plant growth-promoting rhizobacteria (PGPR) associated with groundnut rhizosphere, other root colonizing bacteria including cyanogenic ones that were deleterious to seed germination and seedling growth were frequently isolated. Seedling bioassays were conducted with both deleterious (cyanogenic) and noncyanogenic bacteria by the dual culture technique of Alstrom and Burns (1989) using pregerminated seedlings under aseptic conditions.

Table 1. Growth-affecting attributes of rhizobacteria and their cyanogenic effect on seedling growth of groundnut cultivar JL 24 after 7 days.

Isolate	Organism	IAA (mg L^{-1})	Siderophore	HCN	Root length seedling*[1] (cm)
Fluorescent strain					
C42	*Pseudomonas* spp	1.00	+++	++	1.75
C 103	*Pseudomonas* spp	-	+++	++	0.51
C220	*Pseudomonas* spp	-	+++	++	1.13
C63	*Pseudomonas* spp	-	+++	++	0.74
C285	*Pseudomonas* spp	-	++	+++	2.42
C 185	*Pseudomonas* spp	3.60	++++	-	5.65
Nonfluorescent strain					
363	*Beijerinckia* spp	11.56	++		1.94
359	*Beijerinckia* spp	4.56	+++	-	1.39
397	*Beijerinckia* spp	8.95	+++		1.71
387	*Pseudomonas* spp		++		1.71
379	*Pseudomonas* spp	1.63	-	++	1.93
29	*Pseudomonas* spp	1.67	++	+++	0.64
85	*Pseudomonas* spp	1.77	+++	+++	1.94
2	*Pseudomonas* spp	3.47	+	++	2.44
Control		-	-	-	3.82
LSD (P = 0.05)					1.73

1. Mean of three replications having three seedlings in each.
2. + or - indicates degree of activity.

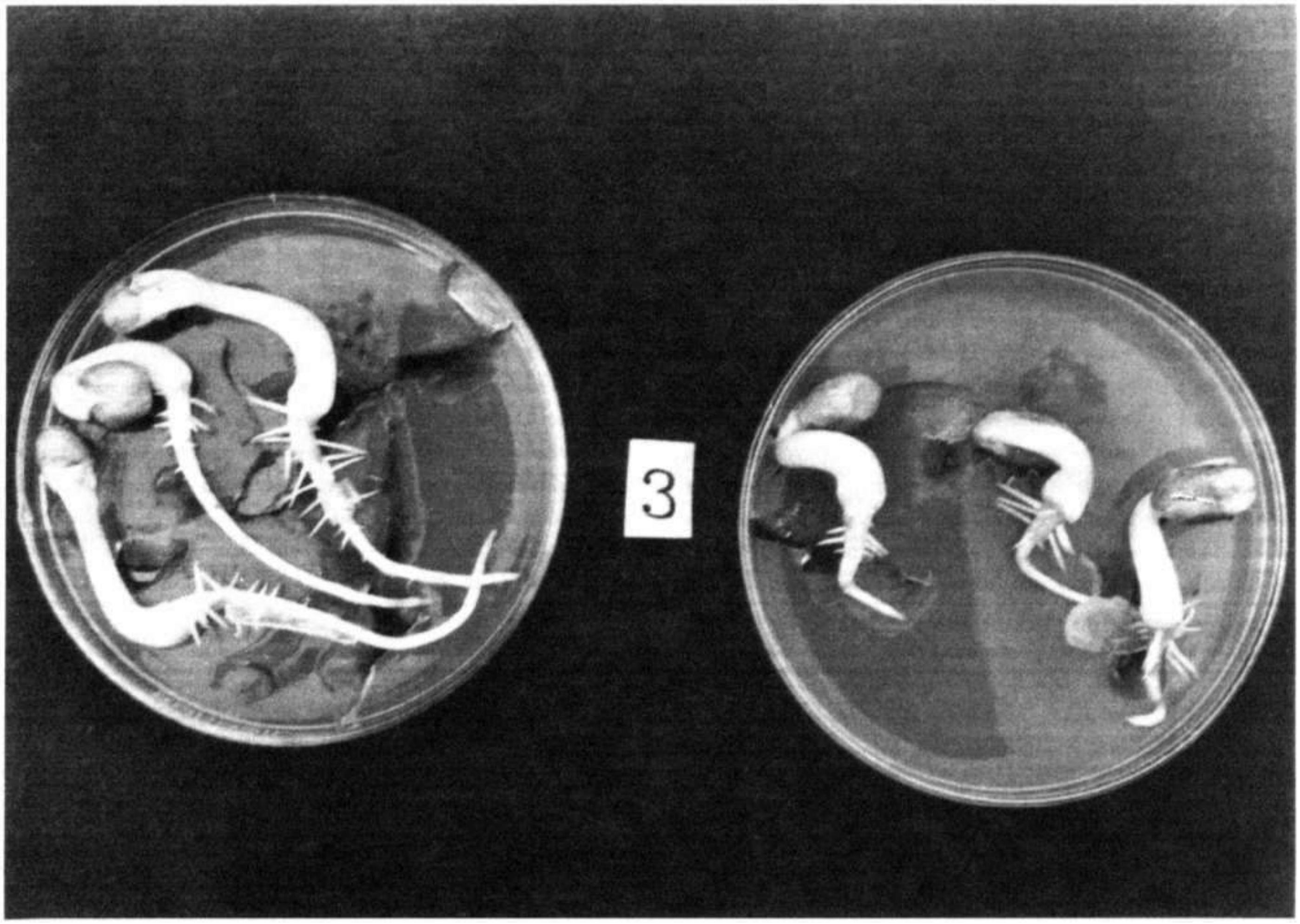


Figure I. Effect of a cyanogenic microorganism, *Pseudomonas* spp strain C 103 (fluorescent), on the seedling growth of groundnut cultivar JL 24 (left: control; right: cyanogenic strain C 103).

The noncyanogenic fluorescent pseudomonad, C 185, significantly increased the root growth compared with the control (Table 1) whereas cyanide produced by the cyanogenic bacterial isolates i.e., C 103, C 63, and 29 strongly inhibited the growth of the root (Fig. 1). Typical blackening and tip burning of the roots were also observed which may be due to cyanogenesis. Further attempts were made to study the effects of the selected cyanogenic and noncyanogenic rhizobacteria on the growth and yield of groundnut as reported here.

A plot experiment was conducted during the rabi/summer season of 1998 using groundnut cultivar JL 24. The experiment had eleven treatments: five potentially cyanogenic bacteria, five noncyanogenic bacteria, and a control. Each treatment was replicated six times and plants from three pots were uprooted for counting nodules at 45 days after sowing (DAS) and at harvest observations were taken from the remaining three pots. Each pot of 35 cm diameter had 20 kg soil and five plants were grown in each pot. All the pots were fertilized with 20 kg N ha^{*1} as urea (0.44 g) and 40 kg P_2O_5 ha^{-1} as single superphosphate (SSP) (2.5 g). Seed pelleting was done using 48-h old broth cultures and the inoculum load was approximately 10^8 cfu $seed^{-1}$. The mean nodule number per plant was recorded at 45 DAS. At harvest, the mean main root length, root and shoot biomass, and pod yield per plant were recorded (Table 2). The length of the main root was measured after removing the root from the soil of the pot by splashing water into the pot at high pressure from a pipe so that the total root system could be taken out. The cyanogenic isolates (C 42, C 103, and C 63) inhibited plant growth and lowered the pod yield as was evident from the significant reduction in root length, root biomass, and pod yield. There was some reduction in shoot biomass also. The reduction in yield was as high as 41.67% in isolate C 63 and 29.32% in isolate C 42 (Table 2). Similar observations on yield loss and inhibition of root growth due to inhibitory bacteria

Table 2. Cyanogenic effect of rhizobacteria on the growth and yield of groundnut cultivar JL 24[1].

Bacterial isolate	Main root length plant^{-1} at harvest (cm)	Biomass plant^{-1} at harvest root(g)	shoot (g)	Pod yield plant^{-1} (g)	Nodule no. plant^{-1} at 45 DAS
C 42 (Cya$^+$)[2]	19.66	1.08	10.39	2.29	61
C 103 (Cya$^+$)	21.00	1.04	9.62	2.30	37
C 220 (Cya$^+$)	26.87	1.45	10.81	2.99	86
C 63 (Cya$^+$)	18.87	1.03	9.42	1.89	22
C 285 (Cya$^+$)	27.90	1.46	11.37	3.54	83
C 185 (Cya)	39.00	2.22	16.68	4.04	112
363(Cya)	34.27	2.00	13.65	3.95	111
359(Cya)	32.47	1.99	11.78	3.95	88
397(Cya)	36.33	2.04	14.54	3.97	79
387(Cya)	27.53	1.57	11.77	2.79	66
Control	26.67	1.50	11.88	3.24	65
SE	±2.58	±0.14	±0.88	±0.24	± 6.11
CV(%)	11.21	10.70	8.97	9.21	10.15

1. Data presented are the means of three replications.
2. Cya*-cyanogenic;Cya = noncyanogenic.

have been made earlier (Bakker and Schippers 1987, Doty et al. 1994). Inhibition of root cell energy metabolism by HCN is suggested as the cause of yield reduction (Bakker and Schippers 1987). Nodulation was also inhibited by C 103 and C 42 isolates. Cyanide is harmful to aerobic organisms such as rhizobia. Thus, the native rhizobial population may have been reduced due to the cyanide effect which in turn affected nitrogen availability. However, increase in yield of groundnut was observed by the seed coating with the noncyanogenic isolates C 185 (24.69%) and 397 (22.53%), which were significantly higher than the control. As fluorescent pseudomonads are abundant and versatile in the soil, the presence of a large number of cyanogenic microflora could affect the growth and yield of groundnut. Glycine and methionine are the two precursors for cyanogenesis. Groundnut also secretes sufficient amounts of cyanogenic precursors in the form of root exudates which may be used by the inoculated cyanogenic micoorganisms to affect the growth and yield of the crop. It will be worthwhile to study the dynamics of soil microflora vis-a-vis cropping systems and soil status to understand the role of these detrimental rhizobacteria on the yield of groundnut.

References

Alstrom, S., and Burns, R.G. 1989. Cyanide production by rhizobacteria as a possible mechanism of plant growth inhibition. Biology and Fertility of Soils 7:232-239.

Bakker, A.W., and Schippers, B. 1987. Microbial cyanide production in the rhizosphere in relation to potato yield reduction and *Pseudomonas* spp-mediated plant growth-stimulation. Soil Biology and Biochemistry 19:451-457.

Chanway, C.P., Turkington, R., and Holl, F.B. 1991. Ecological implications of specificity between plants and rhizosphere microorganisms. Advances in Ecological Research 21:121-169.

Doty, A., Kennedy, A.C., and Pan, W.L. 1994. Rapid bioassay for inhibitory rhizobacteria using digital image analyses. Soil Science Society of America Journal 58:1699-1701.

Sarwar, ML, and Kremer, R.J. 1995. Enhanced suppression of plant growth through production of L-tryptophan-derived compounds by deleterious rhizobacteria. Plant and Soil 172:261-269.

Schwyn, B., and Neilands, J.B. 1987. Universal chemical assay for detection and determination of siderophores. Analytical Biochemistry 160:47-56.

Enhancement of Groundnut Growth and Yield by Plant Growth-Promoting Rhizobacteria

K K Pal, Rinku Dey, D M Bhatt, and S Chauhan
(National Research Centre for Groundnut, PO Box 5, Junagadh 362 001, Gujarat, India)

The bacteria that provide some benefit to plants are of two general types, those that form a symbiotic relationship with them and those that are free-living in the soil, but are often found near, on, or even within the roots of plants. Beneficial free-living soil bacteria are usually referred to as plant growth-promoting rhizobacteria or PGPR. Some of these such as *Rhizobium* spp have considerable potential to alter the composition and activity of rhizosphere microflora (Schroth and Ole Becker 1990) and some promote nodulation by rhizobia and thus are called nodulation-promoting rhizobacteria (NPR) (Kloepper et al. 1988). The beneficial effect of these bacteria has been variously attributed to their ability to produce various compounds including phytohormones, organic acids, and siderophores, to fixation of atmospheric nitrogen, to phosphate solubilization, to antibiotics that suppress deleterious rhizobacteria or to some other unidentified mechanisms (Glick 1995). Motile rhizobacteria may colonize the rhizotic zones of the plant more profusely than nonmotile organisms resulting in better rhizosphere activity and nutrient transformation. They may also eliminate deleterious rhizobacteria from the rhizosphere by niche exclusion giving better plant growth (Weller 1988).

A novel approach was adopted for the isolation of PGPR from the groundnut rhizosphere by ACC deaminase activity using ACC (1-aminocyclopropane-l-carboxylate, Sigma) as the sole source of N. This enzyme lowers the level of ethylene in developing plants by hydrolyzing ACC, ethylene's immediate precursor (Jacobson et al. 1994). If the level of ethylene following germination is too high, root elongation is inhibited. This model predicted that any rhizosphere bacterium with ACC deaminase activity which could bind to plant seeds or roots in the soil should also be able to promote root elongation and thus be a PGPR (Glick 1995). Using this approach, many potential PGPR which had ACC deaminase activity were isolated from groundnut rhizosphere. These isolates were also tested for other growth-influencing characteristics like production of siderophores (Schwyn and Neilands 1987), indole acetic acid (Sarwar and Kremer 1995), and phosphate solubilization (Pikovskaya 1948) (Table 1). Pseudomonas sp (BHU 1) and fluorescent *Pseudomonas* isolate C 185 exhibited almost all the attributes of PGPR in vitro. An open air experiment in pots was conducted during the rabi/summer season of 1998 to evaluate the effect of these rhizobacteria on groundnut growth, yield, and nodulation of groundnut cultivar JL 24, under nonsterile conditions. The experiment had ten treatments: eight isolates with ACC deaminase activity, one without ACC deaminase activity as control {*Arthrobacter* sp), and an uninoculated control. Each treatment was replicated six times with five plants pot^{-1}. Each pot of 35 cm diameter had 20 kg soil and was fertilized with 0.44 g urea (20 kg N ha^{-1}) and 2.50 g single superphosphate (SSP) (40 kg P_2O_5 ha^{-1}). Seed coating

Table 1. Plant growth-promoting attributes of some of the rhizobacterial isolates.

Rhizobacteria	ACC deaminase	Motility	Siderophore	IAA (mg L^{-1})	Phosphate solubilization
Bacillus sp (NN)	++[1]	–	–	-	-
Beijerinckia sp (B 17)	+++	-	-	-	-
Pseudomonas sp (M13-19)	+	++	++	-	-
Pseudomonas sp (BHU 1)	++++	+++	+++	-	+
Arthrobacter sp (9)	-	+	-	-	-
Fluorescent pseudomonads					
strain A 15	++++	+++	-	-	-
strain A 18	++++	+	+	-	-
strain A 19	++++	+	+	-	-
strain C 185	++++	++	+++++	3.6	-

1. + or - indicates degree of reaction.

Table 2. Effect of plant growth-promoting/nodulation-promoting rhizobacteria on the nodulation, growth, and yield of groundnut cultivar JL 24, at Junagadh, Gujarat, India,, during summer. 1998[1].

Isolate	Nodules plant^{-1} at 45 DAS	Root length plant'1 (cm)	Biomass plant^{-1} root (g)	Biomass plant^{-1} shoot (g)	Pod yield plant"' (g)
NN	122	41.0	2.17	16.86	4.70
B17	125	43.0	1.98	6.20	4.75
M 13-19	120	41.0	1.88	14.62	4.32
BHU1	166	46.0	2.29	19.54	5.24
9	77	31.7	1.68	11.26	2.81
A 15	121	43.0	2.17	15.60	4.54
A 18	130	43.0	2.13	15.23	4.59
A 19	163	44.0	2.60	18.34	5.14
C 185	173	47.7	3.24	28.37	5.31
Control	110	38.3	1.82	14.29	4.30
SE	±6.3	±2.2	±0.16	±1.40	±0.31
CV(%)	5.9	6.5	8.8	10.1	8.4

1. Data are the means of three replications.
2. All data were taken at harvest except nodule number.

was done using 48-hour old broth cultures and the inoculum load was approximately 10^8 cfu seed^{-1}. Three replications from each treatment were used for taking nodule counts by uprooting the plants at 45 DAS and the remainder were kept up to harvest. At harvest, the pod yield, root and shoot biomass (dry mass), and root length were recorded (Table 2).

In general, all the inoculated treatments, except the one inoculated with isolate no. 9 (*Arthrobacter* sp) registered better growth, yield, biomass, root length and higher nodule numbers compared with the uninoculated control. Seed coating with pseudomonad isolates like BHU 1, A 19, and C 185 resulted in significantly greater root length, root and shoot biomass, pod yield, and nodule number compared with the control. This may be attributed to various factors such as ACC deaminase activity, siderophore production, and increase in root length. These bacteria may have enhanced the uptake of materials resulting in healthier and better root systems and resultant improved plant growth. As ACC deaminase-negative organism (isolate no. 9) exhibited a deleterious effect on plant growth, ACC deaminase activity had played some positive role in plant growth promotion. Although there was considerable variation in the plant growth promotion by different isolates having ACC deaminase activity, other attributes and population dynamics may also have played a significant role. Rhizobacterial motility did not appear to have any clear role in promoting plant growth. In general, all the inoculants (except isolate no. 9) significantly increased the number of nodules produced. There are reports of enhancement of nodulation by *Rhizobium* in the presence of *Bacillus* sp (Srinivasan et al. 1997). Thus coinoculation of compatible PGPR and *Bradyrhizobium* may promote improved plant growth under natural conditions. At present elucidation of the possible mechanisms of plant growth promotion by these rhizobacteria is being explored. Field trials are underway to confirm the results obtained in the pot experiment.

References

Glick, R.B. 1995. The enhancement of plant growth promotion by free living bacteria. Canadian Journal of Microbiology 41:109-117.

Jacobson, C.B., Pasternak, J.J., and Glick, R.B. 1994. Partial purification and characterisation of 1-aminocyclopropane-l- carboxylate deaminase from PGPR, *Pseudomonas putida* GR12-2. Canadian Journal of Microbiology 40:1019-1025.

Kloepper, J.W., Hume, D.J., Scher, F.M., Singleton, C., Tipping, B., Laliberte, M., Frawley, K., Kutchaw, T., Simonson, C., Lifshitz, R., Zalesua, I., and Lee, L. 1988. Plant growth promoting bacteria on canola (rapeseed). Plant Disease 72:42-46.

Pikovskaya, R.E. 1948. Mobilisation of phosphorus in soil in connection with vital activity of some microbial species. Mikrobiologiya 17:362-370.

Sarwar, M., and Kremer, R.J. 1995. Enhanced suppression of plant growth through production of L-tryptophan-derived compounds by deleterious rhizobacteria. Plant and Soil 172:261-269.

Schroth, M.N., and Ole Becker, J. 1990. Concepts of ecological and physiological activities of rhizobacteria related to biological control and plant growth promotion. Pages 389-414 *in* Biological control of soil-borne plant pathogens (Hornby, D., ed.). CAB International, Wallingford, UK.

Schwyn, B., and Neilands, J.B. 1987. Universal chemical assay for detection and determination of siderophores. Analytical Biochemistry 160:47-56.

Srinivasan, M., Petersen, D.J., and Holl, F.B. 1997. Nodulation of *Phaseolus vulgaris* by *Rhizobium etli* is enhanced by the presence of Bacillus. Canadian Journal of Microbiology 43:1 -8.

Weller, D.M. 1988. Biological control of soil-borne plant pathogens in the rhizosphere with bacteria. Annual Review of Phytopathology 26:379-407.

Genotypic Compatibility in Groundnut/ Pigeonpea Intercropping Systems

P K Ghosh, R K Mathur, A Bandyopadhyay, Devi Dayal, H K Gor, and P R Naik (National Research Centre for Groundnut, PO Box 5, Junagadh 362 001, Gujarat, India)

The concept of intercropping has changed recently from being merely risk avoiding to increasing resource-use efficiency and yield per unit area. However, the system is still not understood adequately compared with that of sole cropping in terms of maximum system efficiency; and more so regarding the concept of genotypic compatibility. The performance of genotypes in intercropping may be dissimilar to the performance of genotypes in sole cropping because when groundnut is grown with a more dominant associated crop, the potential for genotype improvement is expected to be high as a result of possible interactions with the associated crop; and the effect is confounded by many factors. Therefore, there may be a particular need for identification and selection of suitable habit groups as well as genotypes of both base crop and intercrop in such characteristics as optimum and efficient interception of solar radiation, nutrient and water uptake, moisture status of soil, and disease and pest incidence. To date, information is available for relatively few genotypes of groundnut which have been examined with only a few cereal genotypes (Reddy et al. 1991).

Work on this genotypic compatibility has been initiated at the National Research Centre for Groundnut, Junagadh, India, on groundnut/pigeonpea intercropping systems since the kharif (rainy) season of 1996. A brief report on preliminary information on the efficiency of the system based on groundnut equivalent yield for the years 1996 and 1997 is given here. Compatibility of groundnut genotypes belonging to three habit groups i.e., Spanish bunch (SB), Virginia bunch (VB), and Virginia runner (VR) with two habit groups of pigeonpea i.e., compact (C), and medium-tall (MT) was tested in a randomized block design replicated three times. One genotype of groundnut from each habit group and two genotypes of pigeonpea from each habit group were included in the study (Table 1). The SB genotype was sown at a spacing of 30 x 10 cm and VB and VR at 60 x 10 cm. A row ratio of 3 (groundnut) : 1 (pigeonpea) was maintained with SB and 1:1 with VB and VR. A basal application of diammonium phosphate (100 kg ha^{-1}) was applied to both the crops based on area occupied by each crop. The recommended plant population for both the crops was maintained. The plant spread was measured as the distance between the tips of maximum spreading of lateral branches. Grain yield of pigeonpea was converted into groundnut equivalent yield (GEY) as GEY = yield of pigeonpea x unit price of pigeonpea grain / unit price of groundnut pods. The market price of pigeonpea seed was Rs 18 kg^{-1} and of groundnut pods Rs 15 kg^{-1}.

Table 1. Salient characteristics of the groundnut and pigeonpea genotypes.

Genotype	Habit group	Salient characteristics
Groundnut		
GG2	Spanish bunch	Short duration, erect
Kadiri 3	Virginia bunch	Medium duration. semispreading
M 13	Virginia runner	Long duration, spreading
Pigeonpea		
ICPL 87	Compact	Short duration, bushy
ICPL 88039	Compact	Extra-short duration, erect
ICPL 87119	Medium tall	Medium duration, erect
BDN2	Medium tall	Medium duration, bushy

Then total groundnut equivalent yield (TGEY) was estimated as the sum of GEY and pod yield of groundnut.

Results

Early versus late maturity of both the crops

The results indicated that by increasing the crop duration of groundnut and by shifting from bunch to runner type, the groundnut contribution to TGEY tended to increase. Similarly, inclusion of late-maturing pigeonpea genotypes in the intercropping system also resulted in higher TGEY (Table 2). Among the three groundnut genotypes used, M 13, a long-duration VR genotype, gave the highest TGEY. More dry mass (24.35 g as against 16.5 g for GG 2 and 21.48 g for Kadiri 3) and spread of M 13 genotype and its ability to compensate for any stress, particularly shading of pigeonpea, was also evident. The late-maturing pigeonpea genotypes, 1CPL 87119, and BDN 2 were superior to the early-maturing genotypes, ICPL 87 and ICPL 88039.

Compact versus tall habit groups of pigeonpea

In general, bushy genotypes of pigeonpea gave higher yields than the erect types. For example, in the MT habit group BDN 2, a bushy type, gave a higher yield than ICPL 87119, an erect type (Table 2) and in C types, ICPL 87 (bushy type) gave a higher yield than ICPL 88039 (erect). Similarly, the tall-statured genotypes (BDN 2 and ICPL 87119) performed better than short-statured types (ICPLs 87 and 88039) in genotypic combinations (Table 2). This may be attributed to a higher number of secondary branches (10.7-MT versus 7.7-C), number of mature pods (170.7-MT versus 140.5-C), mature pod weight (65.6 g-MT versus 54.3 g-C), dry matter plant^{-1} (72.6 g-MT versus 63.2 g-C) and uniform maturity of these habit groups. Tall types had less spread in the early stage of crop growth. In contrast, growth rate of the ICPL 87, a short-statured type, was high at the initial stage of growth and the plant spread was more (26.1 cm) than BDN 2 (22.5 cm), a tall-statured type, before the harvest of groundnut. With a shift from Spanish to Virginia runner type the dry matter yield of groundnut tended to increase (16.5-24.4 g) irrespective of pigeonpea genotypes.

Interaction

The genotypic combination M 13 x BDN 2 recorded significantly higher TGEY than all other combinations (Table 2). Seed yield of BDN 2 was the highest (1.46 t ha^{-1}) among the pigeonpea genotypes and contributed more towards TGEY in this genotypic combination than pod yield of M 13. BDN 2 behaved like an erect type at the peak period of groundnut growth but as a bushy type (86.7 cm spread) at groundnut maturity, thus, the yield of long-duration groundnut was not affected. The results also indicated that variation in the incidence of early leafspot (ELS), late leafspot (LLS), and rust among the groundnut genotypes was negligible irrespective of the pigeonpea genotypes.

Table 2. Effect of groundnut and pigeonpea genotypes on pod yield of groundnut, seed yield of pigeonpea and total groundnut equivalent yield in groundnut/pigeonpea intercropping, 1995/96 and 1996/97, Junagadh, Gujarat, India.

	Pod yield of groundnut (t ha^{-1})				Seed yield of pigeonpea (t ha^{-1})				Total groundnut equivalent yield (t ha^{-1})			
Groundnut/ pigeonpea	GG2	Kadiri 3	M 13	Mean	GG 2	Kadiri 3	M 13	Mean	GG2	Kadiri 3	M 13	Mean
ICPL 87	0.60	0.46	0.96	0.68	0.42	0.89	0.62	0.64	1.24	1.80	1.89	1.64
ICPL 88039	0.62	0.54	0.82	0.66	0.20	0.45	0.40	0.35	0.93	1.21	1.41	1.19
ICPL 87119	0.67	0.38	0.73	0.60	1.10	0.83	1.40	1.11	2.33	2.39	2.83	2.51
BDN2	0.70	0.79	0.88	0.79	1.25	1.32	1.82	1.46	2.58	2.78	3.63	2.99
Mean	0.65	0.54	0.85	0.68	0.74	0.87	1.05	0.89	1.77	2.04	2.44	2.08
SE for groundnut genotypes		±0.045					±0.095				±0.135	
SE for pigeonpea genotypes		±0.052					±0.110				±0.156	
SE for Interaction		±0.091					±0.191				±0.270	
CV (%)		23.22					31.42				22.4	

These results indicated that bushy, tall, and late-maturing pigeonpea in combination with Virginia runner types of groundnut performed better than the erect, short, and early-maturing types in intercropping systems. The study is being continued for further confirmation.

Reference

Reddy, M.S., Floyd, C.N., and Willey, R.W. 1991. Groundnut in intercropping systems. Journal of Research, Andhra Pradesh Agricultural University, 18:5-14.

Resource-Use Efficiency and Production Potential in Summer Groundnut-Cereal Fodder Associations: Evaluation of a New Concept

P K Ghosh, Devi Dayal, P R Naik, and Virendra Singh (National Research Centre for Groundnut, PO Box 5, Junagadh 362 001, Gujarat, India)

In India, summer groundnut is usually irrigated by the border strip method (one of the most commonly followed surface-irrigation methods) where 3-4 rows of groundnut in each strip are maintained. The borders made for the purpose of irrigating summer groundnut generally remain unused during the entire crop season. Thus, with a view to utilizing the borders and to provide green fodder during the dry season, an experiment in the form of strip cropping was conducted during the summer seasons of 1996 and 1997 at the National Research Centre for Groundnut, Junagadh.

The soil of the experimental plot was medium black (pH 7.7) having organic carbon 0.52 %, available P 10.14 kg ha^{-1} and available K 245 kg ha^{-1}. Cereal fodders i.e., maize (*Zea mays L.*), sorghum (*Sorghum bicolor* (L.) Mocnch) and pearl millet (*Pennisetum glaucum L.*) and groundnut (*Arachis hypogaea L.*) cv GG 2, a Spanish bunch type, were sown simultaneously in the first week of February. The fodder crops were grown on the borders. Three rows of groundnut spaced at 30 cm were maintained in between two rows of fodder. This way, border to border distance was 120 cm. One cutting for all and two cuttings for sorghum and pearl millet were made. The first cut was taken 60 days after sowing (DAS) (flowering stage) and the second cut at 106 DAS (time of groundnut harvest). Larger plot sizes of 4.6 m x 10 m

Table 1. Yields and economics of summer groundnut-cereal fodder combinations (pooled over summers 1996 and 1997), Junagadh, Gujarat, India.

Crop combinations and number of cuttings	Tiller number	Total fodder yield (t ha^{-1})	Number of pods $plant^{-1}$	Pod yield (g $plant^{-1}$)	100-kernel mass (g)	Pod yield (t ha^{-1})	Net return (Rs ha^{-1})	B:C ratio	Production efficiency of fodder (t day^{-1} ha^{-1})
Sole groundnut			9.8	7.9	37.7	2.43	24 717	1.91	—
Groundnut + maize (single cut)		9.00	6.1	4.5	36.7	2.29	32 417	2.33	0.15
Groundnut + sorghum (single cut)	1.9	7.98	6.5	5.5	34.5	2.2	30 060	2.17	0.13
Groundnut + pearl millet (single cut)	2.6	12.81	5.2	4.9	34.7	2.19	33 630	2.40	0.21
Groundnut + sorghum (two cuts)	2.3	12.71	5.9	4.2	33.3	2.04	31 736	2.22	0.12
Groundnut + pearl millet (two cuts)	3.2	16.50	5.0	3.8	34.4	2.01	34 763	2.43	0.16
Mean	2.5	11.8	6.4	5.1	35.2	2.19	31 220	2.24	0.15
SE		±2.32	±0.71	±0.60	±0.66	±0.064	±1458	±0.077	
CV (%)	14.45	25.7	28.1	4.91	9.26	11.8	15.0		

Table 2. Growth dynamics of groundnut in combination with different fodders (pooled over summers, 1996 and 1997), Junagadh, Gujarat, India.

	Dry matter (g plant^{-1})		Nodule number plant^{-1}		Nodule dry mass (mg plant^{-1})	
Crop combinations and number of cuttings	1 st cut	2nd cut	1 st cut	2nd cut	1 st cut	2nd cut
Sole groundnut	5.6	20.85	7.7	17.0	46.2	96.0
Groundnut + maize (single cut)	4.6	10.36	6.4	15.7	39.9	79.5
Groundnut + sorghum (single cut)	4.6	12.01	7.0	15.5	38.5	83.5
Groundnut + pearl millet(single cut)	4.3	12.00	5.9	16.8	32.3	88.5
Groundnut + sorghum (two cuts)	4.2	11.50	4.1	15.1	33.1	72.5
Groundnut + pearl millet (two cuts)	4.0	11.97	5.5	14.8	32.2	69.8
Mean	4.5	13.11	6.1	15.8	37.0	81.6
SE	±0.23	±1.57	±0.50	±0.47	±2.71	±2.95
CV (%)	22.64	28.5	22.6	20.53	28.1	25.5

were maintained. The treatments included sole groundnut, groundnut + maize (single cut), groundnut + sorghum (single cut), groundnut + pearl millet (single cut), groundnut + sorghum (two cuts) and groundnut + pearl millet (two cuts) and were tested in a completely randomized block design replicated three times. The necessary plant protection, irrigation and other management practices were followed during the crop growth. The cereal fodders received 80 N kg ha^{-1}. Twenty kg N ha^{-1} was applied to the fodder crops after harvest of the first cut in treatments where two cuts were planned. One sole groundnut treatment was maintained for comparison. Production efficiency of the fodder was calculated by taking total production divided by the duration of the crop

Data pooled over two years indicated that green fodder yield was the highest in pearl millet with two cuts followed by pearl millet with a single cut and sorghum with two cuts (Table 1). Superiority of pearl millet over sorghum and maize was perhaps due to a higher number of tillers. The production efficiency was the highest in pearl millet with a single cut followed by pearl millet with two cuts. The highest pod yield was recorded in sole groundnut. When two cuts of pearl millet and sorghum were made, the pod yields of groundnut were 0.19 and 0.16 t less with two cuts than with a single cut but two cuts of these crops gave 3.7 and 5.7 t more green fodder than that of a single cut. Moreover, about Rs 1133 and Rs 1676 higher net returns were obtained with two cuttings of the pearl millet and sorghum system than with a single cut. Thus, groundnut yield reduction due to two cuts of pearl millet and sorghum was nullified by high fodder yield and high net return. Reduction in yield of groundnut due to two cuts of pearl millet and sorghum as compared with a single cut and a single cut of maize was evident from reduction in groundnut biomass, nodule number and mass (Table 2), pod yield per plant and 100-kernel mass (Table 1).

Net return based on market prices of Rs 1 kg^{-1} for fresh fodder and Rs 15 kg^{-1} for groundnut pods was maximum and so was the benefit: cost (B:C) ratio when pearl millet was cut twice. The lowest net return and B:C ratio were recorded in sole groundnut. Higher net returns of Rs 10 046 more were obtained from the system with two cuts of pearl millet as compared with sole groundnut. Thus, the present study indicated that two cuts of pearl millet from the crop combination with summer groundnut not only provide additional income to the farmer but also mitigate to some extent the fodder scarcity during the summer season.

Resource-Use Efficiency and Profitability of Intercropping of Summer Groundnut with Short-Duration Vegetables: Evaluation of a Concept

P K Ghosh, Devi Dayal, A Bandyopadhyay, Virendra Singh, and P R Naik (National Reseach Centre for Groundnut, PO Box 5, Junagadh 362 001, Gujarat, India)

Under rainfed situations, intercropping is practised not only for risk avoidance but also to maximize resource-use efficiency and monetary return. Lately, the concept of intercropping has been utilized in irrigated situations also. In India, summer groundnut is grown mainly in pure stands with irrigation. The total area under summer groundnut is 1.09 million ha. This summer crop gives almost double the yield and profit of rainy season groundnut despite a higher cost of cultivation and higher input requirements. The crop is sown from the first fortnight of January to the first fortnight of February. Initial growth of this crop is slow due to low soil and air temperatures. During the initial slow growth period of summer groundnut, the space between the two rows of groundnut can be utilized by sowing short-duration vegetables to be harvested in about a month without substantial effect on groundnut yield. Some attempts have been made to use some vegetables such as chilli (AICORPO 1980) and onion (UNIAS 1978) as intercrops in groundnut but the concept still has to be tested thoroughly.

A pilot study was conducted with fenugreek (*Trigonella foenum-graecum L.*) cv methi consuri, radish (*Rafinus sativus*) cv Japanese white, spinach (*Spinacea oleracea L.*) cv all green, and coriander (*Coriandrum sativum L.*) cv gujarat 1 as the intercrops during the summer seasons of 1997 and 1998 at the National Research Centre for Groundnut, Junagadh, Gujarat. These vegetables were grown between groundnut rows spaced 30 cm apart and also on the bund (usually made for the purpose of irrigating summer groundnut). The distance between two bunds was 4.2 m and this accommodated 14 rows of groundnut. Twelve treatment combinations consisting of four vegetable crops and three methods of sowing (only on bund, between rows, bund + between rows) were tested in a factorial random block design (RBD) replicated three times. One plot of sole groundnut was also maintained as a control. The soil of the experimental plot was calcareous, black soil having low organic carbon and available P and medium available K. The vegetables and groundnut were sown simultaneously in the first week of February. Plant-to-plant distance of 5 cm for fenugreek, spinach, and coriander, and 15 cm for radish were maintained by thinning at ten days after sowing (DAS). Plant samples of both groundnut and vegetables from a one square metre area were collected at 25 and 35 DAS and root length, shoot length, leaf area, and biomass recorded. Fenugreek, spinach, and coriander were harvested at 35 DAS (vegetative stage) whereas radish needed 43 days before harvest. Groundnut cv GG 2, a Spanish bunch type, was harvested at 95 DAS. Groundnut received a basal application of 25 kg N and 50 kg P_2O_5 ha^{-1} in the form of urea and single superphosphate. It may be noted that plant protection, irrigation, and other recommended management practices were used for groundnut only but the vegetables were grown without any inputs specifically recommended for them. Only the

Table 1. Weather parameters during the summer cropping seasons 1997 and 1998 at Junagadh, Gujarat, India.

	Air temperature (°C)				Soil temperature at 10 cm depth (°C)		Relative humidity (%)				Sunshine hours	
	Maximum		Minimum				Maximum		Minimum			
Month	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Feb	31.7	32.8	12.4	13.9	23.9	22.4	65	79	16	42	9.7	9.3
Mar	36.5	36.6	19.1	18.9	27.3	27.4	61	59	26	21	6.8	9.8
Apr	39.3	36.9	22	23.8	30.5	31.9	73	73	30.8	23.8	8.6	9.8
May	40.35	37.5	24.6	26.5	33	34.7	78	78.5	43	36.7	9.1	10

Table 2. Growth dynamics, yields of groundnut and economics under different crop combinations and methods of sowing (pooled over summer seasons of 1997 and 1998), Junagadh, Gujarat, India.

Treatments	Pod yield (t ha^{-1})	Straw yield (t ha^{-1})	100-pod mass (g)	100-kernel mass (g)	Shelling (%)	Biomass (g m^{-2})		Leaf area (cm^2 $plant^{-1}$)		Net return (Rs ha^{-1})	B:C ratio
						25 DAS	35 DAS	25 DAS	35 DAS		
Vegetable crops											
Groundnut + fenugreek	2.82	4.82	70.28	29.58	63.5	30.98	68.3	41.74	163.0	39 112	2.18
Radish	2.30	3.60	68.15	27.48	62.6	27.27	59.1	41.73	163.0	85 673	4.63
Coriander	2.62	4.06	68.66	29.08	62.9	32.13	62.6	44.00	170.0	40 037	2.25
Spinach	2.07	3.19	62.50	28.11	60.4	23.14	46.4	38.21	127.87	63 325	3.45
Mean	2.45	3.86	67.43	28.56	62.35	28.38	59.0	41.43	155.977	57 036	3.12
SE	±0.101	±0.217	±1.207	±0.650	±0.810	±1.590	±4.41	±1.87	±7.23		
Sole groundnut	2.76	4.55	68.0	28.50	63.30	33.43	75.19	44.69	184.2	25 617	1.62
Methods of sowing											
Bund	2.71	4.05	67.80	28.32	62.70	34.12	74.76	43.51	175.55	52 061	2.90
Interrows	2.37	3.91	67.00	28.61	62.76	26.80	53.90	40.47	152.67	61 706	3.36
Bund + interrows	2.30	3.65	67.50	28.76	61.60	24.13	48.60	40.09	139.71	56 593	3.12
SE	±0.088	±0.188	±1.046	±0.563	±0.701	±1.382	±3.820	±1.624	±6.26		
CV (%)	12.38	16.89	5.37	6.83	3.90	16.89	22.34	13.58	13.91		

1. Wholesale market price of fenugreek, coriander, and spinach are Rs 4.5 and 3 kg^{-1}.
2. Market price of radish Rs 0.3 each for mature and Rs 0.1 each for immature radishes.

cost of seed, and labor charges for sowing, thinning, and harvesting were incurred for the vegetables. Production efficiency values were calculated as the ratio of total production of the crop to the total duration of that crop. Weather data for both years is given in Table 1.

Data analysed over two years showed that the years were significantly different for pod yield of groundnut as that in the second year was significantly higher (2.55 t ha^{-1}) than the first year (2.40 t ha^{-1}). This may be attributed to comparatively high biomass, a higher number of pods and pod mass per plant. Comparatively favorable air temperatures, particularly high minimum temperatures in February, and more sunshine hours (Table 1) during the second year were advantageous. Treatments x year interaction was not significant. Consistently, the highest groundnut pod yield was found both years when it was intercropped with fenugreek. The lowest pod yield of groundnut was recorded in association with spinach both years. Results show that both pod and straw yields were improved when intercropped with fenugreek (Table 2). However, in other crop combinations, varying degrees of reduction in yield of groundnut were observed. Maximum reduction in pod and straw yields were recorded with spinach (25 and 29.8%), followed by radish (15.9% and 19.8%) and coriander (5% and 10.8%). As with pod yield and straw yield, improvement in 100-pod mass, 100-kernel mass, and shelling turnover of groundnut also occurred when it was intercropped with fenugreek. Improvement in 100-pod mass and 100-kernel mass also occurred in association with coriander. However, the value of these parameters was reduced when groundnut was sown with radish (except 100-pod mass) and spinach. Maximum reduction in 100-pod mass, 100-kernel mass and shelling turnover of groundnut were found in association with spinach. In fact, in association with spinach the values of all the parameters of groundnut studied were drastically reduced. Biomass and leaf area of groundnut recorded at 25 and 35 DAS were less than the control when grown in association irrespective of the vegetable crops. Though root length, shoot length, leaf area and biomass of radish were greater than spinach, reduction in yield of groundnut caused by radish was less than that of spinach. This may be attributed to the fact that leaf arrangement of radish is such that even in a dense population of radish, groundnut was less affected than when grown in association with spinach. Groundnut was least affected by fenugreek followed by coriander, perhaps because of the lower values of shoot length, leaf area and biomass of these vegetables (Table 3). Soil moisture (%) did not differ as a result of the vegetables. Improvement in yields and yield attributes of groundnut in association with fenugreek may be due to a stimulatory effect which needs further investigation.

All the crop combinations gave higher net return and benefitxost (B:C) ratio than the sole groundnut so that reduction in yield of groundnut by vegetables was nullified by high fresh vegetable yield, high production efficiency and high return (Table 2). For example, in association with radish, reduction in pod yield was about 16% but this combination gave the highest net return and B:C ratio mainly because of high vegetable yield (14.7 t ha^{-1} mature and 7.2 t ha^{-1} immature radish) with high production efficiency (0.341t day^{-1} ha^{-1} of mature and 0.167t day^{-1} ha^{-1} immature radish). It was similar for the

Table 3. Growth dynamics of vegetables in association with groundnut (pooled over summers seasons of 1997 and 1998), Junagadh, Gujarat, India.

Vegetable crop	Fresh vegetable yield (t ha^{-1})	Root length (cm $plant^{1}$)	Shoot length (cm $plant^{1}$)	Leaf Area (cm^2 nr^2)	Biomass (g nv^2)	Production efficiency (t ha^{-1} day^{-1})
Fenugreek	3.55	10.22	16.1	3520	89.01	0.101
Radish	14.7 (0.186[1])	20.72	29.33	27348	259.27	0.341 (0.004[1])
	7.2 (0.132[2])					0.167 (0.003[2])
Coriander	3.68	7.54	23.07	3446	121.28	0.105
Spinach	16.81	11.30	21.01	20903	246.85	0.480
SE	-	±0.477	±1.03	±397.23	-	±0.228
CV (%)	-	11.51	13.82	35.78	-	

1. Mature radish numbers in millions.
2. Immature radish numbers in millions.

groundnut-spinach asssociation. Maximum net returns and B:C ratio were recorded when the vegetables were grown both on bund and interrow of groundnut.

Further detailed work on effect of the vegetables on soil nutrient status, soil microflora and the cause of stimulus are being carried out.

References

AICRPO (All India Coordinated Research Project on Oilseeds). 1980. Annual Progress Report on Groundnut. Rajendranagar, Hyderabad, Andhra Pradesh, India: Directorate of Oilseeds Research. 42 pp.

UNIAS (UNI Agriculture Service). 1978. Intercropping in groundnut. New Delhi, India: 5:107.

Substantial Reduction in Yield of Chickpea (*Cicer arietinum L.*) in Rainy Season Groundnut-Chickpea Crop Rotations

P K Ghosh, Devi Dayal, P R Naik, and Virendra Singh (National Research Centre for Groundnut, PO Box 5, Junagadh 362 001, Gujarat, India)

Groundnut-wheat is a major crop sequence in irrigated tracts of the northern and western parts of India. However, in the western and central parts of India, under moderate soil moisture availability, and/or with limited irrigation facilities particularly, rainy season groundnut is grown mainly in rotation with chickpea, sunflower, and mustard. Information on the performance of various sequential crops following groundnut is lacking. Therefore, the performance of wheat, chickpea, sunflower, and mustard after rainy season groundnut and after rainy season fallow were evaluated at four fertility levels (0,50,100 and 150% of the recommended fertilizer doses). The experiment was conducted on the same site at the research farm of the National Research Centre for Groundnut, Junagadh, over four years (1994/95-1997/98). The treatments consisted of two rainy season crops (groundnut and fallow), four postrainy season crops and four levels of fertilizer applied to each postrainy season crop. Treatments were tested in a factorial randomized block design replicated three times. Wheat was fertilized with the recommended doses of 120 kg ha^{-1} N and 35 kg ha^{-1} P, chickpea with 20 kg ha^{-1} N and 18 kg ha^{-1} P, sunflower with 40 kg ha^{-1} N and 18 kg ha^{-1} P, and mustard with 30 kg ha^{-1} N and 18 kg ha^{-1} P. The soil was calcareous, medium black (Vertic Ustrochrept), and clay loam in texture, with a pH 7.6. Available nutrient status of the soil after two years of cultivating rainy season groundnut and rainy season fallow is given in Table 1. Data on seed and straw yield of chickpea for four years are presented in Table 2.

Table 1. Available nutrient status of soil after two years.

Nutrients	After groundnut	After fallow	SE
Organic carbon (%)	0.571	0.593	±0.0019
Available P (kg ha^{-1})	8.3	7.9	±0.0031
Available K (kg ha^{-1})	328	318	±0.0091
Ca(meq 100 g $soil^{-1}$)	44.3	45	±0.0025
Zn (ppm)	1.06	1.65	±0.0512
Fe(ppm)	2.08	2.20	±0.0015

About 30 days after sowing, growth of chickpea plants grown on plots after a rainy season groundnut crop showed reduction in crop growth, followed by gradual wilting associated with violet coloration (perhaps accumulation of anthocyanin pigments) of the whole plant. The affected plants died within two weeks (Fig. 1). This caused a substantial reduction in plant population: a mean plant stand of 0.272 million ha^{-1} was recorded at harvest with 23.9% mortality. The plant population was 0.342 million ha^{-1} when chickpea followed fallow (Fig. 2). The reduced stand ultimately reflected in yield. Mean seed yield reduced by 17.3% and straw yield by 18.4%, when chickpea was grown after rainy season groundnut when compared with that grown after rainy season fallow. The yield reduction was observed in every year, although the percentage reduction varied from year to year (9.1-24.0% for seed yield and 13.4-22.9% for straw yield). No such decline in yield was observed when sunflower, mustard, and wheat followed rainy season groundnut. Interestingly, plant mortality and yield reduction in chickpea following rainy season groundnut was observed irrespective of the fertility level (Table 2) suggesting that the yield reduction of chickpea was independent of fertility level. The seed yield level in the third year was

Table 2. Seed and straw yield of chickpea (t ha^{-1}) in crop sequence after groundnut and after fallow, 1994/95-1997/1998, Junagadh, Gujarat, India.

Fertility levels (% of the recommended dose)	Seed yield 1994/95	Seed yield 1995/96	Seed yield 1996/97	Seed yield 1997/98	Seed yield Pooled	Straw yield 1994/95	Straw yield 1995/96	Straw yield 1996/97	Straw yield 1997/98	Straw yield Pooled
After rainy season groundnut										
0	1.19	0.94	0.42	0.90	0.86 (21.5)[1]	1.74	1.65	1.64	1.37	1.60 (18.2)
50	1.18	1.00	0.80	0.86	0.96 (17.4)	1.75	1.70	1.75	1.70	1.72 (12.0)
100	1.18	0.94	0.68	0.90	0.92 (14.3)	1.62	1.33	1.30	1.80	1.51 (17.5)
150	1.25	1.05	0.45	0.89	0.91 (15.0)	1.74	1.60	1.60	1.65	1.65 (26.3)
Mean	1.20	0.98	0.59	0.89	0.91	1.71	1.57	1.57	1.63	1.62
	(19.8)	(9.14)	(23.9)	(16.0)	(17.3)	(22.9)	(15.8)	(13.42)	(21.3)	(18.4)
After rainy season fallow										
0	1.60	0.96	0.80	1.04	1.09	2.24	1.81	1.71	2.06	1.96
50	1.57	1.15	0.74	1.20	1.17	2.20	1.78	1.75	2.08	1.96
100	1.42	1.03	0.78	1.03	1.08	2.12	1.64	1.55	2.02	1.83
150	1.35	1.20	0.78	0.97	1.07	2.33	2.23	2.25	2.13	2.23
Mean	1.50	1.08	0.77	1.06	1.10	2.22	1.86	1.81	2.07	1.99
SE for rainy season treatments	±0.0193	±0.0259	±0.033	±0.032	±0.0141	±0.0315	±0.0236	±0.0241	±0.0279	±0.0178
SE for fertilizer levels	±0.0273	±0.0367	±0.0470	±0.0453	±0.0200	±0.0389	±0.0332	±0.0292	±0.0418	±0.0225
SE for treatment x fertilizer level	±0.0386	±0.0519	±0.0664	±0.0640	±0.0283	±0.0630	±0.0472	±0.0482	±0.0558	±().()356
CV (%)	9.61	16.95	26.82	19.42	17.65	18.51	21.61	13.15	23.12	18.99

1. Figures in parenthesis arc percent reduction with respect to the yield after rainy season fallow.

Figure 1. Chickpea crop sown after rainy season groundnut.

Figure 2. Chickpea crop following rainy season fallow.

especially low due to a severe attack of pod borer, in spite of repeated spraying of recommended insecticides. The study thus indicated that the practice of rainy season groundnut - chickpea crop rotation is not to be encouraged from a yield sustainability point of view as there is definite yield reduction of chickpea in this system. The cause of such stunted growth, plant mortality, and low yield of chickpea when grown after rainy season groundnut is being investigated.

Medicinal Weeds in Groundnut Fields of Chhasttisgarh, Madhya Pradesh, India

P Oudhia (Department of Agronomy, Indira Gandhi Agricultural University, Raipur 492 001, Madhya Pradesh, India)

Weeds are always considered as unwanted plants since they compete with crops for nutrients, light and moisture, and harbour diseases and insects. But all weeds are not unwanted plants. In ancient Indian literature it was observed that every plant on this planet is useful. Industrial (Sastry and Kavathekar 1990), medicinal (Oudhia and Tripathi 1998) and allelopathic (Oudhia and Tripathi 1997) uses of many common problematic weeds have been reported. Many studies conducted at the Department of Agronomy, Indira Gandhi Agricultural University, Raipur, India, have clearly revealed that weeds having beneficial properties are a boon to farmers (Oudhia and Tripathi 1999a, Oudhia et al. 1998). Hand weeding is effective but a relatively costly operation for weed management as compared with herbicide application. Harmful effects of herbicides on crops, and environmental and human health have been reported. By identifying the potential national and international markets of common medicinal weeds, farmers can earn additional income (Oudhia and Tripathi 1999b). The economic gain from weeds can not only recover the cost of hand weeding but also generate employment opportunities for unemployed rural youths. For achieving these targets, a detailed survey of medicinal plants is essential. Due to nonavailability of information on the medicinal weed flora of groundnut, a survey was conducted by the Department of Agronomy, Indira Gandhi Agricultural University, Raipur, India, during 1996-98.

The detailed ethno-botanical survey was conducted in the Chhattisgarh region. The study was done in selected districts i.e., Raipur, Bilaspur, Durg, Rajnandgaon, Jagdalpur, and Ambikapur. From each selected district, two blocks and from each selected block, a random sample of four villages was taken. A proportionate sample of villagers from each selected village was taken to give a total sample size of 1000 respondents. The data were collected with the help of personal interviews according to a well-prepared interview schedule. For knowledge of medicinal uses of common weeds in groundnut fields, the help of reference literature of Ayurvedic, Homeopathic, Yunani, Allopathic and other systems of medicine was utilized. The weeds were collected during intensive visits to the targeted villages at intervals of 15 days. Visual assessments were made both on crop fields and wastelands.

The survey revealed that of 42 problematic weeds (belonging to more than 16 families) in groundnut fields of Chhattisgarh, 37 weeds possessed valuable medicinal properties. The medicinal properties of these 37 weeds have been found well documented in the literature. Details of these medicinal weeds are given in Table 1. It also revealed that of 37 medicinal weeds, the villagers were using more than 16 to treat their health problems. Out of 42 weeds, 10 were identified as having the potential to provide additional income to farmers. These weeds were *Abutilon indicum, Achyranthes aspera, Boerhavia diffusa, Cyperus sp., Eclipta alba, Euphorbia hirta, Leucas aspera, Oxalis latifolia, Phyllanthus niruri,* and *Sida cordata* (Table 2). Personal communications made with more than 300 national and international drug company representatives revealed that these weeds are in heavy demand in national and international drug markets. During the study it was noted that different graded and processed parts of weeds were more in demand than crude parts. The study also suggested that there is tremendous scope for generating employment opportunities at the village level for rural youths.

This survey suggested that there is a strong need for: (1) documentation of valuable knowledge about medicinal weeds in groundnut fields; (2) a survey of the major crop fields of Chhattisgarh; (3) identification of villages having a higher density of particular medicinal weeds; (4) establishment of proper linkages between village level cooperative societies and national and international companies; and (5) development of grading and processing methods for medicinal weeds according to international standards. These targets can be achieved by the the joint efforts of government, nongovernmental agencies and local people.

Table 1. Medicinal weeds in groundnut fields of Chhattisgarh, Madhya Pradesh, India.

Scientific name	Local dialect	English name	Family name	Remarks
Abutilon indicum[1]	Raksi	Velvetleaf	Malvaceae	M[2],m[3]
Achyranthes aspera[1]	Latkana	Prickly chafflower	Amaranthaceae	M,m
Ageratum conyzoides	Gandhila	Billy goat weed	Compositae	M
Aeschynomene americana	Soli	Northern joint vetch	Leguminoseae	M
Boerhavia diffusa[1]	Punernava	Spiderling	Nyctaginaceae	M
Borreria hispida	Safed phooli	-	Rubiaceae	M
Caesulia axillaris	Balonda	-	Compositae	M,m
Celosia argentea	Siliyari	Cock's comb	Amaranthaceae	M,m
Cenchrus axillaris	Poonchi ghas	Sand burr	Gramineae	M
Chloris barbata	-	Finger grass	Gramineae	
Commelina benghalensis	Kaua-Kaini	Dayflower	Commelinaceae	M,m
Corchorus acutangulus	Jangli Juti	Wild jute	Tiliaceae	M,m
Cucumis trigonus	Kolhi kekedi	Wild cucumber	Cucurbitaceae	M
Cynodon dactylon	Doobi	Bermuda grass	Gramineae	M,m
Cyperus sp.[1]	Motha	Nut sedge	Cyperaceae	M,m
Dactyloctenium aegyptium	Makra	Crowsfoot grass	Gramineae	M
Digitaria ciliaris	-	Crab grass	Gramineae	M
Echinochloa colona	Sawan	Jungle rice	Gramineae	M
Eclipta alba[1]	Bhengra	-	Compositae	M,m
Eleusine indica	-	Goose grass	Gramineae	M
Ergrostis cilianensis	Chiwra phool	Love grass	Gramineae	
Euphorbia hirta[1]	Dudhi	Spurge	Euphorbiaceae	M,m
Fimbristylis barbata	Chuhaka	-	Cyperaceae	M
Gomphrena decumbens	-	-	Amaranthaceae	
Ischaemum rugosum	Badore	-	Gramineae	M
Kyllinga brevifolius	Bandar phool	-	Cyperaceae	M
Leucas aspera[1]	Gumma	-	Labiatae	M,m
Ludwigia octovalvis	Laung phool	Winter primrose	Onagraceae	
Mimosa pudica	Chhui mui	Sensitive plant	Leguminoseae	M
Oxalis latifolia[1]	Khatti buti	Wood sorrel	Oxalidaceae	M,m
Parthenium hysterophorus	Gajar ghas	Congress weed	Compositae	M
Phyllanthus niruri[1]	Bhuin awla	Niruri	Euphorbiaceae	M,m
Physalis minima	Chirpoti	Ground cherry	Solanaceae	M,
Paspalidium punctatum	-	-	Gramineae	
Phaseolus trilobus	Mungesa	Wild mung	Leguminoseae	M,m
Saccharum spontaneum	Kansi	-	Gramineae	M
Scoparia dulcis	Mithi patti	-	Scrophulariaceae	M
Sida cordata[1]	Bariyara	Sida	Malvaceae	M,m
Solanum nigrum	Makoi	Night shade	Solanaceae	M
Setaria glauca	-	Foxtail	Gramineae	M
Ocimum basilioum	Van tulsa	-	Labiatae	M,m
Tridax procumbens	-	-	Compositae	M,m

1. Weeds of commercial value in national and international drug markets.
2. M = weeds having medicinal properties.
3. m = weeds in use in Chhattisgarh as medicinal plants.

Table 2. Existing uses and valuable parts of ten weeds with medicinal potential in groundnut fields of Chhattisgarh, Madhya Pradesh, India.

Scientific name	Existing uses	Valuable parts	Remarks[1]
Abutilon indicum	In rheumatism, bleeding piles, and fever	Seeds	N,I
Boerhavia diffusa	Dropsy, migraine, coryza, cough	Roots	N,I
Cyperus sp	In skin, urinary, digestive and reproductive diseases	Dried nuts	N,I
Eclipta alba	In skin and digestive diseases, hair nourishment	Whole plant	N,I
Euphorbia hirta	In respiratory troubles	Whole plant	N,I
Leucas aspera	In worms, rheumatism	Whole plant	N
Oxalis latifolia	In skin troubles	Whole plant	N
Phyllanthus niruri	In jaundice	Whole plant	N,I
Sida cordata	In skin troubles	Whole plant	N
Achyranthes aspera	As styptic; antivenom, in diseases of digestive system		

1. N = medicinal weeds having demand in national market; I = medicinal weeds having demand in international market.

References

Oudhia, P., and Tripathi, R.S. 1997. Allelopathic potential of *Calotropis gigantea* R. Br. World Weeds. 4:109-119.

Oudhia, P., and Tripathi, R.S. 1998. Medicinal weeds of kharif crops in plains of Chhattisgarh. Bharatiya Krishi Anusandhan Patrika 13:33-38.

Oudhia, P., and Tripathi, R.S. 1999a. Medicinal weeds: A boon for the farmers of Chhattisgarh. Page 152 *in* Biennial Conference of the Indian Society of Weed Science, VIII, 5-7 Feb 1999, Varanasi, India: Banaras Hindu University.

Oudhia, P., and Tripathi, R.S. 1999b. Medicinal weeds of Raipur and Durg (Madhya Pradesh) region, Pages 71-78 in the proceedings of the National Conference on Health Care and Development of Herbal Medicine, 29-30 Aug 1997, Raipur, India: Indira Gandhi Agricultural University (IGAU).

Oudhia, P., Joshi, B.S., and Kosta, V.K. 1998. The possibilities of preparing homeopathic drugs from obnoxious weeds of Chhattisgarh. Bharatiya Krishi Anusandhan Patrika 13:53-57.

Sastry, C.S.T., and Kavatheker, K.Y. 1990. Plants for reclaimation of wastelands. New Delhi, India: Publication and Information Directorate, Council of Scientific and Industrial Research (CS1R). 684 pp.

Oil Quality of Shandong Export Groundnut as Affected by Early Harvest

Wu Lanrong (Shandong Peanut Research Institute, Laixi, Shandong 266601, China)

The traditional export of large-seeded groundnut from Shandong Province in China has a good reputation in the groundnut trade. However, most of the groundnut cultivars grown in Shandong, 8130, Luhua 10, and Hua 17, are of medium duration (about 140 days). Many foreign traders want supplies of fresh groundnut earlier in the season (Sanders and Bett 1995), before these cultivars are available. Groundnut breeders are trying to address this issue by developing short-duration cultivars. However, very little research has been done on advancing the harvesting of groundnut to solve this problem.

Because the potential application of groundnut in industrial and food uses is largely determined by its oil quality (Dwivedi et al. 1998), this paper reports the results of early harvests on oil content and fatty acid composition of groundnut cultivar, 8130, sown both under polythene mulch and without mulch.

The experiment was sown at Shandong Peanut Research Institute (SPRI) with three replications on 1 May 1997 and 4 May 1998. The plot size was 6.5 x 2.0 m. Each plot consisted of 5 ridges 40 cm apart. The plant spacing was 18 cm (with two seeds per hill) with one row on each ridge. All plots received 750 kg ha^{-1} compound fertilizer (16% N, 16% P, and 16% K) as a basal application applied before ridging. Polythene mulch was laid after sowing with normal technology (Hu Wenguang et al. 1995). Groundnut was harvested at 121 days, 128 days, and 135 days (normal harvest) after sowing (DAS). Randomly selected, sound, mature seeds of export quality were analyzed for oil content and fatty acid composition on a Shimadzu GC-RIA gas chromatograph equipped with a flame ionization detector (FID) (Wu Lanrong et al. 1997). The mean plot values of two years were analyzed following randomized block design. Significant differences among the mean values of early and normal harvests for two years were evaluated using a t-test.

Mean oil and individual fatty acid contents of each treatment are presented in Table 1. Under mulch cultivation, groundnut harvested 121 DAS had the highest oil, palmitic, and linoleic acid contents, which were 7 g kg^{-1} seed and 4.8 and 15.3 g kg^{-1} oil higher than normal harvest (135 DAS). On the contrary, oleic, eicosenoic and stearic acid contents were the lowest at this harvest, as was the O/L ratio (0.16 g kg^{-1} lower than that of the normal harvest). Oil, eicosenoic, and stearic acid contents

Table 1. Mean oil (g kg^{-1}) and fatty acids (g kg^{-1} oil) contents of groundnut cultivar 8130, as affected by early harvests, spring planting (1997-1998), SPR1, China.

DAS	Oil	Palmitic	Oleic	Linoleic	Eicosenoic	Behenic	Stearic	O/L ratio
With mulch								
121	546.0[2]	90.0[2]	518.l[2]	268.1[2]	11.5[2]	26.8	32.6[2]	1.93[2]
128	528.0[2]	86.2	537.2	249.0	17.2[2]	25.9	32.6[2]	2.16
135[1]	539.0	85.2	528.6	252.8	18.2	25.9	36.4	2.09
Mean	538.0	87.1	528.0	256.6	15.6	26.2	33.9	2.06
Without mulch								
121	535.0[2]	91.0	500.8	268.1[2]	24.9[2]	26.8	36.4	1.87[2]
128	527.0	92.9	504.7[2]	277.7	17.2	25.9	30.6	1.82
135[1]	522.0	92.9	492.2	288.2	19.2	26.8	29.7	1.71
Mean	528.0	92.3	499.2	278.0	20.4	26.5	32.2	1.80

1. Normal harvest.
2. Significant at 0.05 probability level.

were lower in 128 DAS harvest than 135 DAS harvest. Without mulch, oil, eicosenoic, and stearic acid contents including O/L ratio were the highest at 121 DAS harvest compared with the other two harvests.

From these experiments we can draw two preliminary conclusions. (1) Groundnut in Shandong Province can be harvested one or two weeks earlier than the normal harvest without any serious consequences for oil content and its quality. (2) As the oil content and O/L ratio were generally higher under mulched conditions (statistical significance not established) this technology needs to be promoted to achieve higher returns.

References

Dwivedi, S.L., Nigam, S.N., and Prasad, M.V.R. 1998. Induced genetic variation for seed quality traits in groundnut. International *Arachis* Newsletter 18:44-46.

Hu Wenguang, Duan Shufen, and Sui Qingwei. 1995. High-yield technology for groundnut. International *Arachis* Newsletter 15 (supplement): 1-22.

Sanders, T.H., and Bett, K.L. 1995. Effect of harvest date on maturity, maturity distribution, and flavor of Florunner peanuts. Peanut Science 22:124-129.

Wu Lanrong, Gu Shuyuan, and Han Shumei. 1997. The evaluation of several excellent germplasm of peanut with their oleic and linoleic contents, and O/L ratio. Peanut Science and Technology 4:13-16.

Protein and Oil Quality of the Brazilian BRS 151 L 7 Groundnut Cultivar

R M M Freire[1], R C dos Santos[1], and S R de Farias[2]
(1. Embrapa Algodao, CP 174, CEP 58107-720 - Campina Grande, PB, Brasil; 2. Centro de Ciencias Biol6gicas da Saude, Universidade Estadual da Paraiba, CP 781/791, CEP 58100-001 - Campina Grande, PB, Brasil)

Groundnut is the fourth most important source of edible oil and the third most important source of vegetable protein, and contributes significantly to the diet of people in many developing countries. In Brazil, 60% of the population of the rural poor lives in the northeast, with 4% of these poor families depending largely on subsistence agriculture. As there is a low consumption of food of animal origin due to high prices, their diet is highly deficient in protein-rich products. The consumption of groundnut, which is of high caloric value because of its oil and protein contents, minerals, and vitamins B and E complexes, can minimize this dietary deficiency. However, its protein is deficient in lysine and methionine. But self-sufficiency in these two amino acids can be achieved through genetic manipulation of diverse genotypes.

Centro Nacional de Pesquisa de Algodao (CNPA) of the Empresa Brasileira de Pesquisa Agropecuaria (Embrapa), in Brazil, has been carrying out research on groundnut crops mainly to provide farmers with improved genetic materials adapted to the semi-arid conditions of the northeast, that are early in maturity and with good seed quality. In 1998, Embrapa released the BRS 151 L 7 cultivar. It was developed by crossing a Brazilian (IAC Tupa) and an exotic cultivar (55 437). It is a short-season cultivar, bunch type, and tolerant to drought. BRS 151 L 7 has large and elongated seeds with a red testa (Santos 1998). Its average pod yield is 1.85 t ha^{-1} in the rainy season. It is also of high nutritive value, due to its improved quality of protein (amino acids) and oil (fatty acids).

The chemical composition of the BRS 151 L 7 and traditional (BR 1) cultivars are shown in Table 1. Both cultivars are low in oil and possess satisfactory protein contents in the seeds. The protein content of the BRS 151 L 7 defatted flour is 8% higher than BR 1. The amino acids in the defatted flour of both cultivars are higher than the levels established by the FAO-85 standard, except for lysine (Table 1). This FAO standard, used as a reference, takes into account a balanced protein that satisfies the requirements of amino acids in the diet. The values of isoleucine, leucine, phenylalanine, threonine, valine, and histidine were considerably higher than the standard established by the FAO-85, demonstrating that its flour contains sufficient levels of essential amino acids.

According to nutritional recommendations, dietary fat should contain high levels of unsaturated and low-saturated fatty acids as vegetable oils rich in unsaturated fat are important for human physiology. For example, an increase in the concentration of unsaturated fatty

Table 1. Chemical composition of seed and defatted flour of the BRS 151 L 7 and BR 1 groundnut cultivars.

Chemical composition	Cultivar		FAO-85 standard
	BRS 151 L 7	BR 1[1]	
Amino acids (g 100 g^{-1} of protein)			
isoleucine	3.17	3.07	2.80
leucine	6.65	6.51	4.40
lysine	3.47	3.66	4.40
phenylalanine	5.80	5.88	2.20
phenylalanine + tyrosine	11.08	10.98	-
methionine + 1/2 cystine	2.73	2.82	2.20
threonine	3.27	3.42	2.80
tryptophan	0.91	0.93	0.90
valine	3.50	3.35	2.50
histidine	2.58	2.64	1.90
Fatty acids (%)			
C 16:0	5.72	5.02	
C 18:2	60.23	47.78	
C 18:1	25.56	39.78	
C 18:0	1.57	1.29	
C 20:0	2.94	2.70	
C 22:0	1.20	1.12	
C 24:0	2.78	2.19	
Composition (%)			
Crude oil in seed	46	45	
Crude protein in seed (Nx5,46)	30	29	
Protein in defatted flour	55	51	
Ash in defatted flour	5	5	

1. Traditional cultivar.

acids in the diet has been shown to be beneficial in the prevention of cardiovascular diseases (Quintao 1992). The seeds of BRS 151 L 7 contain 46% of the crude oil (Table 1) composed mainly of linoleic (C 18:2) and oleic (C 18:1) acids, which together make up 85.8% of the total unsaturated fatty acids. The high concentration of linoleic acid, with its valuable contribution to human nutrition, makes this a useful cultivar in northeastern Brazil.

References

Quintao, E.C.R. 1992. Colesterol e arteriosclerose. Rio de Janeiro, Quality Mark.

Santos, R.C. dos. 1998. EMBRAPA releases BRS 151 Amendoim L 7, a large seeded groudnut cultivar for the northeast region in Brazil. International *Arachis* Newsletter 18:11-12.

Groundnut in the Caucasus and Central Asia

Groundnut in Armenia

A Petrosyan and S Semerjan (Department of Science, Information and New Technology, 48 Nalbandyan Str., Yerevan 375010, Armenia)

Groundnut is grown mainly in the southern part of Armenia in the Megrin region and in the Ararat Valley. Although there are no data available on the area sown there appears to be a trend to expanding the area, which is thought by the Department of Science, Information and New Technology to be about 100 ha at present. In addition, the crop is grown on farms for use by the household. The groundnut is mainly grown on small land plots in high agricultural zones and has a promising future because of the big market demand. In Armenia groundnut is used as a food (fried nut) and for flour and soap. The demand for these latter products is being met by imports from Iran at present.

There is the potential to expand production to an area of 3000 ha or more. However, production of groundnut is limited by several constraints. Firstly, there is a lack of seed material (germplasm) and secondly, a lack of information available to farmers, particularly in relation to the crop's profitability. Armenia lacks any released improved variety, but a local population is grown in the Megrin region, and some varieties of unknown origin in the Ararat Valley. There is a need to establish variety testing nurseries to test and study the most promising varieties of the world collection as well as to investigate further the development of production and irrigation technologies.

The Scientific Center of Crop Husbandry and Plant Protection has begun a 2-year research program, led by Dr Semerjan, Deputy Director, to detect the most promising high-yielding varieties as well as developing technologies suitable for growing groundnut in the favorable soil-climatic conditions in Echmadzin, in the Ararat Valley. It is hoped that this will result in an expansion to more than 30 times the present growing area, increase market consumption, and terminate the importation of groundnut into Armenia.

Groundnut in Azerbaijan

M Nabiev and Z Akperov (Department of Research and Education, Ministry of Agriculture, 4, Kurbanov Str., 370079, Baku, Azerbaijan)

Groundnut is an annual oilseed legume crop, valuable firstly for its oil. There is 45-60% oil content in the seed, 25-37% protein, and between 6 and 20 nonnitrogenous substances can be extracted. In Europe it is mainly grown in Mediterranean countries as well as in Central Asia, West Ukraine, and Caucasus.

In Azerbaijan wide soil and climate diversity, as well as a plentiful availability of soil moisture and sunny days have served as good preconditions for dissemination and cultivating of different crops, including groundnut. Since ancient times, it has been utilized here for production of a diverse number of sweets, and in other spheres of industry.

This stimulated a development of breeding activity on this crop along with rejuvenation of basic crops. A number of high-yielding varieties was developed as a result of the breeding activity, and two of them were released, namely, Persivan 46/2 and Zakataly 294/1. These varieties have been disseminated in both Azerbaijan and the Republics of Centnl Asia.

Zakatalskaya Breeding Station, at the Research Institute of Crop Husbandry in Azerbaijan, has been dealing with elite seed material production during the years Azerbaijan was part of the Soviet Union up to 1951. According to regulations of the Ministry of Agriculture of the USSR this material was distributed to all former Soviet Union Republics engaged in groundnut production.

At the same time some agricultural techniques for cultivation of this crop were developed and by means of geographical sowings, the sowing area was extended in Belokanskiy, Kahskiy, Gabalinskiy, Oguzskiy and Kubaltiskiy regions of Azerbaijan.

Groundnut was a promising crop for this zone and good results have been achieved. The Zakatalskaya Breeding Station was awarded for its achievements in the area of oilseeds and groundnut breeding and participated at the All-Union Agricultural Exhibition that took place in 1940.

Later groundnut was transferred into the private household sector and now is being grown as a traditional crop. Individual farmers are involved in production, seed improvement and plant genetic resources conservation. These traditions are being maintained up to the present.

Production Technology

The sown area of groundnut in Azerbaijan covered about 4000 ha in the 1950s, mainly in the lower part of Zakatal and Belokan regions. According to data of Acad. A. Radjably, groundnut can produce up to 3 t ha^{-1} in irrigated conditions and 1.5 t ha^{-1} in rainfed conditions. This crop needs to be grown in areas with warm climatic conditions (14 -15°C) as autumn frost (0.5°C) can damage leaves. The best soils for groundnut are friable, loam soils. This crop requires a rather high moisture content so a good yield can be achieved only with irrigation input during the whole vegetative period. The long-duration groundnut matures in 140-160 days.

Groundnut is a typical row crop and the best crop to be used in rotation with winter wheat. Soil treatment for groundnut sowing requires a deep autumn plowing and intensive cultivation before sowing. Specific attention should be given to weed control and the friable constitution of the soil because this makes digging of the seed-bed easier. The most frequently applied fertilizers are potassium phosphate ones.

Groundnut sowing is done by specific or adjusted cotton or maize sowing machines with intervals between rows of 70-90 cm and plant intervals of 25-30 cm. Depending on seed rate, method of sowing, and nut size, 60-90 seeds are needed per hectare. Time for harvesting is determined by yellowing of the groundnut leaves. Potato-diggers can be used for harvesting. Virginia and Valencia types are most suitable for the conditions in Azerbaijan.

At present the Research Institute of Horticulture and Subtropics does not deal with groundnut research.

Groundnut Yields in Kyrgyzstan Depend on Time of Sowing

Acad. J Akimaliev (Kyrgyz Agrarian Academy, 68, Mederevo Str., Bishkek 720005, Kyrgyzstan)

Groundnut is a particularly valuable crop due to its high quality fat and protein content. In comparison with other food crops, because of its caloric value, groundnut has become an important crop in Kyrgyzstan. It is cultivated in Kyrgyzstan only in private sector households in the southern part of the country. There is one locally bred variety, Kyrgyzskaya Mestnaya. So far, no targeted research activity has been done on this crop.

However, some activities were started in 1998 in sierozem soils of the Chu Valley, a foothill irrigated zone. The design of the experiment included sowing of two varieties, Ulduz and Kyrgyzskaya Mestnaya, which were sown on the following dates: 1 May, 15 May, 1 June, and 15 June. Results have shown that the optimal sowing time for both varieties was 15 May. Yields obtained were: Ulduz 2.1 t ha^{-1}; and for Kyrgyzskaya Mestnaya 2.3 t ha^{-1}. The green haulm obtained for both varieties for this date of sowing was: 4.3 t h^{-1} for Ulduz and 4.1 t ha^{-1} for Kyrgyzskaya Mestnaya. Results are tabulated in Table 1.

Table 1. Influence of sowing time on seed yield and green mass of groundnut.

	Yield t ha^{-1}	
Time of sowing	Seed yield	Green mass
1 May		
Ulduz	1.4	1.7
Kyrgyzskaya Mestnaya	3.5	3.4
15 May		
Ulduz	2.1	2.3
Kyrgyzskaya Mestnaya	4.3	4.1
1 June		
Ulduz	1.5	1.6
Kyrgyzskaya Mestnaya	3.6	2.9
15 June		
Ulduz	1.4	1.5
Kyrgyzskaya Mestnaya	2.0	2.4

In addition to this experiment, the effect of wide-row method of sowing (60 x 15, 60 x 30,60 x 45,60 x 60 cm) for both these varieties at four different times of sowing is being studied. One-year data confirmed good yield availability with 1 May sowing and row intervals of 60 x 15 cm. This experiment will be continued with the aim of identifying any correlations between yield, plant morphological indices and biological characteristics.

Publications

Copies of titles are available from: Distribution Unit, PIM Division, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India.

Prices. Per-copy prices are listed separately for

- highly-developed countries (HDCs), expressed in US dollars
- less-developed countries (LDCs), also expressed in US dollars
- India and other countries in the Indian subcontinent, expressed in Indian rupees at a rate equivalent to the LDC price.

Air bookpost postage and handling charges are included in these prices.

HDCs include Australia, Brazil, Canada, Dubai, European countries, Iran, Iraq, Japan, Kuwait, Libya, Mexico, New Zealand, Saudi Arabia, South Africa, and USA.

Payment. Prepayment is required in US dollars, or the following negotiable currencies: Deutsche marks, Dutch guilders, French and Swiss francs, Pounds Sterling, and Yen, or Indian rupees, payable to ICRISAT by banker's draft, demand draft, or money order.

Free copies. Single free copies are available only to the following:

- Organizations that formally exchange publications with ICRISAT Libraries;
- Libraries of selected agricultural universities and research institutions in semi-arid tropical countries;
- Journal editors who review ICRISAT publications;
- National program staff who collaborate with ICRISAT research programs.

Discount. Book trade discounts are available on request. Other orders for five or more copies of a single publication are discounted by 20%.

Air/Surface mail. Experience shows that surface packages are often delayed for months, do not always reach their destinations, and may be damaged. Therefore all publications are despatched by air bookpost.

Order codes. Please use ICRISAT order codes when ordering publications. These are given with each entry below.

Publications from ICRISAT

Freeman, H.A., Nigam, S.N., Kelley, T.G., Ntare, B.R., Subrahmanyam, P., and Boughton, D. 1999. The world groundnut economy: facts, trends, and outlook. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 52 pp. ISBN 92-9066-404-5. Order code BOE 027. LDC $15.50. HDC $40.50. India Rs. 570.00.

The world groundnut economy: facts, trends, and outlook reviews the current structure of the world groundnut economy and analyzes the supply and demand situations, both current and projected. Several trends emerging from this analysis are discussed, along with possible implications for research. The book also examines the major constraints to groundnut production, and policy options that could help increase the output and quality of groundnut crops throughout the semi-arid tropics.

Waliyar, F., and Umeh, V.C. (eds.) 1998. Proceedings of the Fifth Regional Groundnut Workshop for Western and Central Africa, 18-21 Nov 1996, Accra, Ghana (In En, Fr.). International Arachis Newsletter no. 18 (Supplement). Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 91 pp.

Representatives from 13 countries in West and Central Africa (Benin, Burkina Faso, Cote d'Ivoire, The Gambia, Ghana, Guinea, Mali, Niger, Nigeria, Central African Republic, Senegal, Togo, Chad), representatives from USA, France, India and the African Groundnut Council attended the 5th Regional Groundnut Workshop. This workshop was jointly organized by CSIR (Ghana), the CORAF Groundnut Network, the Peanut CRSP and ICRISAT. The opening ceremony was attended by Ministers of the Government of Ghana and the international representatives and scientific delegates of countries attending the workshop.

The workshop enabled strengthening collaboration between the NARS and international and regional organizations. Areas of collaboration between NARS and ICRISAT were identified. A total of 33 scientific papers were presented. These proceedings contain summaries of papers presented on agronomy, breeding, crop protection and the utilization of groundnut. Recommendations were made on each discipline.

Singh, A.K., Mehan, V.K., and Nigam, S.N. 1998. Sources de resistance aux maladies fongiques et bacteriennes de l'arachide: le point de la recherche. Bulletin d'information no. 50. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 48 pp. ISBN 92-9066-374-X. Order code IBF 050. LDC $6.00. HDC $16.00. India Rs. 165.00.

Les maladies fongiques foliaires de l'arachide, la pourriture de la tige et des gousses, ainsi que le flerissement bacterien causent des pertes importantes de rendement en grain et de graves problemes de qualite chez l'arachide. Ce bulletin d'information met a jour la liste des sources de resistance a six maladies fongiques et bacteriennes majeures en fournissant des informations utiles sur leurs traits agronomiques et leur reaction a d'autres maladies. Cet ouvrage met en relief les merites et les demerites de ces sources de resistance dans le cadre de leur usage dans diverses situations.

Pande, S., Liao Boshou, Nguyen Xuan Hong, Johansen, C., and Gowda, C.L.L. (eds.). 1998. Groundnut bacterial wilt in Asia: proceedings of the Fourth Working Group Meeting, 11-13 May 1998, Vietnam Agricultural Science Institute, Van Dien, Thanh Tri, Hanoi, Vietnam. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 106 pp. ISBN 92-9066-397-9. Order code CPE 120. LDC $16.00. HDC $42.00. India Rs.590.00.

The current status of research on bacterial wilt of groundnut in Asia (specifically in China and Vietnam) is reviewed. Particular emphasis is given to the available disease management options, and their packaging and validation in on-farm participatory research at hot-spot locations in China and Vietnam. Recommendations are made for further collaborative research with advanced institutes to provide training to scientists and technicians from China and Vietnam in recent advances in serological and molecular techniques for identification and differentiation of races, biovars, and strains of the wilt pathogen, *Burkholderia solanacearum*. Recommendations are also made for further collaborative research, and the need to interest potential donors in promoting the Groundnut Bacterial Wilt Working Group's activities. The publication includes papers describing the status of the disease in China and Vietnam.

Bantilan, M.C.S., and Joshi, P.K. (eds.) 1998. Assessing joint research impacts. Proceedings of an International Workshop on Joint Impact Assessment of NARS/ICRISAT Technologies for the Semi-Arid Tropics, Patancheru, India, 2-4 Dec 1996. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 288 pp. ISBN 92-9066-396-0. Order code CPE 119. LDC $27.50. HDC $74.50. India Rs.1025.00.

Pursuit of a joint approach to the assessment of research impact is critical for the continuing viability of national and international research within the global agricultural R&D system. This workshop on "Joint Impact Assessment of NARS/ICRISAT Technologies for the Semi-Arid Tropics" was organized to achieve three objectives: a) to report results of case studies on adoption and impact undertaken jointly by teams from ICRISAT and the national programs; b) to provide a forum for peer review; and c) identify through working group sessions key issues and priority areas for the ICRISAT/NARS research agenda on impact assessment.

The workshop was attended by ICRISAT scientists from all disciplines, by representatives from private and public sector research institutions, the seed sector, and other international research organizations. These proceedings include the presentation of case studies featuring research impact in four areas—genetic enhancement research; resource management options; intermediate products of research; and impact of networks. That adoption is a condition of impact was noted. The efficiency dimension of impact served as a starting point in most analyses. Other dimensions of impact include food security, gender equity, sustainability, human nutrition, employment, and spillover effects. The integration of these dimensions in the research evaluation process was discussed. Peer review was an important feature of this workshop; it served as a basis for the discussions on priorities for the future research agenda on impact assessment.

Allen, D.J., and Lenne, J.M. (eds.) 1998. The pathology of food and pasture legumes. Wallingford, Oxon, UK: CAB International, and Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 772 pp. *Copies can be ordered from CABI, Wallingford Oxon OX 10 8DE, UK.*

The plant family *Leguminosae* is second in economic importance only to *Gramineae*, which includes the world's cereals and pasture grasses. Indeed, about one quarter of the total output of crop protein in the world as a whole is derived from legumes, which are of great importance both in human diets and in the feeding of livestock. Production is nevertheless limited by major diseases, and therefore there is a great need for a reference book on the pathology of food and pasture legumes.

This book fills this need and provides substantial critical reviews of each crop type as well as a cross-commodity perspective. It is written by leading research workers in the USA, UK, India, Nigeria, Malawi, New Zealand, Syria, Tanzania, and Uganda. The content is thus applicable to both the developed and the developing world, and to temperate and tropical zones. Well illustrated with both monochrome and colour plates, and thoroughly referenced to the research literature, it represents an indispensable volume for plant pathologists as well as plant breeders and agronomists.

Chung, K.R. 1998. The contribution of ICRISAT's mandate crops to household food security: a case study of four rural villages in the Indian semi-arid tropics. Information Bulletin no. 52. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 40 pp. ISBN 92-9066-390-1. Order code IBE 052. LDC $19.50. HOC $55.50. India Rs.775.00.

The conceptual linkage between increased food production and improved nutritional status appears straightforward; yet, devising research strategies that lead to real change has proved difficult. Although intra-household resource allocations are a strong determinant of individual nutritional status, this bulletin focuses on the possibilities for technical change to improve consumption at the household level. The reported study therefore seeks to update knowledge of the role that ICRISAT mandate crops play in the diets of the rural poor. Specifically, it examines the state of undernutrition in the study area, the dependence of the rural poor on ICRISAT's mandate crops, the actions available for improving the diets of the rural poor, and the role agricultural research should play in the fight to reduce undernutrition. These topics are addressed through a household-level analysis of dietary patterns in four rural villages in the semi-arid tropics (SAT). The ultimate purpose is to discuss the menu of options available to researchers interested in strengthening the link between agricultural technology and nutritional well-being. The analysis focuses on identifying current dietary and expenditure patterns in two regions within the Indian SAT.

SATCRIS listings

The following 1998 listings and publications have been generated from ICRISAT's electronic bibliographic database SATCRIS—the Semi-Arid Tropical Crops Information Service. Copies of entries followed by JA or CP numbers can be obtained by writing to

Senior Manager
Library and Documentation Services, PIM Division
ICRISAT
Patancheru 502 324, Andhra Pradesh, India
E-mail: s.srinivas@cgiar.org

Groundnut publications

Abdel-Momen, S.M., and Starr, J.L. 1998. Meloidogyne javanica-Rhizoctonia solani disease complex of peanut. Fundamental and Applied Nematology 21:611-616.

Adisarwanto, T., and Adi, M.M. 1998. Dryland groundnut production technology in Indonesia. Pages 164-171 in Assessing joint research impacts: proceedings of an International Workshop on Joint Impact Assessment of NARS/ICRISAT Technologies for the Semi-Arid Tropics, 2-4 Dec 1996 Patancheru, India (Bantilan, M.C.S., and Joshi, P.K., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Adjetey, J. A., and Sey, S. 1998. Assessment of nitrogen requirements of bambara groundnut in a coastal savanna ecological zone. Applied Plant Science 12:36-38.

Akasaka, Y., Mii, M., and Daimon, H. 1998. Morphological alterations and root nodule formation in Agrobacterium rhizogenes-mediaied transgenic hairy roots of peanut (Arachis hypogaea L.). Annals of Botany 81:355-362.

Akbari, K.N., Sutaria, G.S., Hirpara, D.S., and Yusufzai, A.S. 1998. Response of groundnut to P fertilization with different tillage practices under rainfed agriculture. Indian Journal of Agricultural Research 32:171-175.

Amarteifio, J.O., Karikari, S.K., and Moichubedi, E. 1998. The condensed tannin content of Bambara groundnut (Vigna subterreanea L. Verde). Pages 141-143 in Recent advances of research in antinutritional factors in legume seeds and rapeseed: proceedings of the Third International Workshop, 8-10 Jul 1998, Wageningen, The Netherlands (Jansman, A.J.M., Hill, G.D., Huisman, J., and Poel, A.F.B. van der, eds.). Wageningen, The Netherlands: Wageningen Press.

Andersen, P.C., Hill, K., Gorbet, D.W., and Brodbeck, B.V. 1998. Fatty acid and amino acid profiles of selected peanut cultivars and breeding lines. Journal of Food Composition and Analysis 11:100-111.

Anjos, J.R.N. dos, Kitajima, E.W., Charchar, M.J.A., and Marinho, V.L.A. 1998. Natural infection of *Arachis pintoi* by peanut mottle virus in central Brazil. Fitopatologia Brasileira 23:71-74.

ASAE (American Society of Agricultural Engineers). 1998. Moisture measurement - peanuts. ASAE standard 1998: standards engineering practices data 45:560-561. St Joseph, USA: ASAE.

Ayub, M., Ayub Khan, and Malik, N.J. 1998. Evaluation of peanut *Arachis hypogaea* genotypes for field resistance to *Sclerotium rolfsii* and genetic yield potential. Sarhad Journal of Agriculture 14:597-601.

Bananej, K., Hajimorad, M.R., Roossinck, M.J., and Shahraeen, N. 1998. Identification and characterization of peanut stunt cucumovirus from naturally infected alfalfa in Iran. Plant Pathology 47:355-361.

Bansal, R.K., and Mali, R.P. 1998. *Curvularia lunata* var. *aeria* - a new record on groundnut. Indian Phytopathology 51:206.

Barik, A.K., Mukherjee, A.K., and Mandal, B.K. 1998. Growth and yield of sorghum *(Sorghum bicolor)* and groundnut *(Arachis hypogaea)* grown as sole and intercrops under different nitrogen regimes. Indian Journal of Agronomy 43:241-247.

Bashir, K., Naazar Ali, and Malik, S.N. 1998. Estimation of variability and heritability for quantitative traits in groundnut. Sarhad Journal of Agriculture 14:575-579.

Basu, A. 1998. Effect of some fungicides, herbicides and selective nontoxic chemicals on the growth, nodulation and yield of groundnut. Environment and Ecology 16:638-641.

Behera, B.K., Das, D.K., Mishra, D., and Mohanty, S.K. 1998. Selection of machinery system for farms of coastal Orissa, India, for paddy-groundnut-mung crop rotation. AMA, Agricultural Mechanization in Asia, Africa and Latin America 29:22-26.

Bell, M.J., and Wright, G.C. 1998. Groundnut growth and development in contrasting environments. 1. Growth and plant density responses. Experimental Agriculture 34:99-112.

Bell, M.J., and Wright, G.C. 1998. Groundnut growth and development in contrasting environments. 2. Heat unit accumulation and photo-thermal effects on harvest index. Experimental Agriculture 34:113-124.

Bennison, J.J., Sherington, J., Wacher, T.J., Dempfle, L., and Leaver, J.D. 1998. Effects of *Trypanosoma congolense* infection and groundnut *(Arachis hypogaea)* hay supplementation on ranging, activity, and diet selection of N'Dama cows. Applied Animal Behaviour Science 58:1-12.

Branch, W.D. 1998. Inheritance of a rusty-leaf trait in peanut. Journal of Heredity 89:365-370.

Branch, W.D. 1998. Registration of 'Georgia Bold' peanut. Crop Science 38:895-896.

Bulbule, S.V., and Mayee, CD. 1998. Gradients of groundnut rust in short distance dissemination. Journal of Mycology and Plant Pathology 28:48-50.

Bulbule, S.V., and Mayee, CD. 1998. Interactions of leaf spots and rust on groundnut. Journal of Mycology and Plant Pathology 28:18-20.

Cardet, C, Kandji, T., Delobel, A., and Danthu, P. 1998. Efficiency of neem and groundnut oils in protecting leguminous tree seeds against seed beetles in the Sahel. Agroforestry Systems 40:29-40.

Caris, C, Hordt, W., Hawkins, H.J., Romheld, V., and George, E. 1998. Studies of iron transport by arbuscular mycorrhizal hyphae from soil to peanut and sorghum plants. Mycorrhiza 8:35-39.

Cattan, P., and Fleury, A. 1998. Flower production and growth in groundnut plants. European Journal of Agronomy 8:13-27.

Chandra, S., Kumar, S., and Singh, A.K. 1998. Management of cercospora leaf spot of groundnut *(Arachis hypogaea L.)* with a single fungicidal spray. International Journal of Pest Management 44:135-137.

Chandran, K., Rajgopal, K., and Radhakrishnan, T. 1998. Does variability exist in the old groundnut cultivar TMV 2 collected from different parts of southern India? International *Arachis* Newsletter 18:9-11.

Cheng, H.H., and Yeh, M.S. 1998. Studies on the immature embryo of peanut *(Arachis hypogaea L.)* IV. In vitro embryogenesis from immature embryo axes and cotyledons. Journal of Agriculture and Forestry 47:91-105.

Chengalrayan, K., Mhaske, V.B., and Hazra, S. 1998. Genotypic control of peanut somatic embryogenesis. Plant Cell Reports 17:522-525.

Chiyembekeza, A.J., Subrahmanyam, P., Kisyombe, C, and Nyirenda, N.E. 1998. Groundnut: a package of recommendations for production in Malawi. Lilongwe, Malawi: Ministry of Agriculture and Irrigation. 15 pp.

Chuni Lal, Basu, MS., and Ranvir Singh. 1998. Stability analysis for pod and kernel yield in Spanish bunch groundnut (*Arachis hypogaea L.*). Indian Journal of Genetics and Plant Breeding 58:125-126.

Coffelt, T.A., and Mozingo, R.W. 1998. Registration of VGP 10 peanut germplasm. Crop Science 38:573-574.

Coffelt, T.A., Mozingo, R.W., and Herbert, D.A., Jr. 1998. Registration of VGP 11 peanut germplasm. Crop Science 38:1412.

Cook, G., Rybicki, E.P., and Pietersen, G. 1998. Characterization of a new poty virus isolated from peanut *(Arachis hypogaea)*. Plant Pathology 47:348-354.

Dasgupta, S., Raj, S.K., and Das, S. 1998. Management of collar rot disease of groundnut by seed treatment with growth regulators - an alternative approach. International *Arachis* Newsletter 18:21-22.

Dash, S.K., Das, D.K., Paul, J.C., Mishra, J.N., and Swain, S.K. 1998. Development and performance evaluation of bullock-drawn groundnut diggers. AMA, Agricultural Mechanization in Asia, Africa and Latin America 29:67-70.

Dave, R.S., and Mitra, R.K. 1998. A low temperature induced apoplastic protein isolated from *Arachis hypogaea*. Phytochemistry 49:2207-2213.

Dhopte, A.M., Deotale, R.D., and Beena Pillai. 1998. A case of natural albino mutant and partial chlorophyll mutant in groundnut. Journal of Soils and Crops 8:224-225.

Donolo, A., Fabra, A., and Castro, S. 1998. Influence of the fungicide Vitavax on the growth of *Bradyrhizobium* species. Microbios 93:35-41.

Dudu, P.O., Okiwelu, S.N., and Lale, N.E.S. 1998. Oviposition of *Oryzaephilus mercator*(Fauvel) (Coleoptera: Silvanidae) on *Arachis hypogaea* (L.) (Papilionaceae), *Citrullus lanatus* (Thunb.) (Cucurbitaceae) and *Irvingia gabonensis* var. *excelsa* (Baillon) (Irvingiaceae). Journal of Stored Products Research 34:37-44.

Dwivedi, S.L., Nigam, S.N., Chandra, S., and Ramraj, V.M. 1998. Combining ability of biomass and harvest index under short- and long-day conditions in groundnut. Annals of Applied Biology 133:237-244. (JA 2233)

Dwivedi, S.L., Nigam, S.N., and Prasad, M.V.R. 1998. Induced genetic variation for seed quality traits in groundnut. International *Arachis* Newsletter 18:44-46.

Elsheikh, E.A.E., and Mohamedzein, E.M.M. 1998. Effects of biological, organic and chemical fertilizers on yield, hydration coefficient, cookability, and mineral composition of groundnut seeds. Food Chemistry 63:253-257.

Elsheikh, E.A.E., and Mohamedzein, E.M.M. 1998. Effect of *Bradyrhizobium*, VA mycorrhiza and fertilisers on seed composition of groundnut. Annals of Applied Biology 132:325-330.

Erden, B.F., Ulak, G., Gacar, N., and Ozdemirei, S. 1998. Is arachis oil a solvent only, or does it also have an effect on the central nervous system? Journal of Pharmacy and Pharmacology 50:443-444.

Escobar, A.B., Estevez, A.M.A., Tepper, L.A., and Aguayo, R.M. 1998. Nutritional characteristics of cereal and peanut bars. Archivos Latinoamericanos de Nutricion 48:156-159.

Faftine, O., Muir, J.P., and Massaete, E. 1998. Dry season supplementation of goats tethered on range supplemented with cowpea or groundnut residues with or without fresh leucaena leaves. Animal Feed Science and Technology 76:1-8.

Favreliere, S., Barrier, L., Durand, G., Chalon, S., and Tallineau, C. 1998. Chronic dietary n-3 polyunsaturated fatty acids deficiency affects the fatty acid composition of plasmenylethanolamine and phosphatidylethanolamine differently in rat frontal cortex, striatum, and cerebellum. Lipids 33:401-407.

Feng, S.Y., Wang, F.X., and Huang, G.H. 1998. Experiment on the interaction between water and fertilizer in groundnuts under sprinkler irrigation. Transactions of the Chinese Society of Agricultural Engineering 14:98-102.

Franke, M.D., Brenneman, T.B., Stevenson, K.L., and Padgett, G.B. 1998. Sensitivity of isolates of *Sclerotium rolfsii* from peanut in Georgia to selected fungicides. Plant Disease 82:578-583.

Freitas, V.P.S., and Brigido, B.M. 1998. Occurrence of aflatoxins B1, B2, G1, and G2 in peanuts and their products marketed in the region of Campinas, Brazil, in 1995 and 1996. Food Additives and Contaminants 15:807-811.

Fukumoto, F., and Tochihara, H. 1998. Preservation of purified peanut stripe and turnip mosaic potyviruses by freezing and freeze-drying. Journal of Phytopathology 146:89-95.

Gajendra Giri. 1998. Influence of gypsum application and weed control measures in groundnut on soil fertility and productivity of succeeding mustard. Annals of Agricultural Research 19:104-106.

Gangwar, B., and Dubey, R.P. 1998. Response of groundnut varieties to fertility levels in Andaman Islands. Journal of the Andaman Science Association 14:64-66.

Garside, A.L., Noble, A.D., Berthelsen, J.E., and Richards, C.L. 1998. Fallow histories: effects on nitrogen contribution, growth and yield of plant and ratoon crops of sugarcane. Pages 104-111 *in* Proceedings of the 20th Conference of the Australian Society of Sugar Cane Technologists held at Ballina, NSW, Australia, 28 Apr to 1 May 1998 (Hogarth, D.M., ed.). Brisbane, Australia: PK Editorial Services.

Georgiev, S. 1998. New groundnut varieties. Orfei. Rasteniev"dni Nauki 35:363-366.

Georgiev, S., and Gorbanov, S. 1998. New groundnut varieties. Rositsa. Rasteniev"dni Nauki 35:367-370.

Giesbrecht, F.G., and Whitaker, T.B. 1998. Investigations of the problems of assessing aflatoxin levels in peanuts. Biometrics 54:739-753.

Giliaspie, A.G., Jr., and Ghabrial, S.A. 1998. First report of peanut stunt cucumovirus naturally infecting *Desmodium* sp. Plant Disease 82:1402.

Giri, A.N., Bhosle, R.H., and Shelke, D.K. 1998. Weed management in cotton (*Gossypium hirsutum*)-groundnut (*Arachis hypogaea*) sequence. Indian Journal of Agronomy 43:50-56.

Glasser, W.G., and Wright, R.S. 1998. Steam-assisted biomass fractionation. II. Fractionation behavior of various biomass resources. Biomass and Bioenergy 14:219-235.

Gnanamurthy, P., and Balasubramaniyan, P. 1998. Weed-management practices and their influence on weed growth and yield of groundnut (*Arachis hypogaea).* Indian Journal of Agronomy 43:122-125.

Gowda, S., Satyanarayana, T., Naidu, R.A., Mushegian, A., Dawson, W.O., and Reddy, D.V.R. 1998. Characterization of the large (L) RNA of peanut bud necrosis tospovirus. Archives of Virology 143:2381-2390. (JA 2021)

Gueye, M., James, E.K., Kierans, M., and Sprent, J.I. 1998. The development and structure of root nodules on bambara groundnut (*Voandzeia (Vigna) subterranea).* World Journal of Microbiology and Biotechnology 14:177-184.

Hashimoto, T., Nagayama, T., Kobayashi, M., Haneishi, N., Ito, M., Tamura, Y., and Tomomatsu, T. 1998. Analysis of chlorimuron ethyl and tribenuron methyl in crops by HPLC with a photodiode array detector. Shokuhin Eiseigaku Zasshi [Journal of the Food Hygienic Society of Japan] 39:324-328.

Herzog, E., Hemmer, O., Hauser, S., Meyer, G., Bouzoubaa, S., and Fritsch, C. 1998. Identification of genes involved in replication and movement of peanut clump virus. Virology 248:312-322.

Hicks, T.V., Wehtje, G.R., and Grey, T.L. 1998. The interaction of pyridate and 2,4-DB in peanut (*Arachis hypogaea*), florida beggarweed *(Desmodium tortuosum),* and sicklepod *(Senna ohtusifolia).* Weed Science 46:284-288.

Hirano, S., Okawara, N., and Narazaki, S. 1998. Near infra red detection of internally mouldy nuts. Bioscience, Biotechnology and Biochemistry 62:102-107.

Hoang Kim, and Mai Van Quyen. 1998. A study on the intercropping of peanut in young rubber plantations in the South-East region of Vietnam. Pages 32-41 in Symposium on natural rubber (*Hevea hrasiliensis*): Volume 3. Rubber smallholdings, NR processing and quality and technology sessions, 14-15 Oct 1997, Ho Chi Minh City, Vietnam. Brickendonbury, UK: International Rubber Research and Development Board.

Hoffmann, K., Geske, S.M., and Moyer, J.W. 1998. Pathogenesis of tomato spotted wilt virus in peanut plants dually infected with peanut mottle virus. Plant Disease 82:610-614.

Holbrook, C.C., Noe, J.P., Gorbet, D.W., and Stephenson, M.G. 1998. Evaluation of peanut breeding lines with resistance to the peanut root-knot nematode. Crop Science 38:260-262.

Holzhauser, T., Dehne, L.I., Hoffmann, A., Haustein, D., and Vieths, S. 1998. Rocket Immunoelectrophoresis (RIE) for determination of potentially allergenic peanut proteins in processed foods as a simple means for quality assurance and food safety. Zeitschrift fur Lebensmittel-Untersuchung und-Forschung 206:1-8.

Hu Chung Chi, Sanger, M., and Ghabrial, S.A. 1998. Production of infectious RNA transcripts from full-length cDNA clones representing two subgroups of peanut stunt virus strains: mapping satellite RNA support to RNA1. Journal of General Virology 79:2013-2021.

Hu, C.C. 1998. Production of infectious RNA transcripts from full-length cDNA clones representing two subgroups of peanut stunt virus strains: mapping satellite RNA support to RNA1. Journal of General Virology 79:2013-2021.

Hu, C.C., and Ghabrial, S.A, 1998. Molecular evidence that strain BV-15 of peanut stunt cucumovirus is a reassortant between subgroup 1 and 11 strains. Phytopathology 88:92-97.

Hunt, P.G., Bauer, P.J., Camp, C.R., and Matheny, T.A. 1998. Nitrogen accumulation in cotton grown continuously or in rotation with peanut using subsurface microirrigation and GOSSYM/COMAX management. Crop Science 38:410-415.

Ingole, B.M., Bhakare, A.H., Paslawar, A.N., and Gade, R.M. 1998. Effect of gypsum and zinc sulphate on yield and quality of summer groundnut under broad bed and furrow system. Journal of Soils and Crops 8:64-66.

Jain, R.K., Pappu, S.S., Pappu, H.R., Culbreath, A.K., and Todd, J.W. 1998. Molecular diagnosis of tomato spotted wilt tospovirus infection of peanut and other field and greenhouse crops. Plant Disease 82:900-904.

Jana, P.K., and Saren, B.K. 1998. Dry-matter accumulation, yield attributes and yield of summer maize (*Zea mays*) and groundnut (*Arachis hypogaea)* intercropping systems as influenced by irrigation. Indian Journal of Agronomy 43:18-22.

Jana, T.K., Mandal, B.K., and Sanjoy Saha. 1998. Effect of rice *(Oryza sativa)*-groundnut *(Arachis hypogaea)* intercropping on yield complementarity. Indian Journal of Agricultural Sciences 68:317-319.

Joshi, P.K., and Bantilan, M.C.S. 1998. Measuring returns to investment in groundnut production technology. Pages 155-163 *in* Assessing joint research impacts: proceedings of an International Workshop on Joint Impact Assessment of NARS/ICR1SAT Technologies for the Semi-Arid Tropics, 2-4 Dec 1996, Patancheru, India (Bantilan, M.C.S., and Joshi, P.K., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (CP 1359)

Kamerschen, D.R. 1998. State court fraud decision influenced by economics of US peanut industry. Agribusiness 14:55-62.

Kanenga, K., and Boughton, D. (eds.) 1998. Proceedings of the Zambia Groundnut Sector Stakeholders Workshop, 15-16 Jul 1997, Lusaka, Zambia, Chipata, Zambia: Ministry of Agriculture, Food and Fisheries, Soil and Research Branch, Department of Research and Specialist Services. 40 pp.

Karunasagar, G., and Reddy, S.N. 1998. Moisture-use pattern of a groundnut (*Arachis hypogaea*)-based intercropping system in semi-arid environment. Indian Journal of Agricultural Sciences 68:171-173.

Kaushik, M.K., Sharma, G.L., Mahapatra, B.S., and Chaubey, A.K. 1998. Effect of spatial association of pearl millet *(Pennisetum glaucum)* and groundnut (*Arachis hypogaea)* on resource utilization and economic yield. Indian Journal of Agronomy 43:33-37.

Khan, A., and Rahim, M. 1998. High-yielding groundnut genotypes for the North West Frontier Province, Pakistan. International *Arachis* Newsletter 18:18-19.

Kirby, J.S., Melouk, H.A., Stevens, T.E., Jr., Banks, D.J., Sholar, J.R., Damicone, J.P., and Jackson, K.E. 1998. Registration of 'Southwest Runner' peanut. Crop Science 38:545-546.

Kotzamanidis, S., and Stavropoulos, N. 1998. Characterization and preliminary evaluation of Greek groundnut (*Arachis hypogaea L.)* germplasm for earliness, high pod concentration and synchronized maturity. Agricoltura Mediterranea 128:21-27.

Krishnan, H.B. 1998. Identification of genistein, an anticarcinogenic compound, in the edible tubers of the American groundnut *(Apios americana* Medikus). Crop Science 38:1052-1056.

Kritchevsky, D., Tepper, S.A., and Klurfeld, D.M. 1998. Lectin may contribute to the atherogenicity of peanut oil. Lipids 33:821-823.

Ku, K.L., Lee, R.S., Young, C.T., and Chiou, R.Y.Y. 1998. Roasted peanut flavor and related compositional characteristics of peanut kernels of spring and fall crops grown in Taiwan. Journal of Agricultural and Food Chemistry 46:3220-3224.

Laan, M.P., Tibbe, G.J.M., Oranje, A.P., Bosnians, E.P.E., Neijens, H.J., and Savelkoul, H.F.J. 1998. CD4+ cells proliferate after peanut-extract-specific and CD8+ cells proliferate after polyclonal stimulation of PBMC of children with atopic dermatitis. Clinical and Experimental Allergy 28:35-44.

Latha, M.S., Sharma, S.B., Gour, T.B., and Reddy, D.D.R. 1998. Comparison of two populations of *Meloidogyne javanica* based on morphology, biology and pathogenicity to groundnut. Nematologia Mediterranea 26:189-194.

Lauber, E., Bleykasten-Grosshans, C., Erhardt, M., Bouzoubaa, S., Jonard, G., Richards, K.E., and Guilley, H. 1998. Cell-to-cell movement of beet necrotic yellow vein virus: I. Heterologous complementation experiments provide evidence for specific interactions among the triple gene block proteins. Molecular Plant-Microbe Interactions 11:618-625.

Legreve, A., Deifosse, P., Vanpee, B., Goffin, A., and Maraite, H. 1998. Differences in temperature requirements between *Polymyxa* sp. of Indian origin and *Polymyxa graminis* and *Polymyxa betae* from temperate areas. European Journal of Plant Pathology 104:195-205.

Li DeHong, Xing Da, Tan ShiCi, and Wang WeiJiang. 1998. Ultraweak biophoton emission from mung beans and groundnuts. Acta Phytophysiologica Sinica 24:177-182.

Lien, R.J., Hess, J.B., Conner, D.E., Wood, C.W., and Shelby, R.A. 1998. Peanut hulls as a litter source for broiler breeder replacement pullets. Poultry Science 77:41-46.

Lige, B., Ma, S.W., and Van Huystee, R.B. 1998. Expression of the peanut peroxidase cDNA in *Escherichia coli* and purification of the protein by nickel affinity. Plant Physiology and Biochemistry 36:335-338.

Lin, J J., and Ping, T.Y. 1998. Mechanized cultivation of summer-sown peanut. AMA, Agricultural Mechanization in Asia, Africa and Latin America 29:39-41.

Lokhande, N.M., Lanjewar, R.D., and Newaskar, V.B. 1998. Effect of different fungicides and neem products for control of leaf spot of groundnut. Journal of Soils and Crops 8:44-46.

Lokhande, N.M., Newaskar, V.B., and Lanjewar, R.D. 1998. Epidemiology and forecasting of leaf rust of groundnut. Journal of Soils and Crops 8:216-218.

Lopez, A.G., Grosso, N.R., Vargas, G., and Guzman, C.A. 1998. Chemical and physical characteristics of Argentinian groundnut milk. International *Arachis* Newsletter 18:42-44.

Lopez, F.D., White, C.E., French, E.C., and McDowell, L.R. 1998. Perennial peanut hay for gestating sows. I. Feeding value. International Journal of Animal Sciences 13:1-6.

Lopez, F.D., White, C.E., French, E.C., and McDowell, L.R. 1998. Perennial peanut hay for gestating sows. II. Reproductive performance. International Journal of Animal Sciences 13:7-12.

Lopez, F.D., White, C.E., French, E.C., and McDowell, L.R. 1998. Perennial peanut hay for gestating sows. III. Effect of fiber on plasma constituents. International Journal of Animal Sciences 13:13-18.

Lourduraj, A.C., Pannerselvam, S., and Sanbagavalli, S. 1998. Intercropping in groundnut. Agricultural Science Digest 18:195-197.

Lourduraj, A.C., Rajagopal, A., and Meyyazhagan, N. 1998. Effect of irrigation regimes, organic and inorganic manures on physico-chemical characteristics of soil, yield and quality attributes of groundnut. Agricultural Science Digest 18:129-132.

Lourduraj, A.C., Rajagopal, A., and Pannerselvam, S. 1998. Growth analysis in groundnut as influenced by irrigation and nutrient management. Agricultural Science Digest 18:191-194.

Mackowiak, C.L., Wheeler, R.M., Stutte, G.W., Yorio, N.C., and Ruffe, L.M. 1998. A recirculating hydroponic system for studying peanut *(Arachis hypogaea L.).* HortScience 33:650-651.

Maiti, D., Mahalanobis, D., and Ghosh, M. 1998. Competitive functions of groundnut and sesame with different fertilizers and cropping systems in the coastal saline zone of West Bengal. International Arachis Newsletter 18:33-34.

Malavia, D.D., Dudhatra, M.G., Vyas, M.N., and Mathukia, R.K. 1998. Direct and residual effect of farm-yard manure, irrigation and fertilizer on rainy season groundnut (*Arachis hypogaea)*-summer pearl millet *(Pennisetum glaucum)* cropping sequence. Indian Journal of Agricultural Sciences 68:117-118.

Marinelli, A., March, G.J., Rago, A., and Giuggia, J. 1998. Assessment of crop loss in peanut caused by *Sclerotinia sclerotiorum, S. minor,* and *Sclerotium rolfsii* in Argentina. International "Journal of Pest Management 44:251-254.

Mathur, R.K., Manivel, P., Gor, H.K., and Chikani, B.M. 1998. Fixing the sublethal dose for sodium azide on groundnut. International Arachis Newsletter 18:16-17.

Metcalf, P.A., Stevens, J., Shimakawa, T., Hutchinson, R.G., Schmidt, M., Dennis, B.H., Davis, C.E., and Heiss, G. 1998. Comparison of diets of NIDDM and non-diabetic African Americans and whites: the atherosclerosis risk in communities study. Nutrition Research 18:447-456.

Mhaske, V.B., Chengalrayan, K., and Hazra, S. 1998. Influence of osmotica and abscisic acid on triglyceride accumulation in peanut somatic embryos. Plant Cell Reports 17:742-746.

Michel, P. 1998. New products at Columa 1998: eleven new herbicide molecules. Phytoma 511:5-6.

Militao, V., Moreno, I., Rodriguez-Cerezo, E., and Garcia-Arenal, F. 1998. Differential interactions among isolates of peanut stunt cucumovirus and its satellite RNA. Journal of General Virology 79:177-184.

Mishra, C M . 1998. Constraints in groundnut *(Arachis hypogaea L.)* cultivation in Khargone district (West Nimar), Madhya Pradesh, India. International *Arachis* Newsletter 18:34-35.

Mishra, R.K., Tripathi, A.K., Choudhary, S.K., and Sharma, R.B. 1998. Effect of varieties and plant spacing on growth and yield of groundnut in Surguja, Madhya Pradesh. International *Arachis* Newsletter 18:37-38.

Misra, J.B., and Mathur, R.S. 1998. A simple and economical procedure for transmethylation of fatty acids in groundnut oil for analysis by GLC. International *Arachis* Newsletter 18:40-42.

Moss, J.P., Singh, A.K., Nigam, S.N., Hildebrand, G.L., Govinden, N., Ismael, F.M., Subrahmanyam, P., and Reddy, L.J. 1998. Registration of ICGV-SM 86715 peanut germplasm. Crop Science 38:572. (JA 2037)

Mukherjee, P.S., and Nandi, B. 1998. Preservation of seeds with some antifungal volatile compounds. Journal of Mycopathological Research 36:25-29.

Munaswamy, V., Raju, K.V., Reddy, P.V., Balaguravaiah, D., and Raju, A.S. 1998. Effect of primary tillage on yield, phosphorus uptake and root distribution of rainfed groundnut in Alfisols. Journal of Nuclear Agriculture and Biology 27:28-34.

Munger, P., Bleiholder, H., Hack, H., Hess, M., Stauss, R., Boom, T. van den, and Weber, E. 1998. Phenological growth stages of the peanut plant (*Arachis hypogaea L.)*: codification and description according to the BBCH scale. Journal of Agronomy and Crop Science 180:101-107.

Naidu, B.P. 1998. Separation of sugars, polyols, proline analogues, and betaines in stressed plant extracts by high performance liquid chromatography and quantification by ultra violet detection. Australian Journal of Plant Physiology 25:793-800.

Naidu, R.A., Bottenberg, H., Subrahmanyam, P., Kimmins, F.M., Robinson, D.J., and Thresh, J.M. 1998. Epidemiology of groundnut rosette virus disease: current status and future research needs. Annals of Applied Biology 132:525-548. (JA 2225)

Naidu, R.A., Robinson, D.J., and Kimmins, F.M. 1998. Detection of each of the causal agents of groundnut rosette disease in plants and vector aphids by RT-PCR. Journal of Virological Methods 76:9-18. (JA 2264)

Narasimhamurthy, K., Vishwanatha, S., and Raina, P.L. 1998. Long term feeding effects of thermally oxidized oils on the erythrocyte fatty acid composition, haematology and histology in rats. Nutrition Research 18:1245-1259.

Nasir Saleh, Baliadi, Y., and Nugrahaeni, N. 1998. Performance of ICRISAT's groundnut foliar disease-resistant breeding lines in East Java, Indonesia. International *Arachis* Newsletter 18:23-24.

Nath, P., and Singh, A.K. 1998. Effect of intercropping of groundnut with millets and pigeonpea on the relative incidence of insect pests. Annals of Plant Protection Sciences 6:151-154.

Nie, H.M., and Jing, J.G. 1998. Yu Hua 9, a new peanut cultivar with high yield and high content of protein. Crop Genetic Resources 1:56-57.

Nigam, C.P., Prakash, S., and Srivastava, M.M. 1998. A neural network based model for the uptake of chromium by groundnut plant using radiotracer. Journal of Nuclear Agriculture and Biology 27:79-89.

Nigam, S.N., Hildebrand, G.L., Syamasonta, B., Bock, K.R., Subrahmanyam, P., and Reddy, L.J. 1998. Registration of ICGV-SM 83005 peanut germplasm. Crop Science 38:571. (JA 2035)

Nigam, S.N., Hildebrand, G.L., Bock, K.R., Ismael, F.M., Govinden, N., Subrahmanyam, P., and Reddy, L.J. 1998. Registration of ICGV-SM 85048 peanut germplasm. Crop Science 38:572-573. (JA 2036)

Nigam, S.N., Rao, R.C.N., and Wynne, J.C. 1998. Effects of temperature and photoperiod on vegetative and reproductive growth of groundnut *(Arachis hypogaea L.).* Journal of Agronomy and Crop Science 181:117-124. (J A 1968)

Njapau, H., Muzungaile, E.M., and Changa, R.C. 1998. The effect of village processing techniques on the content of aflatoxins in corn and peanuts in Zambia. Journal of the Science of Food and Agriculture 76:450-456.

Novo, M.C.S.S., Cruz, L.S.P., Pereira, J.C.V.N.A., and Nagai, V. 1998. Post-emergence herbicide effect on plant growth and symbiotic nitrogen fixation in peanut. Scientia Agricola 55:276-284.

NRCG (National Research Centre for Groundnut). 1998. Annual Report 1996-97. Junagadh, India: National Research Centre for Groundnut. 104 pp.

Ntare, B.R., and Williams, J.H. 1998. Heritability of components of a simple physiological model for yield in groundnut under semiarid rainfed conditions. Field Crops Research 58:25-33. (JA 2067)

Ntare, B.R., Williams, J.H., and Ndunguru, B.J. 1998. Effects of seasonal variation in temperature and cultivar on yield and yield determination of irrigated groundnut *(Arachis hypogaea)* during the dry season in the Sahel of West Africa. Journal of Agricultural Science 131:439-448. (JA 1987)

O'B Hourihane, J., Roberts, S.A., and Warner, J.O. 1998. Resolution of peanut allergy: case-control study. British Medical Journal (Clinical Research edition) 316:1271-1275.

Okiwelu, S.N., Dudu, P.O., and Lale, N.E.S. 1998. The effects of photoperiod on some aspects of the biology of *Oryzaephilus mercator* (Fauvel) (Coleoptera: Silvanidae). Journal of Stored Products Research 34:189-193.

Osborn, G.S., Lacey, R.E., and Singleton, J.A. 1998. Detecting high temperature curing off-flavors in peanuts [groundnuts] using an electronic nose. ASAE Annual International Meeting, 12-16 Jul 1998, Orlando, Florida, USA. St Joseph, USA: American Society of Agricultural Engineers (ASAE). 25 pp.

Pae, S.B., Oh, K.W., Kim, J.T., Park, C.K., and Kwack, Y.H. 1998. The evaluation of relationships between peanut growth and yield by mulching and nonmulching cultivation in southern region of Korea. RDA Journal of Industrial Crop Science 40:1-6.

Pae, S.B., Oh, K.W., Kim, J.T., and Kwack, Y.H. 1998. A study on the changes of peanut flowering habit by different years. RDA Journal of Industrial Crop Science 40:7-13.

Pappu, S.S., Pappu, H.R., Chang, C.A., Culbreath, A.K., and Todd, J.W. 1998. Differentiation of biologically distinct peanut stripe potyvirus strains by a nucleotide polymorphism-based assay. Plant Disease 82:1121-1125.

Paranjpe, S.A., and Gore, A.P. 1998. Wait and see strategy for leaf miner control in rainfed groundnut. Current Science 74:296-299.

Patel, S.R., and Thakur, D.S. 1998. Effect of phosphorus and bacterial inoculation on yield and quality of groundnut *(Arachis hypogaea)*. Indian Journal of Agricultural Sciences 68:119-120.

Patil, M.N., Deshmukh, P.W., Nikesar, R.J., and Naphade, K.T. 1998. Response of groundnut to sulphur and farmyard manure on Lithic Ustorthent. PKV Research Journal 22:13-15.

Paudel, K.P., Martin, N.R., Jr., Wehtje, G., and Grey, T. 1998. Economic decision making using enterprise budgeting and statistical analysis: an illustration in weed control practices in peanut production. Journal of Production Agriculture 11:48-52.

Perry, C.D., Durrence, J.S., Vellidis, G., Thomas, D.L., Hill, R.W., and Kvien, C.S. 1998. Field experiences with a prototype peanut (groundnut) yield monitor. ASAE Annual International Meeting, 12-16 Jul 1998, Orlando, Florida, USA. St Joseph, USA: American Society of Agricultural Engineers (ASAE). 10 pp.

Perumal, V., Geetha, N., and Jayabalan, N. 1998. Influence of growth regulators on plant regeneration from epicotyl and hypocotyl cultures of two groundnut *(Arachis hypogaea L.)* cultivars. Journal of Plant Biology 41:1-8.

Phirke, P.S., and Umbarkar, S.P. 1998. Influence of magnetic treatment of oilseed on yield and dry matter. PKV Research Journal 22:130-132.

Phulekar, C.S., Chetti, M.B., Nalini, A.S., and Patil, A.B. 1998. Relationship of leaf characters with total dry matter and yield in groundnut as influenced by growth retardants. Indian Journal of Agricultural Research 32:195-200.

Ponsamuel, J., Huhman, D.V., Cassidy, B.G., and Post-Beittenmiller, D. 1998. In vitro regeneration via caulogenesis and brassin-induced shoot conversion of dormant buds from plumular explants of peanut *(Arachis hypogaea L.* cv 'Okrun'). Plant Cell Reports 17:373-378.

Powell, N.L., and Wright, F.S. 1998. Subsurface microirrigated corn and peanut: effect on soil pH. Agricultural Water Management 36:169-180.

Prakash, B.G., Sajjanar, G.M., and Naykar, N.Y. 1998. A promising groundnut variety, R 8808, suitable for the northern dry zone of Karnataka. International Arachis Newsletter 18:8.

Prasad, M.N.R., Gowda, M.V.C., and Patil, R.K. 1998. Screening groundnut mutants for resistance to

Spodoptera litura and thrips. International *Arachis* Newsletter 18:29-30.

Prasad, M.S., Lakshmi, B.S., and Shaik Mohiddin. 1998. Survival of sclerotia of *Rhizoctonia solani* in rice soils amended with oilcakes and green leaf manures. Annals of Agricultural Research 19:44-48.

Prasad, P.E., and Reddy, R.R. 1998. Effect of formaldehyde treated groundnut cake on in vitro and in sacco protein degradability. Indian Journal of Animal Nutrition 15:52-54.

Provance, P. 1998. World peanut production. World Agricultural Production 2:59-61.

Purushotham, M.G., Veerangouda Patil, Raddey, P.C., Prasad, T.G., and Vajranabhaiah, S.N. 1998. Development of in vitro PEG stress tolerant cell lines in two groundnut *(Arachis hypogaea L.)* genotypes. Indian Journal of Plant Physiology 3:49-51.

Qiu Qingshu, Li Zhengchao, Shen Fuyu, Wang Chuangtang, and Miao Huarong. 1998. Groundnut breeding through mutation techniques in China. International *Arachis* Newsletter 18:17.

Rajendran, K., and Lourduraj, A.C. 1998. Response of groundnut (*Arachis hypogaea L.)* to nitrogen and phosphorus nutrition - a review. Agricultural Reviews 19:137-139.

Ramesh, R., Shanthamallaiah, N.R., Jayadeva, H.M., Hiremath, R.R., and Bhairappanavar, S.T. 1998. Yield and quality parameters of irrigated groundnut as influenced by sources of phosphate, FYM and phosphate solubilizing microorganisms. Crop Research 15:144-147,

Ramulu, V., and Reddy, B.B. 1998. Effect of irrigation, seeding methods and seed densities on yield and economic returns of groundnut after kharif rice. Annals of Agricultural Research 19:110-111.

Rao, R.V.S., Sridhar, R., Singh, U., and Rao, G.V.R. 1998. Bio-chemical basis in groundnut (*Arachis hypogaea)* resistant to leafminer *(Aproaerema modicella).* Indian Journal of Agricultural Sciences 68:104-109.

Rao, T.P., and Ito, O. 1998. Differences in root system morphology and root respiration in relation to nitrogen uptake among six crop species. JARQ, Japan Agricultural Research Quarterly 32:97-103.

Rao, T.V.R., Filho, J.F., and Silva, L.C. 1998. Development of vegetation indices to estimate the biomass and leaf area of an irrigated peanut crop. ASAE Annual International Meeting, 12-16 Jul 1998, Orlando, Florida, USA. St Joseph, USA: American Society of Agricultural Engineers (ASAE). 13 pp.

Ravankar, H.N., Puranik, R.B., and Deshmukh, P.W. 1998. Soil fertility management with legume-wheat sequence. PKV Research Journal 22:15-18.

Reddy, A.S., Hobbs, H.A., Delfosse, P., Murthy, A.K., and Reddy, D.V.R. 1998. Seed transmission of Indian peanut clump virus (IPCV) in peanut and millets. Plant Disease 82:343-346. (JA 2205)

Reddy, C.D.R., Reddy, P.N., Reddy, M.V., Ramesh Babu, P., Munendra Babu, A., and Lavakumar Reddy, M. 1998. Kadiri 4: a high-yielding, short-duration groundnut cultivar for the postrainy and summer seasons: a boon to Rayalaseema farmers of Andhra Pradesh, India. International Arachis Newsletter 18:20-21.

Reijsen, F.C. van, Felius, A., Wauters, E.A.K., Bruijnzeel-Kooman, C.A.F.M., and Koppelman, S.J. 1998. T-cell reactivity for a peanut-derived epitope in the skin of a young infant with atopic dermatitis. Journal of Allergy and Clinical Immunology 101:207-209.

Rochester, I.J., Peoples, M.B., Constable, G.A., and Gault, R.R. 1998. Faba beans and other legumes add nitrogen to irrigated cotton cropping systems. Australian Journal of Experimental Agriculture 38:253-260.

Rocke, T., and Provance, P. 1998. World grains and oilseeds area and production. World Agricultural Production 11:41-52.

Rocquelin, G., Tapsoba, S., Dop, M.C., Mbemba, F., Traissac, P., and Martin-Prevel, Y. 1998. Lipid content and essential fatty acid (EFA) composition of mature Congolese breast milk are influenced by mothers' nutritional status: impact on infants' EFA supply. European Journal of Clinical Nutrition 52(3): 164-171.

Rocquelin, G., Tapsoba, S., Mbemba, F., Gallon, G., and Picq, C. 1998. Lipid content and fatty acid composition in foods commonly consumed by nursing Congolese women: incidences on their essential fatty acid intakes and breast milk fatty acids. International Journal of Food Sciences and Nutrition 49:343-352.

Rosolem, C.A., and Caires, E.F. 1998. Yield and nitrogen uptake of peanuts as affected by lime, cobalt, and molybdenum. Journal of Plant Nutrition 21:827-835.

Runkulatile, H., Homma, K., Horie, T., Kurusu, T., and Inamura, T. 1998. Land equivalent ratio of groundnut-finger millet intercrops as affected by plant combination ratio, and nitrogen and water availability. Plant Production Science 1:39-46.

Rusike, J., and Rohrbach, D.D. 1998. Seed stocks of maize, sorghum, pearl millet, groundnut, pigeonpea, and cowpea in Southern African Development Community Countries. Bulawayo, Zimbabwe: SADC/ICRISAT Sorghum and Millet Improvement Program. 58 pp. (Limited distribution.)

Ryabov, E.V., Oparka, K.J., Cruz, S.S., Robinson, D.J., and Taliansky, M.E. 1998. Intracellular location of two groundnut rosette umbravirus proteins delivered by PVX and TMV vectors. Virology 242:303-313.

Ryder, S.D., Jacyna, M.R., Levi, A.J., Rizzi, P.M., and Rhodes, J.M. 1998. Peanut ingestion increases rectal proliferation in individuals with mucosal expression of peanut lectin receptor. Gastroenterology 114:44-48.

Sahayaraj, K. 1998. Antifeedant effect of some plant extracts on the Asian armyworm, *Spodoptera litura* (Fabricius). Current Science 74:523-525.

Sahoo, A., and Pathak, N.N. 1998. Comparative growth performance of preruminant crossbred calves after replacement of fish meal with groundnut cake in the calf starter. Indian Journal of Dairy Science 51:73-77.

Sailaja, P.R., Podile, A.R., and Reddanna, P. 1998. Biocontrol strain of *Bacillus subtilis* AF 1 rapidly induces lipoxygenase in groundnut *(Arachis hypogaea L.)* compared to crown rot pathogen *Aspergillus niger.* European Journal of Plant Pathology 104:125-132.

Sailaja, P.R., and Podile, A.R. 1998. A phytoalexin is modified to less fungitoxic substances by crown rot pathogen in groundnut *Arachis hypogaea L.* Indian Journal of Experimental Biology 36:631-634.

Salara, B.S., and Gowda, M.V.C. 1998. Variability and correlation studies in segregating generation of inter sub specific crosses of groundnut (Arachis hypogaea). Crop Improvement 25:122-123.

Sanford, S. 1998. U.S. peanut consumption rebounds. Agricultural Outlook AO-257:12-15.

Sanghani, L.U. 1998. Long term effect of NH_4C1 sludge on soil properties and crop yield. Indian Journal of Environment and Toxicology 8:64-65.

Santos, R.C. dos. 1998. EMBRAPA releases BRS 151 Amendoim L 7, a large-seeded groundnut cultivar for the Northeast region in Brazil. International Arachis Newsletter 18:11-12.

Sarkar, R.K., Chakraborty, A., and Bala, B. 1998. Analysis of growth and productivity of groundnut *(Arachis hypogaea L.)* in relation to micronutrients application. Indian Journal of Plant Physiology 3:234-236.

Sathiyabama, ML, and Balasubramanian, R. 1998. Short note: Effect of *Acremonium obclavatum glucan* on groundnut leaf rust disease caused by *Puccinia arachidis* Speg. World Journal of Microbiology and Biotechnology 14:783-784.

Satyanarayana, T., Gowda, S., Reddy, K.L., Mitchell, S.E., Dawson, W.O., and Reddy, D.V.R. 1998. Peanut yellow spot virus is a member of a new serogroup of Tospovirus genus based on small (S) RNA sequence and organization. Archives of Virology 143:353-364. (JA 1889)

Savitri, H., Reddy, M.S., and Reddy, B.M. 1998. Effect of seed treatment with fungicides and insecticides on seed borne fungi, storage insect pest, seed viability and seedling vigour of groundnut. Seed Research 26:62-72.

Sembene, M., and Delobel, A. 1998. Genetic differentiation of groundnut seed-beetle populations in Senegal. Entomologia Experimentalis et Applicata 87:171-180.

Senthil, N., and Vindhiyavarman, P. 1998. Combining ability studies in groundnut. Annals of Agricultural Research 19:231-232.

Shenoy, S. 1998. Effect of home scale processing on the aflatoxin BI content of selected food grains. Indian Journal of Nutrition and Dietetics 35:90-94.

Shim, M.Y., Starr, J.L., Keller, N.P., Woodard, K.E., and Lee, T.A., Jr. 1998. Distribution of isolates of Sclerotium rolfsii tolerant to pentachloronitrobenzene in Texas peanut fields. Plant Disease 82:103-106.

Silva, L.C., Beltrao, N.E. de M., Rao, T.V.R., and Fideles Filho, J. 1998. Effect of irrigation management on yield and quality of groundnuts cv. BR1. Revista Brasileira de Engenharia Agricola e Ambiental 2:175-178.

Silva, L.C., Fideles Filho, J., Beltrao, N.E. de M., and Rao, T.V.R. 1998. Diurnal variation in stomatal resistance in irrigated groundnuts. Pesquisa Agropecuaria Brasileira 33:269-276.

Singh, A.K. 1998. Hybridization barriers among the species of *Arachis L.,* namely of the sections Arachis (including the groundnut) and Erectoides. Genetic Resources and Crop Evolution 45:41-45. (JA 2011)

Singh, A.K., and Smartt, J. 1998. The genome donors of the groundnut/peanut *(Arachis hypogaea L.)* revisited. Genetic Resources and Crop Evolution 45:113-118.

Singh, A.K., Smartt, J., Simpson, C.E., and Raina, S.N. 1998. Genetic variation vis-a-vis molecular polymorphism in groundnut, *Arachis hypogaea L.* Genetic Resources and Crop Evolution 45:119-126. (JA 2062)

Singh, A.L., Nautiyal, P.C., and Zala, P.V. 1998. Growth and yield of groundnut varieties as influenced by seed size. Tropical Science 38:48-56.

Singh, D.N. 1998. Variability and dose effect of gamma rays in combined mutagenesis of groundnut *(Arachis hypogaea L.).* Annals of Agricultural Research 19:49-53.

Singh, D.N. 1998. Shift in heritability and character association within M3 population of groundnut (*Arachis hypogaea L.*). Annals of Agricultural Research 19:98-99.

Singh, S.B., and Singh, J.P. 1998. Variation in yield and agromorphological characters in groundnut cultivars *(Arachis hypogaea L.).* Crop Research 16:146-149.

Smith, O.D., Simpson, C.E., Black, M.C., and Besler, B.A. 1998. Registration of 'Tamrun 96' peanut. Crop Science 38:1403.

Sojitra, V.K., and Pethani, K.V. 1998. Stability for seed size in bunch groundnut *(Arachis hypogaea* Linn.). Indian Journal of Genetics and Plant Breeding 58:215-218.

Srikanta Das, and Raj, S.K. 1998. Comparison of transformation equations on the epiphytotic development of groundnut rust at different stages of crop growth. Indian Journal of Agricultural Sciences 68:215-217.

Subrahmanyam, P., Hildebrand, G.L., Naidu, R.A., Reddy, L.J., and Singh, A.K. 1998. Sources of resistance to groundnut rosette disease in global groundnut germplasm. Annals of Applied Biology 132:473-485. (JA 2219)

Taliansky, M.E., Ryabov, E.V., and Robinson, D.J. 1998. Two distinct mechanisms of transgenic resistance mediated by groundnut rosette virus satellite RNA sequences. Molecular Plant-Microbe Interactions 11:367-374.

Taran, S.A., Haq, M.I., Bugti, R.A., and Nasibullah Taran. 1998. Evaluation of groundnut varieties under irrigated condition in coastal area of Uthal Balochistan. Sarhad Journal of Agriculture 14:225-228.

Taurian, T., Castro, S., and Fabra, A. 1998. Physiological response of two peanut rhizobia strains to acid pH. Symbiosis 24:327-336.

Thakare, S.K., Gawande, R.P., Selukar, S.S., and Dawane, P.N. 1998. Influence of sulphur and calcium on yield and quality attributes of groundnut (*Arachis hypogaea L.*). Journal of Soils and Crops 8:163-164.

Throne, J.E., Hagstrum, D.W., and Nawrot, J. 1998. Computer model for simulating almond moth (Lepidoptera: Pyralidae) population dynamics. Environmental Entomology 27:344-354.

Tiwari, V.N., Lehri, L.K., Tiwari, K.N., and Hari Singh. 1998. Effect of the incorporation of groundnut plant residue on wheat yield, nutrient uptake and soil productivity. Journal of the Indian Society of Soil Science 46:43-47.

Tripp, R., Walker, D.J., Miti, F., Mukumbuta, S., and Zulu, M.S. 1998. Seed management by small-scale farmers in Zambia: a study of cowpea, groundnut and sorghum seed in the Southern and Western Provinces. Bulletin - Natural Resources Institute no.76. Chatham, UK: Natural Resources Institute (NRJ). 36 pp.

Upadhyaya, H.D., and Nigam, S.N. 1998. Epistasis for vegetative and reproductive traits in peanut. Crop Science 38:44-49. (JA 1981)

Upadhyaya, H.D., Nigam, S.N., Rao, M.J.V., Reddy, A.G.S., Yellaiah, N., and Reddy, N.S. 1998. Registration of early-maturing peanut germplasm ICGV 92196, ICGV 92206, ICGV 92234, and ICGV 92243. Crop Science 38:900-901. (JA 2052)

Van Huystee, R.B., Ma, S.W., Zhao, D.L., and Lige, B. 1998. Cationic peanut peroxidase: expression and characterization in transgenic tobacco and purification of the histidine-tagged protein. Plant Science 136:159-168.

Vanisree, G., and Prasad, M.V.R. 1998. Mutational rectification of certain defects in the aerial podding genotype TAP 5' of groundnut (*Arachis hypogaea*). Indian Journal of Agricultural Sciences 68:158-161.

Vardhini, B.V., and Rao, S.S.R. 1998. Effect of 28-homobrassinolide on growth, metabolite content and yield of groundnut (*Arachis hypogaea L.*). Indian Journal of Plant Physiology 3:58-60.

Vardhini, B.V., and Rao, S.S.R. 1998. Effect of brassinosteroids on growth, metabolite content and yield of *Arachis hypogaea.* Phytochemistry 48:927-930.

Varman, P.V., Joel, A.J., Mylswami, V., Nagarajan, P., Raveendran, T.S., Sridharan, C.S., Dwivedi, S.L., Nigam, S.N., and Rao, G.V.R. 1998. Registration of 'ALR 2' peanut. Crop Science. 38:1716. (JA 2022)

Varman, P.V., and Senthil, N. 1998. Combining ability in inter-subspecific crosses of groundnut. Annals of Agricultural Research 19:229-230.

Vasanthi, R.P. 1998. Testa colour inheritance in groundnut (*Arachis hypogaea L.*). Indian Journal of Genetics and Plant Breeding 58:433-437.

Vasanthi, R.P., and Harinath Naidu, P. 1998. Evaluation of advanced groundnut lines for resistance to late leaf spot. International *Arachis* Newsletter 18:14-16.

Vasanthi, R.P., Ramachandra Reddy, J., and Harinath Naidu, P. 1998. Evaluation of advanced groundnut breeding lines for resistance to Kalahasti malady (*Tylenchorhynchus brevilineatus*). International Arachis Newsletter 18:13-14.

Velu, G. 1998. Effect of water stress on yield potential of groundnut (*Arachis hypogaea*). Indian Journal of Agricultural Sciences 68:284-286.

Venkatachalam, P., Rao, K.S., Kishor, P.B.K., and Jayabalan, N. 1998. Regeneration of late leaf spot-resistant groundnut plants from *Cercosporidium personatum* culture filtrate-treated callus. Current Science 74:61-65.

Wadia, K.D.R., McCartney, H.A., and Butler, D.R. 1998. Dispersal of *Passalora personata* conidia from groundnut by wind and rain. Mycological Research 102:355-360.

Waliyar, F., Sharma, S.B., and Traore, A. 1998. Host preferences of plant parasitic nematodes associated with growth variability problem of groundnut in Niger. International Journal of Nematology 8:1-4. (JA 2249)

Wang Q., Yu LuGang, Campbell, B.J., Milton, J.D., and Rhodes, J.M. 1998. Identification of intact peanut lectin in peripheral venous blood. Lancet 352:1831-1832.

Wang, A.M., Fan, H.L., Chong, S.S., and Ozias-Akins, P. 1998. Transformation of peanut with a soybean vspB promoter-uidA chimeric gene. I. Optimization of a transformation system and analysis of GUS expression in primary transgenic tissues and plants. Physiologia Plantarum 102:38-48.

Wang, Y.Y., Zhang, Y., Shang, S.Q., and Zhang, X.Z. 1998. Test study on performance of groundnut shelling by gas burst. Transactions of the Chinese Society of Agricultural Engineering 14:222-227.

Wang, Z., Zhu, Y.C., and Shi, P.F. 1998. Ideas on the development of multiple cropping systems in Jiangsu Province. Jiangsu Agricultural Sciences 3:2-4.

Watson, I.N., Watson, L.M., Murray, T.A., Bao LiGe, Huystee, R.B. van, and McManus, M.T. 1998. Identification of two further cationic peroxidase isoenzymes secreted by peanut cells in suspension culture. Plant Physiology and Biochemistry 36:591-599.

Whitaker, T.B., Hagler, W.M., Jr., Giesbrecht, F.G., Dorner, J.W., Dowell, F.E., and Cole, R.J. 1998. Estimating aflatoxin in farmers' stock peanut lots by measuring aflatoxin in various peanut-grade components. Journal of AOAC International 81:61-67.

White, R. 1998. Mexico oilseeds production. World Agricultural Production 6:52-53.

Wicklow, D.T., Norton, R.A., and McAlpin, C.E. 1998. Beta-carotene inhibition of aflatoxin biosynthesis among *Aspergillus flavus* genotypes from Illinois corn. Mycoscience 39:167-172.

Wong, S.M., Lee, K.C., Yu, H.H., and Leong, W.F. 1998. Phylogenetic analysis of triple gene block viruses based on the TGB 1 homolog gene indicates a convergent evolution. Virus Genes 16:295-302.

Wright, G.C., Rao, R.C.N., and Basu, M.S. 1998. Selection for water-use efficiency in food legumes -- extension phase report. ACIAR Food Legume Newsletter 27:4-6.

Wu, H., Zhou, J.W., Jing, S.Q., Zhu, C.Y., and Zhan, D. 1998. Study of the process for the manufacture of peanut yoghurt. China Dairy Industry 26:16-17.

Wu, J.C., Kong, X.X., and Li, X.D. 1998. On the development trends in sustainable agriculture in the sandy area of Henan Province. Journal of Henan Agricultural Sciences 4:14-16.

Xu, Z.Y., Higgins, C.M., Dietzgen, R.G., Chen, K.R., Zhang, Z.Y., Yang, L.Y., and Fang, X.P. 1998. Evidence for a third taxonomic subgroup of peanut stunt virus from China. Plant Disease 82:992-998.

Yadav, G.L., Sharma, P.K., and Sharma, B.L. 1998. Effect of nitrogen, phosphorus, and gypsum on yield of rainfed groundnut *(Arachis hypogaea L.).* International Arachis Newsletter 18:35-37.

Yang XiaoQuan, Jiang XiaoCheng, and Fu JiaRui. 1998. Soluble sugar [accumulation] and the acquisition of desiccation tolerance in groundnut *(Arachis hypogaea)* seeds. Acta Phytophysiologica Sinica 24:165-170.

Yang, H., Singsit, C., Wang, A., Gonsalves, D., and Ozias-Akins, P. 1998. Transgenic peanut plants containing a nucleocapsid protein gene of tomato spotted wilt tospovirus show divergent levels of gene expression. Plant Cell Reports 17:693-699.

Yang, X.Q., Jiang, X.C., and Fu, J.R. 1998. Membrane behaviour, water status and acquisition of desiccation tolerance in peanut *(Arachis hypogaea)* seed. Acta Scientiarum Naturalium Universitatis Sunyatseni 37:78-82.

Yankov, B., Ivanov, K., Angelova, V., and Takhsin, N. 1998. Uptake and localization of Pb, Cu, Zn and Cd in groundnuts from an industrially polluted region. Rasteniev"dni Nauki 35:183-187.

Yu WanJun, and Chu, F.S. 1998. Improved direct competitive enzyme-linked immunosorbent assay for cyclopiazonic acid in corn, peanuts and mixed feed. Journal of Agricultural and Food Chemistry 46:1012-1017.

Yu, W.J., Dorner, J.W., and Chu, F.S. 1998. Immunoaffinity column as cleanup tool for a direct competitive enzyme-linked immunosorbent assay of cyclopiazonic acid in corn, peanuts, and mixed feed. Journal of AOAC International 81:1169-1175.

Zhang, Z.Y., Chen, K.R., Xu, Z.Y., Fang, X.P., and Yan, L.Y. 1998. Occurrence and epidemiology of peanut common mosaic virus (PSV). Chinese Journal of Oil Crop Sciences 20:78-82.

Zharare, G.E., Blarney, F.P.C., and Asher, C.J. 1998. Initiation and morphogenesis of groundnut (*Arachis hypogaea L.*) pods in solution culture. Annals of Botany 81:391-396.

Zwickenpflug, W., Meger, M., and Richter, E. 1998. Occurrence of the tobacco alkaloid myosmine in nuts and nut products of *Arachis hypogaea* and *Corylus avellana*. Journal of Agricultural and Food Chemistry 46:2703-2706.

Notes

Notes

Notes

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, USA. It is intended as a worldwide communication link for all those who are interested in the research and development of groundnut or peanut *(Arachis hypogaea L.)* and its wild relatives. Though the contributions that appear in IAN are peer-reviewed and edited, it is expected that the work reported will be developed further and formally published later in refereed journals. It is assumed that contributions in IAN will not be cited unless no alternative reference is available.

IAN welcomes short contributions (not exceeding 600 words) about matters of interest to its readers.

What to contribute?(ICRISAT)

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 germ plasm 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 600 words is the upper limit (no more than two double-spaced pages).
- If necessary, include one or two small tables (and no more). Supply only the essential information; round off the data-values to just one place of decimal whenever appropriate; choose suitable units to keep the values small (e.g., use tonnes instead of kg). Every table should fit within the normal type-written area of a standard upright page (not a 'landscape' page).
- 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 arc 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.
- 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.**
- Contact the Editors for detailed guidelines on how to format text and diskettes.
- **Include the full address with telephone, fax, and e-mail numbers of all authors**

The Editors 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. Wherever substantial editing is required, a draft copy of the edited version will be sent to the contributor for approval before printing.

Contributions and requests for inclusion in the mailing list should be sent to:

Africa and Asia

IAN Scientific Editor
ICRISAT
Patancheru 502 324
Andhra Pradesh, India

Fax 4 9140241239
E-mail newsletter@icrisat.exch.cgiar.org
Tel +9140 3296161

Americas, Europe, and Oceania

IAN Scientific Editor
c/o Peanut CRSP
1109 Experiment Street
Griffin, GA 30223-1797,USA

Fax +770 229 3337
E-mail crspgrf@gaes.griffin.peachnet.edu
Tel +770 228 7312

Peanut CRSP

The Peanut Collaborative Research Support Program
The University of Georgia, College of Agricultural Environmental Sciences
1109 Experiment Street, Griffin, GA 30223-1797, USA

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

ISSN 1010-5824

32-99