International *Arachis* Newsletter

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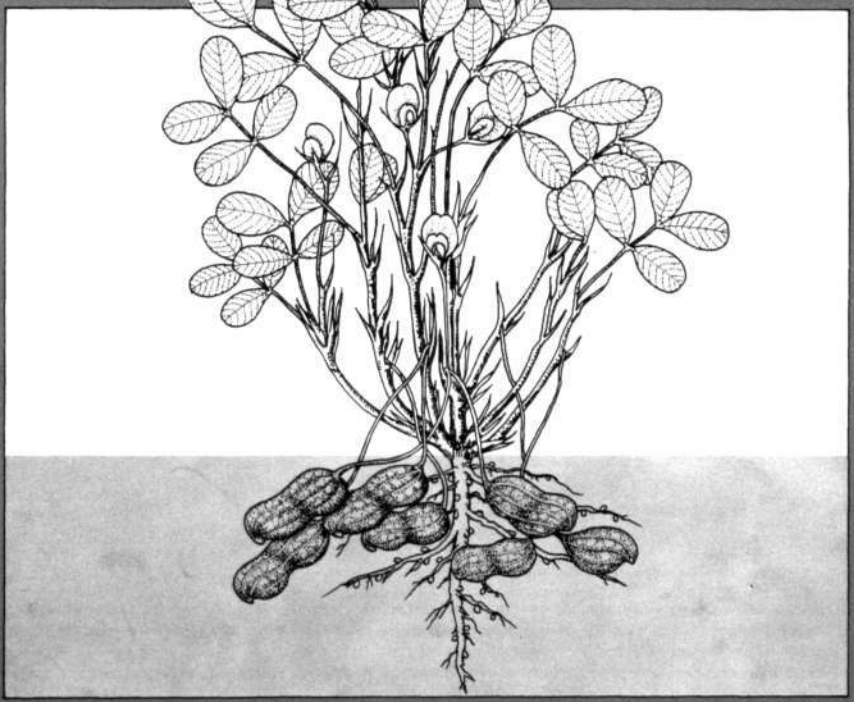

International *Arachis* Newsletter (IAN)

Co-publishers

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

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

About Peanut CRSP

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

The Peanut CRSP provides support for collaborative research, training, and exchange of information through grants to 10 universities in USA linked to 14 host countries in the developing world. Both host countries and USA are expected to benefit from the activities of Peanut CRSP. Peanut CRSP actively collaborates with other organizations with interest in advancing development through the application of science and technology.

About ICRISAT

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

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the SAT. 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 16 nonprofit research and training eenters funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR 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 United Nations Development Programme (UNDP), and the World Bank.

IAN Scientific Editor

S N Nigam

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News and Views

From the Editor

By the time this issue is in your hands, it would be a festive season again—Christmas and New Year. The IAN group at ICRISAT and Peanut CRSP wishes its readers a very happy New Year. In spite of our best efforts, we could not bring out this issue in October for many reasons. Among others, the two guidelines that can help in improving this situation are strict adherence to the deadline (June 30) for submission to the current issue and a quick response from authors. For an easy and smooth processing of manuscripts, it is essential that authors follow the guidelines given for publication. With cooperation from all, let us hope we do better next time.

I am glad that some scientists have come forward to share their experiences from on-farm/farmer participatory research. We need more such examples. Information on new releases of groundnut is also welcome. We also need some updates on research in the area of biotechnology in groundnut. Many of our partners in developing countries and from remote areas do not have access to scientific journals and Internet to get new information in science and technology of groundnut. IAN, in a small way, tries to fill in this gap.

With continuous decline in resources for agricultural research and development, we need to strongly justify each activity. We believe that IAN serves a useful purpose in sharing and disseminating relevant information among the members of groundnut community. However, we would like to hear about it from you. We have enclosed a form with this issue for you to fill in and return to us. This will help us in making a strong case in support of IAN.

I would like to acknowledge S Chandra, S L Dwivedi, N Kameswar Rao, J V D K Kumar Rao, S Pande, P Parthasarathy Rao, G V Ranga Rao, K P C Rao, D V R Reddy, T J Rego, O P Rupela, R Serraj, H C Sharma, P Subrahmanyam, R P Thakur, H D Upadhyaya, and F Waliyar from ICRISAT, and R C Nageswara Rao, Department of Primary Industries, Australia.

I look forward to your contributions to the 2002 issue of IAN, which should reach us before 30 June.

S N Nigam

About Scientists

F Waliyar, Principal Scientist (Pathology), who was based at ICRISAT-Bamako, Mali has been relocated to ICRISAT, Patancheru, India. He will focus his research on aflatoxins.

Through a letter from Nguyen Xuan Hong, Vice Director, National Institute of Plant Protection, Hanoi, Vietnam, the Minister of the Ministry of Agriculture and Rural Development, Vietnam, has honored **S N Nigam,** Principal Scientist, Genetic Resources and Enhancement Program (GREP), ICRISAT with the Medal for Agriculture and Rural Development, for his distinguished contributions to groundnut research and development in Vietnam. The Medal will be awarded soon at a ceremony in Hanoi.

New Millennium International Groundnut Workshop

The New Millennium International Groundnut Workshop was held from 4 to 7 September 2001 at Qingdao, China. The workshop was co-sponsored by Shandong Academy of Agricultural Sciences (SAAS), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), China International Centre for Economic and Technical Exchanges (CICETE), Peanut Group/China Crops Association, National Agro-Technical Extension Service Centre (China), and the People's Government of Qingdao, and organized by the Shandong Peanut Research Institute (SPRI). The theme of the workshop was enhancing groundnut production and utilization in the new millennium. Scientists from Argentina, China, Japan, South Africa, Thailand, USA, and Vietnam, and officials and representatives from international organizations such as ICRISAT and UNDP and FAO Representative Offices in Beijing as well as leaders from the Ministry of Science and Technology, Ministry of Agriculture, and CICETE of China, and Shandong People's Representative Conference, the People's Government of Shandong Province and the People's Government of Qingdao attended the meeting. The workshop was

successful and achieved its multiple objectives. All participants agreed to make the Qingdao Declaration as follows:

1. The New Millennium International Groundnut Workshop is the first international peanut meeting held in this century. More than a hundred scientists from leading institutions and universities in peanut-producing countries around the world gathered at Qingdao to review the technological advances in peanut research, production, and utilization; discuss the future research direction to alleviate production and utilization bottlenecks; and provide for technology exchange and cooperation among different institutions in the new century. This effort is expected to benefit the development of world peanut production, and improve the well-being of the poor and marginal farmers. The international peanut workshop is proposed to be held once every 5 years and hosted by major peanut-producing countries in the world.

2. As a major oil and food crop, peanut is widely cultivated in Asia, Africa, the Americas, and Oceania. Peanut and its products are consumed all over the world, playing an important role in providing protein, oil, and other nutrition to both human beings and livestock. Both public and private sector research and development institutions, marketing bodies, and processing industries should increase their input to peanut research and technical innovation.

3. Peanut scientists globally have made great contribution to peanut science and technology advancement and rapid increase in production and quality. This effort should be continued in the future to provide for further advances in global peanut science and technology to benefit the human kind and to protect the environment.

4. Levels of research and technology development among peanut-production areas vary considerably and need to be balanced. The level of production, the scope and the depth of research are also different. Scientists from different countries should learn from each other and strengthen exchange of information, technology, and germplasm for mutual benefit, and furthering the cause of peanut science. The developed countries should provide technical assistance, expertise, and training for peanut personnel from developing countries.

5. In order to promote international cooperation in peanut scientific research, information and technology exchange among peanut researchers, farmers, processors and consumers, and rational utilization of peanut, all participants agreed to establish the International Peanut Research and Development Association (IPRADA)—an organization for promoting peanut science, research, production and consumption all over the world. China, ICRISAT, USA, Argentina, South Africa, Japan, Thailand, and Vietnam are the initiators of the Association. All peanut workers of the world are invited to participate in IPRADA. The constitution of the Association has been agreed in the New Millennium International Groundnut Workshop.

6. Through group discussion, the workshop has identified the future directions of peanut research in the new century. Germplasm enhancement, genetics and breeding, seed health and quality, biotechnology, soil management, pests and disease management, and food processing and safety are regarded as the main research areas in which in-depth studies are needed in the long term.

International Peanut Research and Development Association (IPRADA)

The International Peanut Research and Development Association (IPRADA) is an international organization acting as a bridge among groundnut researchers, extensionisls, producers, processors, traders, consumers, and policy makers worldwide to promote the global development of groundnut science and technology, production, marketing, and utilization.

The main objectives of IPRADA are:

- To strengthen cooperation among R&D institutions in groundnut-producing countries;
- To promote enhanced utilization and consumption of groundnut and its products;
- To promote international exchange of germplasm;
- To facilitate the exchange of groundnut scientists globally;
- To provide a forum to archive the past research results and technology and to accelerate information exchange in groundnut science and technology;
- To promote consultancy service and opportunity for training of groundnut personnel;
- To collect, publish, and distribute research information through print media, videos, and electronic media on groundnut science and technology.

The Executive Council of IPRADA includes:

Chairperson
Wan Shubo, Director General, SPR1, Qingdao, China

Vice Chairpersons
William D Dar, Director General, ICR1SAT, Patancheru, Andhra Pradesh, India

Thomas G Isleib, President, American Peanut Research and Education Society (APRES), Raleigh, North Carolina, USA

Board of Directors
Li Tieshen, Vice President, National Agro-Technical Extension Service Centre, Beijing, China

Oscar Giayetto, Professor, National University, Rio Cuarto, Argentina

S N Nigam, Principal Scientist, GREP, ICRISAT, Patancheru, Andhra Pradesh, India

C L L Gowda, Director, Information Resource Management Program (IRMP), ICRISAT, Patancheru, Andhra Pradesh, India

Zeng Lingqing, Official, Ministry of Agriculture, Beijing, China

A J Cilliers, Professor, Agricultural Research Council, Potchefstroom, South Africa

Phan Lieu, Professor, Oil Plant Institute, Ho Chi Minh City, Vietnam

Yu Shanlin, Vice Director, Shandong Peanut Research Institute, Qingdao, China

Liao Boshou, Professor, Oil Crops Research Institute, Wuhan, China

Aran Patanothai, Professor, Khon Kaen University, Khon Kaen, Thailand

Akihiro Isoda, Professor, Faculty of Horticulture, Chiba University, Chiba, Japan

Secretary in Chief
Hu Wenguang, Director, International Cooperation Office, SPR1, Qingdao, China

Special events

An Aide Memoire for strengthening collaboration between the National Oil Crops Improvement Peanut Centre (NOCIPC) and ICRISAT was signed by Wan Shubo (Director General, SPRI) and William D Dar (Director General, ICRISAT).

At a special ceremony held on 5 September, SPRI honored the following scientists as International Advisors for their contributions to research and development activities of the Institute:

S N Nigam, Principal Scientist, GREP, ICRISAT, Patancheru 502 324, Andhra Pradesh, India
(E-mail:s.nigam@cgiar.org)

C L L Gowda, Director, IRMP, ICRISAT, Patancheru 502 324, Andhra Pradesh, India
(E-mail:c.gowda@cgiar.org)

Thomas G Isleib, Professor and President, APRES, North Carolina State University, Box 7629, Raleigh, NC 27695-7629, USA

C Corley Holbrook, Research Geneticist, USDA-ARS, CPMRU, PO Box 748, Tifton, GA 31793, USA
(E-mail:holbrook@tifton.cpes.peachnet.edu)

Oscar Giayetto, Professor, Facultad de Agronomia y Veterinaria, Universidad Nacional de Rio Cuarto (Cordoba province, Argentina), Ruta Nacional 36 km 601.5800 Rio Cuarto, Cordoba, Argentina
(E-mail:ogiayetto@ayv.unrc.edu.ar).

China Groundnut Collaboration Awarded

Research on strains of groundnut viruses, epidemiology and control of virus diseases of groundnut in China conducted by Xu Zeyong of the Oil Crops Research Institute, China has received China's National Award for Science and Technology. Xu Zeyong has acknowledged the help of D V R Reddy, C L L Gowda, and other ICRISAT scientists. He hopes to keep in contact with the scientists and continue to receive information and support from ICRISAT in future researches.

Action Plan to Combat Groundnut Stem Necrosis

While at the World Trade Organization (WTO) meeting in Hyderabad, William D Dar, Director General, ICRISAT presented ICRISAT's Action Plan to Combat

Peanut Stem Necrosis Disease to Shri Chandrababu Naidu, Chief Minister of Andhra Pradesh, India. The action plan was formulated on the basis of a breakthrough made by scientists from ICRISAT, National Bureau of Plant Genetic Resources (NBPGR) in Hyderabad, Acharya N G Ranga Agricultural University (ANGRAU) in Anantapur, and National Research Centre for Groundnut (NRCG) in Junagadh. The disease had caused large-scale damage to the groundnut crop last season in about 0.25 million ha in Anantapur and Kurnool districts of Andhra Pradesh.

Groundnut Farming Communities in the Philippines

A R Librero, Deputy Director of the Philippine Council for Agriculture and Resources Research Development (PCARRD), Los Banos, Philippines, and R L Moxley, Professor of Sociology, North Carolina State University, Raleigh, North Carolina, USA presented a paper titled "A study of Philippine peanut farming communities: adoption of new technology and nonadoption (without blaming the victims)" at the national Rural Sociological Society annual meetings in Albuquerque, New Mexico, USA on August 18,2001.

Four communities, two that received a Government sponsored program, and two which did not were studied. The paper examines the extent of adoption of new varieties of groundnut including a variety developed with Peanut CRSP funding. Influences on adoption rates were also studied. The study indicated that farmers in the "commercial" program communities had the highest rates of adoption but farmers who did not participate in the program had the second highest rates. Some farmers in the non-program communities also adopted one of the two new varieties studied.

Groundnut News from West Africa

Three groundnut varieties resistant to rosette released in Nigeria

Groundnut rosette disease is the most destructive disease of groundnut in sub-Saharan Africa, especially in Nigeria and other countries in West Africa. Lack of resistance to rosette in early-maturing varieties has been of major concern in rosette endemic areas.

In 1987, ICRISAT and the Institute for Agricultural Research (IAR) at Samaru, Nigeria endeavored to search for solutions to rosette disease problems in West and Central Africa. The two institutes launched a collaborative program to promote the exchange of germplasm and conduct joint breeding activities. This collaborative program has resulted in the development of high-yielding short- and medium-duration rosette resistant lines. With additional support from the Common Fund for Commodities (CFC), IAR has become a lead center in West Africa to develop rosette resistant varieties.

In May 2001, the National Variety Release Committee of Nigeria approved three groundnut varieties for registration and large-scale production. These varieties are ICGV-IS 96894, UGA 2, and M572.80I.

ICGV-IS 96894 is high yielding, early maturing (90-100 days), and resistant to groundnut rosette disease. It is suitable for areas with a growing season of 3 months. ICGV-IS 96894 was developed by bulk selection in the F_4 populations obtained from the SADC/ICRISAT Groundnut Project in Malawi. The new cultivar was selected by ICRISAT and IAR breeders in the collaborative breeding program in 1996. A series of preliminary and advanced trials in Nigeria demonstrated its potential, after which, ICGV-IS 96984 was evaluated in multilocational trials for two seasons during 1998-99 (7 locations each year). These trials were supported by the Groundnut Germplasm Project. Pod yield of ICGV-IS 96984 was 37% higher than those of the two popular varieties, RRB and 55-437. Also, the new variety is superior in fodder yield (3-4 t ha^{-1}), shelling outturn (60-70%), and seed size (100-seed mass 45 g).

UGA 2 and M572.80I are medium-maturing (115-120 days) varieties and were developed by IAR. In multilocational trials, these varieties exhibited good agronomic characteristics such as high pod yield (2.3-2.9 t ha^{-1}) and fodder yield (5.2-6.0 t ha^{-1}) as well as high fodder quality (crude protein content: 137-168 g kg^{-1} in leaf and 114-136 g kg^{-1} in stem). The varieties were also evaluated by farmers in the dry and humid savanna zones. Pod yield was 1.5-2.0 t ha^{-1} and fodder yield was 2-4 t ha^{-1}.

These three varieties have also shown good performance in regional trials supported by the Groundnut Germplasm Project in Mali, Burkina Faso, and Guinea. In Nigeria demand for the released varieties is high and

efforts are geared towards sustainable production and distribution of seeds of these varieties to farmers.

Strengthening the goundnut seed sector in Senegal

Twenty-two groundnut specialists from the national seed services and NARS of 13 countries in West and Central Africa gathered in Bambey, Senegal from 20 to 30 March 2001 for training in groundnut seed production. The training workshop was organized by the Institut Senegalais de Recherche Agricole (ISRA) and funded by CFC.

The workshop allowed participants not only to share their experiences in groundnut seed production, but also exposed them to the more developed groundnut seed sector of Senegal. The private sector in Senegal contributes about 35% of the country's total groundnut seed production while the remaining 65% comes from the informal sector. In contrast, in most other countries, groundnut seed production is still dominated by the public sector that supplies breeder and foundation seeds, and small-scale farmers handle the remainder in an informal manner. The Senegalese model could help other countries improve the efficiency and sustainability of their groundnut seed production sector.

The workshop is part of a series of training programs being held with the financial support of CFC to improve groundnut production in the regions by equipping local scientists and technicians with the necessary skills. This meeting follows the one on aflatoxin detection in groundnut, which took place at ICRISAT-Bamako, Mali in February-March 2001. B Ntare of ICRISAT-Bamako was one of the resource persons at the seed production workshop, along with personnel from partners of the Groundnut Germplasm Project (C1RAD and ISRA), and representatives of the private seed sector in Senegal. A wide range of topics were covered including varietal development, groundnut seed production principles, seed sector organization, essential steps in seed production, crop protection, laboratory tests (sampling, moisture content, purity, etc), seed stock management, commercialization, distribution, formal and informal markets, seed regulation, and seed policy. Also, field visits to groundnut collection centers and processing industries for oil and edible groundnut were organized.

A national consultative committee on groundnut sector formed in Niger

A one-day meeting was organized by the sub-project manger and staff at Sadore, Niger to share experiences among representatives from research institutions [Institut national de recherches agronomiques du Niger (INRAN), ICRISAT], Ministry of Agriculture, local non-governmental organizations (NGOs), farmers' groups, and association of professional seed growers. Forty participants attended the meeting. It was stressed that for a seed system to develop there has to be a national seed plan to guide development and diffusion of new varieties; roles of different actors must be clearly defined; the state has to be an active partner; and farmers' groups must be empowered to produce seed to satisfy community seed needs. It was also stressed that there is a need for every actor to recognize the value of seed and mechanisms to enhance information flow. It was recommended that an information coordination point (ICP) should be created to ensure flow of information at all levels. Membership of this coordination point will comprise INRAN, ICRISAT, Ministry of Agriculture, representatives of NGOs and farmers' groups, and a representative of the association of seed producers. INRAN will take the lead and formulate the terms of reference of the ICP. Participants highly commended the organization of such a meeting and were encouraged by the establishment of the groundnut germplasm genebank at ICRISAT-Niamey, Niger.

Following this meeting, a committee has been formally launched to develop modalities for revitalization of the groundnut sector in Niger. The committee is known as "Comite Consultatif sur la Filiere Arachidere au Niger" (CCFAN) and is chaired by INRAN.

ICRISAT/INRAN work in Niger stirs village involvement

At Bengou in the Gaya region of Niger, farmers are turning to groundnut seed production after witnessing the results of an ICRISAT/INRAN collaboration in the region. It all began two years ago, when Mr Abdou Hassane, Chief of the Bengou village, wrote to ICRISAT-Niamey:

"The Bengou population has been following with great interest the groundnut seed multiplication work conducted by your service at the INRAN station in Bengou. After several visits to the multiplication plots, and based on their own traditional knowledge, farmers were able to follow and appreciate the high yield potential of several groundnut varieties. To the 50 participating farmers, your staff promised to give at least 1 kg from each variety they selected. To make the best use of this gift, I have decided to allocate a 2-ha field to be used uniquely for seed multiplication by farmers themselves.

I ask however that you provide us with the necessary technical backstopping so that we are able to increase our groundnut production."

This began a successful partnership between ICRISAT, INRAN, and PADEL (Local Initiatives Support Project), a Swiss-funded development project. ICRISAT provided seeds and training. PADEL funded the purchase of small equipment and organized the field days, and the fanners provided the labor.

All varieties were chosen by the farmers based on their observations, information given by ICRISAT technicians, and their own know-how. Seventy varieties were tested and three field days organized: 45 days after planting to show plant biomass, at harvest, and the third one during oil extraction. More than 150 women and men farmers were present at each of the field days.

Women with at least 20 years experience in groundnut oil extraction led the Oil Extraction Field Day activities. Farmers retained groundnut varieties 55-437, 1CGV 86124, ICG 9199, ICG 9346, and ICG 7299 for further multiplication. Seeds of these varieties are being produced under irrigation in order to meet the high demand from both livestock owners and farmers. ICRISAT/PADEL is also testing four new groundnut varieties resistant to leaf spots, and with high yield in fodder, seed, and oil. These varieties were offered by the ICRISAT/CFC Groundnut Germplasm Project and had already been tested with success at Bengou during four years.

Groundnut research and production project

The Sixth Steering Committee meeting of the Groundnut Germplasm Project funded by the CFC was held from 7 to 11 May 2001 in Bamako, Mali. F Waliyar represented ICRISAT as Project Executive Agency. Other participants were the CFC representative, Ms Lydie Boka-Mene; the FAO representative Peter Thoeness; and representatives of NARS in Burkina Faso, Mali, Nigeria, and Senegal, who are partners in the project. FAO is the Supervisory Body (SB) of this project.

Welcoming these groundnut specialists to the meeting, ICRISAT Site Leader B Shapiro, thanked CFC and the SB for their commitment to the project and their continued follow-up of its activities. Thoeness commended ICRISAT and its partners "for having developed and put in place over the last year, appropriate solutions for most of the issues raised." He was referring to recommendations and requests made following an in-depth evaluation of the project a year ago. Thoeness observed that since then, project management has been re-organized, collaboration with partners streamlined, and work plan and budget have been re-adjusted. "Under the present set-up" he added, "the SB is confident that the project will be completed successfully."

The project's outputs during the past year include the release of three rosette resistant groundnut varieties by the National Variety Release Committee in Nigeria, and two trainers training workshops geared toward staff of the participating NARS. In addition, the project has resulted in: (1) a broad range of germplasm being assembled for future development; (2) the availability of a range of improved groundnut varieties in the region; and (3) an enhanced capacity of NARS to handle germplasm.

In anticipation of the project's end and a second phase to it, a special task force was established to prepare a follow-up project proposal. A meeting of this task force with members of the Steering Committee and representatives of several international NGOs in Bamako was organized to exchange ideas and clearly articulate issues relevant to a sustainable seed production and delivery system. B Ntare made a presentation on the project achievements, and Richard B Jones presented the challenges of seed production systems in Southern and Eastern Africa. Both were highly appreciated. A document entitled "Informal groundnut seed production in Africa: Elements for developing a system" was produced by Robert Schilling for use by the Steering Committee.

Regional groundnut workshop

The Seventh Regional Groundnut Workshop for West and Central Africa was held from 6 to 8 December 2000 in Cotonou, Benin. The objective of this workshop was to review regional groundnut production, assess research and development aspects, and develop a strategy for sustainable groundnut production in the region. A special session on management of aflatoxin contamination was organized. Several lead papers were presented. ICRISAT, Peanut CRSP, CORAF SG 2000, and INRAB sponsored the workshop.

Systems Modeling to Discover Yield Gaps and Constraints on Groundnut Yield in Ghana and Benin

Production of groundnut in developing countries is constrained by many limitations including weather, soil water-holding capacity, soil fertility, poor farmer management, diseases, insect pests, and weeds. For the

past five years, researchers at the University of Florida, Gainesville, Florida, USA (K J Boote and J W Jones); Savanna Agricultural Research Institute (SARI), Tamale, Ghana (J B Naab); and Institut National des Recherches Agricoles du Benin (lNRAB), Cotonou, Benin (M Adomou) have worked in a collaborative research support program. Initially host country experiments focused on observing and measuring growth of two groundnut cultivars sown at 3 or 4 sowing dates under typical local management conditions. After collecting data for 2 years at both Tamale, Ghana and Ina, Benin, the two researchers traveled to the University of Florida (to work with Boote and Jones), and learned to use the CROPGRO-groundnut model to evaluate constraints on groundnut growth and yield. Both researchers quickly learned, assisted by the model analyses, that soil water was relatively non-limiting in the years tested, and that fertility was reasonably good, but late season diseases particularly leaf spot caused most of the leaves to be abscised by maturity. As the CROPGRO-groundnut model was developed for good leaf spot control in USA, the crop in the model did not lose leaves, while the real crop did. As a result, the model overpredicted growth during the last half of the season and predicted much higher potential pod yield, up to 4 t ha^{-1}. However, the model correctly predicted pod yield and late season biomass when the observed percent defoliation was input (as a pest coupling point) along with approximated percent necrosis from leaf spot.

This led to a new round of experimentation for the next 2 years, with use of split-plot fungicide treatments. This turned out to be highly successful, at least for the site in Ghana where Folicure® was used (by Naab and pathologist Francis Tsigbey) in a high frequency schedule (weekly). Groundnut pod yields in the fungicide-treated plots were doubled compared to the no-fungicide treatments. More importantly, pod yields well over 41 ha^{-1} were obtained even for late sowing dates, as suggested by previous model simulations. For the Ina site, a less effective fungicide, chlorothalonil, was used in a 15-day schedule starting at 45 days after sowing, and yield enhancement from this treatment was much less.

Having found this potential that high groundnut yield was feasible, Benin and Ghanian researchers in the next 5-year project are planning on-farm trials of fungicide treatment and other practices to improve groundnut yields. Before this, they will do economic feasibility studies to determine whether the twofold yield enhancement from fungicide is enough to cover the costs of treatment. In both countries, collaborative efforts are underway for on-farm trials with farmer and extension groups and in Benin, collaborations are planned with a French development assistance team [Programme d'Appui a la Diversification des Systemes d'Exploitation (PADSE)] that is attempting to reestablish groundnut production as an export crop, particularly the marketing, collection, and export aspects. The group also has farmer advisory teams. There is a high level of excitement about potential improvement in groundnut production in both countries.

SP-IPM Pilot Site Activities Facilitate Farmers in Southwestern Kenya to Experiment with Rosette Resistant Groundnut

Groundnut cultivation is widespread in western and southwestern areas of Kenya in the Lake Victoria zone. The main production constraints according to the farmers include the lack of seed of improved high-yielding varieties, diseases (particularly rosette virus complex and leaf spots), insect pests (termites, aphids, grubs, defoliators), and unpredictable weather conditions. Groundnut rosette is a major constraint to groundnut production in eastern Africa. The disease is transmitted by aphids *(Aphis craccivora).*

Most farmers in western Kenya grow the medium- and long-duration genotypes that in recent years have greatly suffered from terminal drought due to unreliable

A woman farmer in Kenya testing rosette resistant groundnut genotypes ICG 12991 and ICG 12988.
[She staled: "These two groundnut varieties are free from SWAO (local Luo name for chlorotic rosette), grow so fast, are very tasty, and provide food for our children very early in the season."]

seasonal rains. This is in addition to frequent aphid infestations that occur as a result of frequent dry spells during the season. Aphids multiply fast during the dry spells and these facilitate the spread of the viruses. In 1997, the Kenya Agricultural Research Institute (KARI) at Kakamega in Western Province became aware of the short-duration rosette resistant materials developed through the 1CRISAT/SADC regional project at Chitedze in Malawi and requested for trial materials of the promising lines. ICGs 12991 and 12988 were tested on-station at KARI-Kakamega and KARI-Kisii during 1998 cropping season. The performance was excellent and KARI agronomists requested the SADC project to facilitate on-farm testing. However, such support was beyond the regional mandate of the project.

E Minja, ICRJSAT-Nairobi participated in a stakeholder workshop held in January 2000 for the Systemwide Program on IPM (SP-IPM Pilot Site in western Kenya) strategy testing on *Striga* management in cereals in Western Kenya. During the workshop farmers from Suba District (location of the Pilot Site) where participatory technology testing has been in progress between farmers, KARI, CIMMYT, ICIPE. IITA, CABI, ICRAF, and NGOs [CARE-Kenya and the Catholic Relief Services (CRS)] and the KARI-Kakamega agronomist requested that the two groundnut lines be incorporated as one of the strategies for *Striga* management. Some of the participating farmer groups have project activities with the two local NGOs (CARE-Kenya and CRS) and CARE accepted the responsibility of promoting seed increase for the short-duration rosette resistant lines in Suba district through farmer groups.

In mid-2000, Richard B Jones, ICRISAT-Nairobi organized the availability of about 6 kg unshelled pods of each of ICGs 12991 and 12988 to CARE office in Homa Bay as part of seed systems and technology exchange activity. CARE gave the seed to two of their participating farmers. The two farmers are to be trained by CARE to produce seed for their respective communities. The first crop was planted during October to January 2000/01 short rainy season and the second planting was done in March 2001. Seed plots have doubled in size despite theft and small amounts for family use. Farmers are impressed by the cleanliness of the two lines from rosette (less than 1% of plants showed chlorotic rosette at full podding stage), earliness, plant type, kernel size and color, and taste. *Striga* weed suppression (though at a very small scale) was visualized by farmers during recent field days organized by IITA/ICIPE/KARI and Suba extension services. CRS on the other hand, went a step ahead and took the responsibility of multiplying breeder seed of ICG 12988 and the medium-duration rosette resistant genotype ICGV-SM 90704 through a private seed company in 2000 and the seed was distributed to farmers in Suba and Homa Bay districts for the 2001 cropping season.

Groundnut Workshop in Zambia

A workshop on constraints and opportunities to groundnut marketing in Malawi, Zambia, and Mozambique was held in Chipata, Zambia, 26-27 June 2001. It was the first workshop in the region, focusing on groundnut marketing. The meeting was sponsored by ICRISAT through the SADC/ICRISAT Groundnut Project, Malawi in collaboration with the Ministry of Agriculture in Zambia. Thirty-seven participants from Malawi, Mozambique, South Africa, and Zambia participated.

Established and improved groundnut varieties for the region as well as new postharvest technologies of groundnuts were demonstrated by P J A van der Merwe (ICRISAT). The new technologies and improved varieties attracted substantial interest from participants.

Participants included researchers, producers, traders, processors, NGOs, donors, COMESA, and Chamber of Commerce and Industries. Groundnut trade partnerships across country borders were established and important market opportunities were identified. It was decided that another regional marketing workshop will be organized in Malawi next year. Strategies to improve marketing in the region were developed and responsibilities for future activities were identified.

Training Courses on Groundnut Production Technologies in Malawi

Two training courses on groundnut production technologies were conducted by ICRISAT-Malawi for research, extension, community volunteers, and non-governmental organizations (NGOs). The first course was held at the Natural Resources College (NRC), Lilongwe from 7 to 9 March 2001 while the second was held at Kasungu Inn, Kasungu from 12 to 14 March 2001. The objectives of the courses were: (1) to develop

Demonstration of peanut butter maker at Kusungu, Malawi.

Participants admiring the performance of groundnut variety CG 7 in farmers' fields near Kasungu, Malawi.

and upgrade skills of the participants in current groundnut production technologies; (2) to empower the participants with skills to increase groundnut production; and (3) to encourage cross-fertilization of ideas among participants through field visits and discussions.

The course at NRC, which was funded by the 1CR1SAT-DARTS-USAID Groundnut and Pigeonpea Project, attracted 60 participants, of which 15 were women. The largest number of participants (33) came from the Ministry of Agriculture and Irrigation. Fourteen participants came from the NGO community in Malawi (CARE 4, Christian Service Committee 2, NASFAM 4, OXFAM 2, and GTZ Integrated Food Security Project 2). Also three participants came from CARE, Mozambique and four participants from CLUSA-NRM-Zambia.

I M G Phiri presided over the opening session on behalf of the Director of DARTS. On behalf of the Ministry of Agriculture and Irrigation and DARTS in particular, Phiri was very grateful to ICRISAT and USAID for joining hands to organize such a training course.

The three days were indeed very fruitful to the participants as most of them were attending this kind of course for the first time. Speaking on behalf of the participants at the end of the course, Ms Margaret Mkandawire of CARE, Malawi thanked ICRISAT for organizing such a course. She assured ICRISAT of the participants' commitment in implementing all that they had learned at this course to increase groundnut production.

The course at Kasungu Inn was organized in partnership with PLAN International, Malawi. Participants of this course were drawn from PLAN communities in Lilongwe, Kasungu, and Mzuzu Units. A total of 74 participants including 33 women attended this course.

In his opening remarks, Mr Ben Sizilande, Programme Manager for Kasungu Agricultural Development Division, commended the ICRISAT-PLAN partnership in enhancing groundnut production in Malawi. He was particularly happy to note a large number of women participants at this course.

In general, participants were very appreciative of the course, which they said had come at a time when groundnut production was increasing in their areas. The information imparted to them at the course was indeed useful.

ICRISAT Groundnut Special Projects

The ongoing special projects on groundnut research at ICRISAT are listed in the table on page 10. ICRISAT appreciates the support of the investors to groundnut research and development activities.

Current ICRISAT groundnut research and integrated projects.

Investor	Project title	Project coordinator	Grant amount (in US$)	Duration
Asian Development Bank	Rapid crop improvement for poor farmers in the semi-arid tropics of Asia	JH Crouch	1,200,000	Jan 2001–Dec 2003
Australia/ACIAR	Selection for peanut varieties with low aflatoxin risk	SN Nigam	200,000	Jul 2001–Jun 2004
Australia/ACIAR	Seeds of life – East Timor	SN Nigam	58,000	Nov 2000–Jun 2003
Australia/ACIAR	More efficient breeding of drought resistant peanuts in India and Australia	SN Nigam	42,000	Oct 1998–2001
Australia/ACIAR	Management of white grubs in peanut cropping systems in Asia and Australia	NRMP	51,000	1998–2001
Belgium	Towards sustainability of groundnut and cereal production in West Africa: management of peanut clump virus	DVR Reddy	795,000	2000–2004
CFC	Conservation, evaluation and dissemination of groundnut germplasm, and foundation seed production and distribution for the West African region	F Waliyar	1,760,000	1996–2002
CFC and World Bank	Preservation of wild species of *Arachis*	PJ Bramel	396,000	1996–2001
CGIAR-CAC	Research activities on groundnut and on management of drought in chickpea, targeted to the Central Asia and the Caucasus (CAC) region	SN Nigam	30,000	2000/2001
Germany/BMZ/GTZ	Promotion of legume cultivation (groundnuts) – Phase V	PJA van der Merwe	524,000	Oct 2000–Sep 2003
India/ICAR/NATP	Aflatoxin contamination in groundnut: mapping and management in Gujarat and Andhra Pradesh	SN Nigam	39,900	2000–2003
India/ICAR/NATP	An integrated approach to control stem necrosis disease of groundnut	SN Nigam	40,700	2001–2004
India/Mahyco Research Foundation	Management of tospoviruses in selected crops and strategies for management of tobacco streak virus	DVR Reddy	10,500	2001–2003
OPEC Fund for International Development	Technological empowerment of poor groundnut farmers in Asia: a step towards better rural economy	SN Nigam	100,000	Jul 2001–Jun 2002
PLAN International	Groundnut Project in Malawi	P Subrahmanyam	182,000	Nov 1998–Dec 2001
UK-DFID/CPP	Strategies for reducing aflatoxin levels in groundnut-based foods and feeds in India: A step towards improving health of humans and livestock (Phase I)	DVR Reddy	223,000	Jul 2000–Jun 2002
USA/University of Georgia (Peanut CRSP)	Travel support for aflatoxin modeling workshop, work on rosette resistance markers, publications	F Waliyar	10,716	2000/2001
USA/University of Georgia (Peanut CRSP)	Support to regional groundnut workshop	F Waliyar	18,000	2000/2001
USA/University of Georgia (Peanut CRSP)	Support for publication costs for International *Arachis* Newsletter; support for regional workshop in southern Africa	F Waliyar	12,800	May 2001–Apr 2002
USA/USAID	Rural prosperity in 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	677,000	Aug 1999–Jan 2002

Genetics and Plant Breeding

Performance of Groundnut Lines Developed from Interspecific Derivatives

P Vindhiyavarman, P Lakshmanan, and S E Naina Mohammed (Regional Research Station, Vriddhachalam 606 001, Tamil Nadu, India)

Early leaf spot (*Cercospora arachidicola)* and late leaf spot (*Phaeoisariopsis personata)* are the two most important diseases of groundnut *(Arachis hypogaea)* worldwide. However, in India, late leaf spot is currently predominant. In southern India, where groundnuts are grown for most of the year, the combined incidence of late leaf spot and rust *(Puccinia arachidis)* is common and yield losses up to 70% was reported by Subrahmanyam et al. (1980). High level of resistance to both the diseases is available in some wild relatives of groundnut (Moss 1980).

At the Regional Research Station, Vridhachalam in Tamil Nadu, India *Arachis cardenasii,* a diploid wild species, exhibited high level of resistance to both late leaf spot and rust. It was hybridized with cultivated groundnut to transfer this resistance in superior agronomic genotypes. As a result three advanced breeding lines, VG 9514, VG 9515, and VG 9516 were developed with high levels of resistance to both the diseases. VG 9514 and VG 9515 are Spanish bunch types with smaller pods while VG 9516 is a Virginia bunch type with low shelling outturn (69%). In order to improve their pod size and shelling outturn, these lines were again hybridized with commercial cultivars, viz., VRI 2, ALR 2, and Local Red. The performance of some of the promising lines obtained from such crosses are presented (Table 1).

Eleven genotypes were evaluated along with two commercial cultivars, VRI 2 and VRI 4, during the rainy season in 1999 and 2000 and postrainy season 2000/01. Mean pod yields of VG 9807, VG 9812, VG 9817, and VG 9816 were >2.5 t ha^{-1} and indicated an increase of 21.5-32.7% over the control VRI 4 (Table 1). The mean

Table 1. Performance of groundnut genotypes over three seasons at the Regional Research Station, Vriddhachalam, Tamil Nadu, India[1].

		Pod yield (t ha^{-1})						Disease score[2]	
Genotype	Duration (days)	Rainy 1999	Rainy 2000	Postrainy 2000/01	Mean	Shelling outturn (%)	100-seed mass (g)	Rust	Late leaf spot
VG 9807	110	3.61	2.18	2.58	2.75	73.5	40.0	1.0	1.5
VG 9812	110	3.13	1.87	2.95	2.65	74.0	52.0	1.2	1.8
VG 9824	110	2.81	2.27	2.02	2.35	74.0	78.0	2.5	3.5
VG 9816	105	3.01	1.76	2.18	2.52	73.5	30.0	3.0	4.0
VG 9817	105	2.94	2.27	2.11	2.62	72.0	28.5	1.0	1.8
VG 9809	105	2.50	1.91	2.13	2.18	73.5	30.0	1.5	2.5
VG 9834	105	2.78	1.82	2.13	2.24	74.8	46.0	1.8	2.8
VG 9849	105	2.59	1.82	2.45	2.29	75.0	40.5	2.3	3.0
VG 9839	105	2.27	1.79	2.34	2.13	74.3	37.2	2.5	3.5
VG 9840	105	2.30	1.56	2.55	2.13	73.5	40.0	3.2	3.9
VG 9828	105	2.25	1.54	1.97	1.94	72.0	36.0	3.5	4.6
VRI 2 (control)	105	1.93	1.74	1.19	1.83	73.5	44.0	8.3	8.5
VRI 4 (control)	108	2.41	1.85	1.96	2.07	73.0	38.0	3.2	4.5
SE ±		0.19	0.11	0.20	0.18	0.62	0.50		
LSD (*P* = 0.05)		0.61	0.41	0.57	0.50	1.20	1.01		
CV (%)		12.1	10.5	13.7	11.0	10.0	9.3		

1. Data are means of three seasons, i.e., rainy season 1999 and 2000, and postrainy season 2000/01.
2. Recorded on a 1-9 scale, where 1 = no disease; and 9 = >80 % defoliation

shelling percentage of the eleven test lines over three seasons ranged from 72.0% to 75.0%. The mean 100-seed mass ranged from 30.0 g to 78.0 g (Table 1). VG 9824 being large-seeded has a potential for the development of confectionery types.

These lines were also screened for rust and late leaf spot resistance under natural disease epiphytotic conditions. The reaction against late leaf spot and rust was recorded on a 1-9 scale, where 1 = no disease and 9 = >80% defoliation (Subrahmanyam et al. 1980). The mean rust score ranged from 1.0 in VG 9807 to 3.5 in VG 9828 in test lines as compared to 8.3 in VRI 2 used as check (Table 1). Similarly, the mean score for late leaf spot ranged from 1.5 in VG 9807 to 4.6 in VG 9828 as compared to 8.5 in VRI 2 (Table 1).

Seed coat color of VG 9807, VG 9812, and VG 9809 was red while that of other test lines was tan. The plant type of the small-seeded genotype VG 9809 is compact with dark green foliage. The leaflet of VG 9816 is ashy green in color. These lines have further potential for commercial exploitation.

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Evaluation of Foliar Disease Resistant Groundnut Varieties of ICRISAT at Vriddhachalam, India

S E Naina Mohammed, P Vindhiyavarman, and K Sathithanandam (Regional Research Station, Vriddhachalam 606 001, Tamil Nadu, India)

Groundnut (*Arachis hypogaea*) is an important oilseed crop in India. Late leaf spot (*Phaeoisariopsis personata*) and rust (*Puccinia arachidis)* are the two major foliar diseases affecting this crop in Tamil Nadu, India. Yield loss up to 70% due to the combined attack of these two diseases was reported by Subrahmanyam et al. (1980a). Further, the seed quality and the fodder value of the plants are also severely affected (Gupta et al. 1987). These foliar diseases have become particularly important in Tamil Nadu, where groundnut is grown for most part of the year and where conditions favor development and spread of the pathogens. As the crop is raised predominantly under rainfed conditions, the farmers are reluctant to adopt any plant protection measures. Hence, growing of resistant varieties is cheap and best method for the control of foliar diseases. The foliar disease resistant varieties developed at ICRISAT, Patancheru, India (VII International Foliar Diseases Resistant Groundnut Varietal Trial) were evaluated at the Regional Research Station, Vriddhachalam, Tamil Nadu during 1999 and 2000 both in rainy and postrainy seasons.

The crop was raised under irrigated conditions during both rainy and postrainy seasons. The trials were laid out in a randomized block design with three replications. Interrow spacing of 30 cm and plant spacing of 10 cm within a row were followed. Insecticides were sprayed to control insect pests but no fungicides were sprayed.

During rainy season 1999, the yield of three varieties, ICGV 92080, ICGV 92093, and ICGV 92102, was significantly superior to the local check VRI 4 (Table 1). But during postrainy season 1999 none of the genotypes outyielded the local check variety VRI 4. Also, during rainy season 2000, none of the entries were significantly superior to the check. However, during postrainy season 2000, except for three genotypes, all other test genotypes were found superior to the check variety. The experiments were conducted in sandy soils during postrainy season 1999 and rainy season 2000 whereas they were carried out in red sandy loam during rainy season 1999 and postrainy season 2000. This may be one of the possible reasons for varying performance of varieties during different seasons (Mercer-Ouarshie 1980). The overall performance of ICGV 92080 and ICGV 92093 was superior to VRI 4. The mean shelling outturn over four seasons was 74.2% in ICGV 92080 and 70.8% in ICGV 92093. The seeds were medium in size as measured by 100-seed mass of 49.2 g and 47.1 g respectively. They compared favorably with VRI 4 for these traits.

The genotypes were screened for late leaf spot and rust diseases on a 1-9 scale as per the procedure suggested by Subrahmanyam et al. (1980b). The mean data over four seasons are presented in Table 1. The mean disease score of the test entries for late leaf spot and rust

Table 1. Performance of varieties included in the VII International Foliar Diseases Resistant Groundnut Varietal Trial at Vriddhachalam, Tamil Nadu, India, 1999-2000.

Variety	Duration (days)	Pod yield (t ha^{-1})					Mean shelling outturn (%)	100-seed mass (g)	Mean disease score[1] (range)	
		Rainy 1999	Postrainy 1999	Rainy 2000	Postrainy 2000	Mean			Late leaf spot	Rust
ICGV 92080	103	4.22	1.97	2.22	3.80	3.05	74.2	49.2	3.3 (2.0-3.9)	1.8 (1.0-2.2)
ICGV 92083	107	2.74	2.23	1.86	3.25	2.52	61.4	45.0	2.4 (2.1-2.9)	1.5 (1.0-2.5)
ICGV 92086	105	2.65	0.82	1.43	3.43	2.08	68.9	47.4	2.2 (1.9-3.0)	1.5 (1.0-1.8)
ICGV 92088	107	2.53	1.74	1.52	2.91	2.17	69.5	51.7	2.5 (1.0-3.2)	1.5 (1.0-1.8)
ICGV 92093	105	3.66	2.19	2.23	4.01	3.02	70.8	47.1	2.8 (1.0-3.5)	1.7 (1.0-2.2)
ICGV 92097	110	2.61	2.07	2.00	3.63	2.58	70.4	57.0	2.2 (1.0-2.7)	1.3 (1.0-2.5)
ICGV 92098	103	3.09	1.31	1.96	3.05	2.35	61.2	62.4	3.1 (2.0-3.8)	1.6 (1.0-2.0)
ICGV 92102	105	3 60	1.78	2.01	2.53	2.48	67.8	64.3	4.2 (2.0-4.8)	1.9 (1.0-2.5)
ICGV 92106	107	2.68	1.39	1.86	2.32	2.06	68.0	46.6	4.1 (3.0-5.3)	1.8 (1.0-2.8)
ICGV 93187	105	2.66	1.74	1.46	2.77	2.16	71.6	54.5	2.9 (1.5-3.5)	1.4 (1.0-2.0)
ICGV 93197	107	2.23	1.48	1.53	2.96	2.05	74.5	59.6	5.0 (3.5-6.0)	1.6 (1.0-2.4)
ICGV 93218	105	2.94	2.44	2.25	3.25	2.72	74.2	50.9	2.6 (1.5-4.0)	1.6 (1.0-2.2)
ICGV 93222	107	2.71	1.92	1.43	3.48	2.39	74.6	41.6	2.4 (1.0-2.8)	1.0 (1.0-1.2)
ICGV 93229	107	2.18	2.11	1.68	2.66	2.16	74.3	47.5	2.8 (1.0-3.5)	1.6 (1.0-2.4)
ICGV 87160	105	2.94	1.27	2.27	2.92	2.35	69.5	44.1	2.7 (1.5-3.8)	1.7 (1.0-2.6)
VRI 4 (control)	105	3.10	2.27	2.15	2.62	2.53	71.4	50.2	4.6 (3.0-5.0)	1.2 (1.0-2.2)
SE±		0.43	1.67	0.87	0.31		0.8	0.56		
LSD (*P* = 0.05)		0.12	0.47	0.25	0.09		2.4	1.6		
CV(%)		2.5	16.0	8 1	1.7		2.0	1.9		

1. Rating 1-9 scale, where 1=no disease; and 9=>80% defoliation The range observed over four seasons is given in parentheses.

ranged from 2.2 to 5.0 and from 1.0 to 1.9 respectively as compared to 4.6 and 1.2 of the local resistant check VRI 4.

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Screening Groundnut Varieties for In Vitro Colonization with *Aspergillus flavus*

T S N Varma, S Geetha, G K Naidu, and M V C Gowda
(Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad 580 005, Karnataka, India)

Groundnut *(Arachis hypogaea)* is one of the important crops in India. Because of near self-sufficiency and of competition from cheaper sources of edible oil, groundnut is no longer considered as an economical source of edible oil in India. There is a greater interest to promote its export and use in confectionery all over the country. The aflatoxin contamination of groundnut by *Aspergillus flavus* is an important constraint affecting the quality of groundnut (Mehan 1989). Management of aflatoxin contamination requires both preventive and curative approaches starting from sowing and harvesting to processing and storage. Resistant variety can be a desirable component of any integrated aflatoxin management system. In Karnataka, one of the important groundnut-growing stales of India, no information is available on the varietal reaction to *A. flavus* infection. The present study was

Table 1. Varietal response to in vitro seed colonization by *Aspergillus flavus*.

Variety	Pedigree	Year of release	Colonization severity[1]
TMV2	Selection from Gudiatham Bunch	1940	4.00
Spanish Improved	Selection from Spanish peanut	1940	1.38
S 206	Selection from Manvi Local	*1969*	1,73
S230	Selection from Tandur Local	1969	3.78
JL24	Selection from EC 94943	*1978*	3.70
KRG1	Selection from Argentina	*1981*	1.95
Dh8	Selection from RS 144	1984	3.45
R 8808	ICGS 11 x Chico	1992	3.52
Dh40	Dh 3-30 x TGE 2	1994	3.74
Dh43	Selection from Marudur Local	1995	3.71
R 9251	BARCGI x TG 23	1997	3.68
TAG24	TGS 2 x TGE 1	2000	3.53
28-2	Mutant from VL 1	-[2]	3.00
GPBD4	KRG 1 x CS 16	-	1.98
SEm±			1.01
CV *(%)*			12.35

1 Scored on a 1-4 rating scale, where 1 = <5% seed surface colonized with scanty mycelial growth and no sporulation; 2 = 5-25% seed surface colonized with good mycelial growth and scanty sporulation; 3 = 26-50% seed surface colonized with good mycelial growth and good sporulation; and 4 = >50% seed surface colonized with heavy sporulation.

2. - = Not known

undertaken to screen the currently available cultivars for resistance to in vitro seed colonization with a toxigenic strain of *A. flavus* (UASD-1).

Sixty seeds from each of 14 varieties were surface sterilized with 0.1% aqueous solution of mercuric chloride for 2 min and washed in two changes of distilled sterilized water. Seeds were uniformly wounded by pricking with a sterile needle to allow invasion by spores. Seeds were placed in sterile petri dishes and inoculated with *A. flavus* spore suspension (1 x 10^6 spores ml^{-1}). The petri dishes were shaken to roll the seeds allowing uniform distribution of inoculum. The experiment was conducted in two replications with 30 seeds per replication. The petri dishes were placed at high humidity (95% RH) in plastic boxes lined with wet cotton wool and blotting paper, with closely fitting lids, and incubated at 25°C in the dark for 10 days. Individual seeds were scored for surface colonization using a 1-4 rating scale (Thakur et al. 2000) and the mean of two replications was expressed as colonization severity.

Most of the varieties exhibited colonization comparable to the most susceptible variety TMV 2 (Table 1). Three genotypes S 206, KRG 1, and GPBD 4 recorded relatively low level of colonization rating indicating their tolerance *to A. flavus.* The varieties S 206 and KRG 1 are adapted to drier tracts of northern Karnataka, where aflatoxin is a serious problem. These are popular varieties among farmers because of their desirable pod and seed features. GPBD 4, a foliar disease resistant genotype with good pod and seed features, is under adaptive trials. The results need confirmation by a repeat in vitro experiment and testing under *A. flavus* sick field condition for resistance to seed infection.

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Response of Groundnut Genotypes to Environmental Diversities in Yemen

Yahya Abdullah Ali Molaaldoila (Agronomy Section, Southern Highland Agriculture Research Station, PO Box 4332, Taiz, Yemen. Present address: Department of Botany and Plant Physiology, CCS Haryana Agricultural University. Hisar 125 004, Haryana, India)

Groundnut (*Arachis hypogaea*) is one of the most widely cultivated oilseed crops in the coastal area of Yemen. But in the Southern Highland region of Yemen, it is considered a newly introduced crop. No reports are available on the response of groundnut to environmental diversities in the country. Studies elsewhere have shown the presence of genotype x environment interaction in groundnut, which means that the best genotype in an environment may not be the best in another environment (Wright et al. 1996).

Fifteen groundnut genotypes, obtained from ICRISAT, India, were studied at two locations in the Southern Highland region in Taiz (13°36' N and longitude 43°55' E, 1200 m above sea level) and Ibb (13°58' N and 44°12' E, 1760 m above sea level) under rainfed condition in summer crop season (April-September) during 1992 and 1993. The experiment was laid out in a randomized complete block design with four replications. The plot size was 10 rows, each row of 5 m length, Interrow spacing was 50 cm and spacing within a row was 20 cm. Uniform cultural practices were maintained in the experiments. No fertilizers were applied.

Observations on pod and seed yields were recorded on a whole plot basis. The harvest index was estimated on 10-plant sample and 100-seed mass and oil content on random seed samples. The data were averaged over years for each location and analyzed.

The results obtained are summarized in Table 1. Means of all parameters were significantly higher at Taiz than at Ibb. High precipitation and low temperature at Ibb might be responsible for lower groundnut yields and other attributes at this location. At both the locations, genotypes differed significantly for all the traits except for oil content. Location x genotype interaction was also significant for all the traits except for oil content. Several other workers (Singh et al. 1975, Wynne and Isleib 1978, Yadava and Kumar 1979, Lal et al. 1998, Sojitra and Pethani 1998) have reported significant genotype x environment interactions for many of these traits.

Among the top five genotypes, for pod yield, ICGV 86635, ICG 6743, and ICG 4747, and for seed yield, ICGV 86635 and ICG 6743 were common at both the locations. ICGV 86635 and ICG 6743 had higher harvest index at both locations. The top five genotypes for 100-seed mass at both the locations were ICG 6743, ICG 4747, ICG 2716, ICGV 86635, and ICG 1697. However, the differences in seed mass between the two locations

Table 1. Mean performance of groundnut genotypes at Taiz and Ibb in Southern Highland region, Yemen during summer in 1992 and 1993.

Genotype	Pod yield (kg ha^{-1})	Seed yield (kg ha^{-1})	100-seed mass (g)	Harvest index (%)	Oil content (%)
Taiz					
ICG 221	2635	1731	39.1	37	34.16
ICG 1697	2997	2764	53.5	54	43.64
ICG 2716	3665	2735	56.6	53	37.83
ICG 2738	3465	2362	39.5	53	38.71
ICG 3704	3373	1937	50.0	49	42.19
ICG 4601	3678	1973	45.3	46	44.17
ICG 4747	3695	2878	56.8	54	41.13
ICG 6743	4392	2884	68.2	58	41.18
ICGV 86635	4413	3159	56.1	54	35.84
ICGV 86644	3538	2614	41.6	52	43.29
ICGV 86707	3494	2426	41.0	43	36.28
ICGV 86708	3043	2215	48.6	52	42.15
ICGV 86742	3553	2128	50.6	32	41.77
ICGV 86744	3138	1651	42.6	41	36.25
ICGV 86745	2603	1605	39.7	46	33.94
Mean	3445	2337	48.6	48	39.16
Ibb					
ICG 221	1431	1023	35.3	34	32.26
ICG 1697	1390	1244	43.9	42	37.22
ICG 2716	1625	1032	54.0	40	34.19
ICG 2738	950	699	35.8	31	36.49
ICG 3704	1087	699	41.8	42	35.18
ICG 4601	1258	887	42.2	40	34.81
ICG 4747	1700	1049	50.7	35	35.29
ICG 6743	2840	1805	58.3	43	36.26
ICGV 86635	2435	1946	51.7	46	32.16
ICGV 86644	1633	619	40.7	14	39.16
ICGV 86707	1608	898	36.4	22	32.71
ICGV 86708	1870	1211	41.5	33	34.28
ICGV 86742	1115	826	43.8	38	36.61
ICGV 86744	1200	824	40.5	28	33.35
ICGV 86745	713	390	40.0	42	31.62
Mean	1522	1010	43.8	34	35.19
CD at 5%					
Location (L)	476	466	4.2	6.3	3.67
Genotypes (G)	381	293	5.7	8.1	NS[1]
L x G	518	436	8.9	11.4	NS

1. NS = Not significant.

were significant. These genotypes also differed in their rankings at the two locations.

From the results, it is concluded that groundnut can be grown successfully at Taiz. ICGV 86635 and ICG 6743 performed well at both the locations. However, these genotypes should be tested further and the agronomic practices for cultivation of groundnut in the country should be worked out.

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Release of Foliar Disease Resistant Groundnut Cultivar VRI Gn 5 in Tamil Nadu, India

P Vindhiyavarman and S E Naina Mohammed
(Regional Research Station, Vriddhachalam 606 001, Tamil Nadu, India)

The groundnut *(Arachis hypogaea)* genotype VG 971 1 was released in 2001 as variety VRI Gn 5 for general cultivation in Tamil Nadu, India by the State Variety Release Committee. It has decumbent 3 growth habit with irregular branching, and matures in 105-110 days. It originates from a cross between CG 26 and ICGS 44. CG 26 is an interspecific derivative obtained from the cross between CO 1 and *Arachis cardenasii.* ICGS 44 is a widely adapted groundnut cultivar in India (Nigam et al. 1990).

VG 9711 was evaluated at different research stations in 27 locations in Tamil Nadu during the rainy and postrainy seasons in 1995-2000. It was also evaluated along with VRI 2 and VRI 4 in farmers' fields at 69 locations in Tamil Nadu during the rainy season in 1999 and 2000 and postrainy season 1999/2000. It recorded a mean pod yield of 2.1 t ha^{-1} (rainfed) and 2. 4 t ha^{-1} (irrigated) as compared to 1.7 t ha^{-1} and 1.8 t ha^{-1} (rainfed) and 2.0 t ha^{-1} and 2.1 t ha^{-1} (irrigated) of control cultivars VRI 2 and VRI 4 respectively.

The disease score for rust and late leaf spot was recorded on a 1-9 scale where 1 indicates no disease and 9 refers to >80% leaf area infected (Subrahmanyam et al. 1980). VRI Gn 5 (VG 9711) is resistant to rust (a score of 3.0) and late leaf spot (a score of 3.5) as compared to VRI 2 which showed a score of 9.0 for rust and late leaf spot (Table 1). Dry fodder yield was high in VRI Gn 5 (4.2 t ha^{-1}) as compared to VRI 2 (3.3 t ha^{-1}) and VRI 4 (3.9 t ha^{-1}). The reproductive efficiency, as measured by

Table 1. Reproductive efficiency, disease reaction, and seed quality traits of groundnut cultivar VRI Gn 5 evaluated at Vriddhachalam, Tamil Nadu, India.

Traits	VRI Gn 5	VRI 2[1]	VRI 4[1]
Reproductive efficiency[2] (%)			
Mature pods	50.0	33.2	34.1
Mature + immature pods	60.4	48.0	49.9
Disease reaction[3]			
Rust	3.0	9.0	5.0
Late leaf spot	3.5	9.0	6.0
Seed quality			
Testa color	Red	Light rose	Tan
Shelling outturn (%)	75.0	73.5	72.1
100-seed mass (g)	41.5	46.4	40.8
Oil content *(%)*	50.5	48.0	47.0
Cured-seed dormancy (days)	45	Nil	Nil

1. Control cultivar.
2. Percentage of flowers that produced pods.
3. Recorded on a 1 -9 scale, where 1 = no disease; and 9 = >80% leaf area infected.

proportion of pods obtained to the flowers produced, was high in VR1 Gn 5 when compared with VRI 2 and VRI 4 (Table 1).

VRI Gn 5 has 6-7 primary branches and 4-6 secondary branches. The leaves are dark green. The pods are of medium size (100-pod mass of 96.5 g) with moderate constriction and prominent beak. The seed is oblong and red in color. It has shelling outturn of 75%, oil content of 50.5%, and cured-seed dormancy of 45 days (Table 1).

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ICGS(E) 27: A High-yielding ICRISAT Groundnut Genotype for the Ilocos Region, Philippines

F P Sugui, R E Rasalan. C C Sugui, E C Pastor, and D A Tadena (Mariano Marcos Stale University, Dingras. Ilocos Norte, 2913, Philippines)

Groundnut (*Arachis hypogaea)* is a dry season (November-April) cash crop in the Philippines. It is considered a key commercial crop under the Key Production Area (KPA) approach (to crop production) of the Department of Agriculture, Philippines. The current average yield has risen from 500 kg ha^{-1} in the early 1980s to 715 kg ha^{-1}. In view of this small increase in national productivity of groundnut, the development and regional adaptation of high-yielding varieties has been one of the research priorities of the national field legumes varietal improvement program of the National Seed Industry Council (NSIC), Philippines.

Considering the importance of groundnut crop in the country, the Mariano Marcos State University (MMSU), Philippines in collaboration with the Cereals and Legumes Asia Network (CLAN), based at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India, screened and evaluated in the late 1980s several advanced groundnut breeding lines of ICRISAT for adaptation to the local conditions of the Ilocos region in the Philippines.

During 1988-91 dry season, field trials with 20 lines were conducted at MMSU-Batac, Ilocos Norte, Philippines. Of these, 10 lines were further tested at 10 locations. During the 2-year trials, three promising lines were selected for inclusion in the regional yield test for groundnut. These were ICGS(E) 27, ICGS(E) 19, and 1CGS(E) 10. However, only ICGS(E) 27 survived and was thus, included in the National Cooperative Testing (NCT) with 9 other genotypes. The NCT was conducted during 1995-97 in a randomized complete block design with four replications at 8 locations in the country. Each entry was planted in a 4-row plot of 5.0 m length with an interrow distance of 50 cm. Fifteen to eighteen seeds per linear meter were drill-planted in furrows. Optimum cultural requirements from planting to harvesting were followed to permit expression of genetic potential. Fertilizers applied in the field at planting time included 30 kg N ha^{-1}, 30 kg P_2O, ha^{-1}, and 30 kg K_2O ha^{-1}. Spraying of the plants against leaf defoliators with Lannate® and Thiodan® was done 45 and 60 days after planting (DAP), respectively. Harvesting was done when 80-85% of the foliage turned yellow green and pods and seeds showed maturity symptoms. Stripping of pods was done manually and the pods were sun-dried for 3 days.

In 2 years (1995-97) of NCT, three genotypes IPB Pn 88 3970 (2.15 t ha^{-1}), ICGS(E) 27 (1.92 t ha^{-1}), and IPB Pn 88 3610 (1.84 t ha^{-1}) produced significantly greater pod yields than the control variety (1.48 t ha^{-1}) (Table 1). The same trend was observed in the seed production plots with an increase in yield of 19.92-36.65%. These genotypes had significantly higher 100-seed mass (58.8-60.8 g) compared with the control variety (56.1 g). However, the shelling outturn in these genotypes (70.5-73.0%) was comparable with that of the control variety. These genotypes showed resistant to moderately resistant reaction to insect pests and diseases.

In seed quality analysis, ICGS(E) 27 had higher moisture (6.10%), crude fat (43.04%), and crude protein (26.04%) than the other genotypes tested but had lower carbohydrate (22.90%) and ash (1.92%) content (Table 2). Aflatoxin was not detected.

Based on the above results, ICGS(E) 27, IPB Pn 88 3970, and IPB Pn 88 3610 were further evaluated under farmer-managed conditions in Ilocos Norte during 1997-99 dry season. In these evaluations, the three varieties were consistent in seed yield produced across locations with a mean yield of 1.24-1.33 t ha^{-1} compared with 1.24 t ha^{-1} of a national variety and 0.64 t ha^{-1} of the

Table 1. Performance of promising groundnut genotypes in Ilocos, Philippines, 1995-97[1].

Genotype	Pod yield[2] (t ha-')	Pod yield increase over control (%)	Seed yield[2] (t ha^{-1})	Seed yield increase over control (%)	100-seed mass[2] (g)	Shelling (%)	Reaction[3]	
							Defoliators	Leaf spots and rust
ICGS(E) 27	1.92 ab	29.0	1.38 ab	26.6	60.7 a	72.2	2.2	2.8
IPB Pn88 2124	1.71 bc	15.0	1.23 c	12.1	58.2 b	71.8	2.0	2.8
IPB Pn88 4159	1.69 c	13.5	1.22 c	11.2	58.5 b	73.0	3.0	3.0
IPB Pn88 3970	2.15 a	44.9	1.49 a	36.3	60.8 a	70.5	2.5	3.0
IPB Pn88 3610	1.84 b	23.9	1.31 bc	19.9	58.8 b	71.5	2.7	3.0
Control	1.48 c		1.09 d		56.1 c	71.7	1.5	3.0
CV (%)	11.7		13.5		4.85	1.8	19.7	22.3

1. Data are means of eight locations
2. Figures followed by the same letter in each column do not differ significantly at $P<0.05$, based on Duncan's Multiple Range Test (DMRT).
3. Rating scale of 1-5. where 1 = highly resistant; and 5 - highly susceptible.

Table 2. Seed quality traits of promising groundnut genotypes grown during 1995-97 dry season at different locations in the Philippines[1].

Genotype	Moisture (%)	Ash (%)	Crude fat (%)	Crude protein (%)	Carbohydrate (%)	Anatoxin
ICGS(E) 27	6.10	1.92	43.04	26.04	22.90	ND[2]
IPB Pn 88 2124	4.73	2.29	42.61	22.38	27.99	ND
IPB Pn 88 4159	5.45	2.32	39.97	24.26	28.00	ND
IPB Pn 88 3970	4.68	2.29	40.06	25.34	27.63	ND
IPB Pn 88 3610	5.21	2.36	41.93	23.04	27.46	ND
Control	6.05	2.28	39.63	23.18	28.86	ND

1. Analysis done at the Laboratory Services Division, Bureau of Plant Industry. Manila, Philippines.
2. ND = not detected.

Table 3. Performance of promising genotypes of groundnut at three locations in Ilocos Norte, Philipines, 1997-99.

Genotype	Seed yield[1] (t ha^{-1})				100-seed mass (g)	Shelling (%)
	Dingras	Marcos	Banna	Mean		
ICGS(E) 27	1.34	1.19	1.42	1.32	66.6	72.4
IPB Pn 88 3970	1.40	1.21	1.37	1.33	69.7	72.1
IPB Pn 88 3610	1.31	1.14	1.26	1.24	66.6	74.4
National variety	1.25	1.16	1.30	1.24	66.8	73.0.
Farmers' variety	0.75	0.56	0.60	0.64	48.9	62.0

1. Data for each location are incans of yields obtained by 4 farmers.

farmers' variety (Table 3). These genotypes recorded a 100-seed mass of 66.6-69.7 g and 72.1-74.4% shelling compared with 66.8 g 100-seed mass and 73% shelling of the national variety and 48.9 g 100-seed mass and 62% shelling of the farmers' variety.

The promising genotypes ICGS(E) 27. IPB Pn 88 3970, and IPB Pn 88 3610 will be further evaluated for final selection of the variety acceptable to the farmers and for wider adoption by the groundnut growers in the Ilocos region. ICGS(E) 27 had good seed quality traits.

Registration of Groundnut Cultivar ICGV-SM 90704 with Resistance to Groundnut Rosette

P J A van der Merwe[1], P Subrahmanyam[1], G L Hildebrand[2], L J Reddy[3], S N Nigam[1], A J Chiyembekeza[1], C M Busolo-Bulafu[4], and T Kapewa[5] (1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). PO Box 1096. Lilongwe, Malawi; 2. Seed Co. Ltd.. PO Box CH 142, Chisipite, Harare, Zimbabwe; 3. ICRISAT, Patancheru 502 324, Andhra Pradesh, India; 4. Serere Agricultural and Animal Production Research Institute (SAARI), PO Seroti, Uganda; 5. Department of Agricultural Research and Technical Services, Chitedze Research Station, PO Box 158, Lilongwe, Malawi)

Purpose of registration

ICGV-SM 90704 is a high-yielding medium-duration groundnut *(Arachis hypogaea* subsp. *hypogaea* var. *hypogaea)* germplasm developed at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Lilongwe, Malawi. It was evaluated in southern and eastern Africa through collaboration with the national agricultural research systems (NARS). It was released in Uganda in 1999 as Serenut 2 (Busolo-Bulafu 1999) and in Malawi in 2000 as ICGV-SM 90704 (Chiyembekeza et al. 2000). It is in the pre-release phase in Zambia under the name Chishango (K Kanenga, Ministry of Agriculture, Food and Fisheries, Zambia, personal communication). It is widely adaptable in southern and eastern Africa and resistant to groundnut rosette virus (GRV) but susceptible to aphid vector (*Aphis craccivora*) for GRV transmission (van der Merwe et al. 2001).

Origin and development

ICGV-SM 90704 is derived from a cross between varieties RG1 and Mani Pintar made in 1983. RG1 is a Virginia bunch, rosette resistant variety developed by the Department of Agricultural Research and Technical Services in Malawi. Mani Pintar is a rosette susceptible, long-duration variety with a red and white variegated seed color developed by the Department of Research and Specialized Services in Zambia. ICGV-SM 90704 was developed by ICRISAT following repeated bulk selections for rosette disease reaction using infector row technique (Nigam and Bock 1990) and for other desirable characters. Its other identity and pedigree is ICGX-SM83124/7/3-B1.

Yield performance

ICGV-SM 90704 was entered into a preliminary yield trial at the Chitedze Research Station, Lilongwe, Malawi during 1990/91 and evaluated up to 1998/99 cropping season. It was evaluated in on-farm replicated trials from 1992/93 to 1998/99 cropping seasons by NARS in Malawi in partnership with ICRISAT with local varieties Chalimbana and CG7 as controls (Chiyembekeza et al. 2000). The average seed yield of ICGV-SM 90704 across four cropping seasons was 1.04 t ha^{-1} compared to 0.52 t ha^{-1} for Chalimbana and 0.84 t ha^{-1} for CG7. ICGV-SM 90704 was introduced to Uganda in 1994 and was evaluated in multilocational on-farm trials during 1996 and 1997 cropping seasons (Busolo-Bulafu 1999). It produced an average seed yield of 2.3 t ha^{-1} compared to 1.4 t ha^{-1} of the control cultivar Red Beauty in Uganda.

Resistance to groundnut rosette

Under high disease pressure situation at the Chitedze Research Station, ICGV-SM 90704 had an average low rosette incidence of 2% compared to Chalimbana (81%) and CG7 (83%). In on-farm trials across 12 sites in 1995/96 in Malawi, the rosette incidence in ICGV-SM 90704 was 1% compared to 30% in Chalimbana and 18%. in CG7. The rosette incidence of ICGV-SM 90704 in on-farm trials in Uganda was 1% compared to 26% in Red Beauty.

Plant and seed characters

ICGV-SM 90704 has a semi-erect growth habit with alternate branching pattern; it has oval darker green leaves. The pods are moderately constricted with 1 to 2 tan colored seeds per pod. On average the shelling is 67% and the 100-seed mass is 40 g. Fresh seeds of ICGV-SM 90704 have dormancy of 3-4 weeks and contain 45-48% oil. The oleic acid to linoleic acid ratio is 1.5. ICGV-SM 90704 matures in 130-140 days after sowing depending on the locations in Malawi and 100-110 days after sowing in Uganda.

Seed availability

ICRISAT-Malawi maintains the breeder seed of ICGV-SM 90704. Limited quantities of seed without limitation on uses will be made available on request by signing a Material Transfer Agreement. Large quantities of basic seed are also produced for sale. Seeds of ICGV-SM 90704 are deposited with the Genebank, Genetic Resources

and Enhancement Program at ICRISAT, Patancheru, India.

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Registration of Groundnut Cultivar Sylvia (ICGV 93207)

L J Reddy[1], S N Nigam[1], P Subrahmanyam[2], F M Ismael[3], N Govinden[3], and P J A van der Merwe[2]
(1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India; 2. ICRISAT PO Box 1096, Lilongwe, Malawi; 3. Mauritius Sugar Industry Research Institute, Reduit, Mauritius)

Purpose of description

The Mauritius Sugar Industry Research Institute in 1998 released the groundnut (*Arachis hypogaea*) variety ICGV 93207 as Sylvia for commercial plantation in pure stand and in sugarcane (*Saccharum officinarum*) interrows in Mauritius (MSIRI 1998). Sylvia significantly outyielded the popular control cultivar Cabri by 38.8% with more stable yields than the control. It is adapted to all soils and regions in Mauritius where groundnut is grown. It is resistant to rust (caused by *Puccinia arachidis).*

Origin and development

ICGV 93207 is a high-yielding improved Spanish groundnut (*Arachis hypogaea* subsp. *fastigiata* var. *vulgaris)* genotype developed at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. It is derived from a cross between two advanced breeding lines, ICGV 86594 and ICGV 86672. ICGV 86594 is a derivative from a cross between NC Ac 1107 and a rust resistant genotype, NC Ac 17090; ICGV 86672 is a triple cross derivative of (JH 60 X PI 259747) X NC Ac 17133 (RF). JH 60 is a Virginia runner breeding line from Gujarat, India. PI 259787 is a landrace from Peru belonging to the botanical variety, *peruviana* and is resistant to rust and late leaf spot (caused by *Phaeoisariopsis personata)* (Subrahmanyam et al. 1995) and tolerant to drought (Reddy et al. 1994). NC Ac 17133 (RF) is a red flowered variant from NC Ac 17133, a landrace originally from Peru, belonging to the botanical variety *vulgaris* and resistant to rust (Subrahmanyam et al. 1995). ICGV 93207 was developed by repeated bulk selections for rust resistance and other agronomically desirable characters. Phenotypically similar F_2 plants with rust resistance and moderate to high pod yield were selected and bulked and advanced to higher generations. This process of bulking phenotypically similar plants was continued until the F_8 generation, when the bulk was phenotypically homogeneous. The full pedigree of ICGV 93207 is ICGV 86594 X ICGV 86672 F_2-B_1-B_1-B_3-B_1-B_1-B_1. It was evaluated at ICRISAT, Patancheru and in the southern and eastern Africa region, through the Southern African Development Community (SADC)/ ICRISAT Groundnut Project, Malawi.

Performance

In trials conducted during the 1993 rainy season at two locations on ICRISAT-Patancheru farm, ICGV 93207, with a mean pod yield of 1.75 t ha^{-1}, outyielded both the control cultivars JL 24 and ICGS 44 by 75% higher pod yields (Table 1). The haulm yield of ICGV 93207 was also higher than that of both the control cultivars. In the disease nurseries conducted during 1993/94 at Chitala, Malawi it outyielded the control cultivars, Malimba and JL 24. In the rust disease nursery, it gave a pod yield of 3.6 t ha^{-1} as compared to 1.3 t ha^{-1} of the best control, JL 24 (Table 2). In the late leaf spot nursery ICGV 93207 had a pod yield of 2.9 t ha^{-1} and outyielded both the local cultivar Malimba (1.3 t ha^{-1}) and improved variety JL 24 (2.1 t ha^{-1}). In 26 trials conducted during 1994-97 at different locations and seasons in Mauritius, ICGV 93207

had a mean pod yield of 3.86 t ha^{-1} and outyielded the local control cultivar Cabri (2.78 t ha^{-1}) (Table 3). Mean pod yield superiority of ICGV 93207 over Cabri in the 26 trials was 38.8%. From the stability analysis based on 23 trials conducted in Mauritius, Ismael and Govinden (1998) found ICGV 93207 more stable in its yield performance than Cabri.

Plant characters

ICGV 93207 is a Spanish variety with erect growth habit, sequential branching, oval and medium green leaves. It has 3 primary and 5 secondary branches. It matures in about 130 to 140 days depending on the location in Mauritius. At ICRISAT, Patancheru, it took 110-120 days from emergence to maturity during the rainy season and 130-135 days during the postrainy season. It has moderately reticulated pods with no constriction. The pods are one- to three-seeded with an average shelling of 68%. The seeds are tan with a 100-seed mass of 32 g. ICGV 93207 has higher proportion (65.8%) of seeds in Virginia medium and Spanish jumbo grades compared to that of Cabri (38.9%) (Ismael and Govinden 1998). In a consumers' survey, it was found to be as good as Cabri for salted nuts, boiled nuts, and roasted in-shell nuts (Govinden and Ismael 1997).

Table 1. Performance of ICGV 93207 and control cultivars at ICRISAT, Patancheru, India during 1993 rainy season.

	Pod yield[1] (t ha^{-1})			Haulm yield[2]	Disease score[1]						Jassid damage[4]
					Late leaf spot			Rust			
Variety	L1	L2	Mean	(t ha^{-1})	L1	L2	Mean	L1	L2	Mean	
ICGV 93207	1.6	1.9	1.75	2.4	7	6	6.5	3	5	4.0	5
Control											
JL 24	0.8	1.2	1.00	1.0	8	8	8.0	7	7	7.0	8
ICGS 44	0.7	1.3	1.00	0.9	8	7	7.5	7	7	7.0	8
SE±	0.13	0.14	0.28	0.2	0.3	0.2	0.2	0.6			
CV (%)	17	13	20	8	13	6	5	15			

1. L1 = Location 1: High fertility (60 kg P_2O, ha^{-1}; 400 kg gypsum ha^{-1}) field with supplemental irrigation and protection from insects
   L2 = Location 2: Low fertility (20 kg P_2O_5 ha^{-1}) rainfed field with no protection from insects.
2. At L1.
3. Scored on a 1-9 scale, where 1 = no disease; and 9 = 81-100% foliage damaged.
4. At L2; scored on a 1-9 scale, where 1 = no damage; and 9=81-100% foliage damaged.

Table 2. Performance of ICGV 93207 and control cultivars in the groundnut disease nursery at Chitala, Malawi, during 1993/94 crop season.

	Yield[1] (t ha^{-1})				Disease score[2]	
	Nursery 1		Nursery 2			
Variety	Pod	Seed	Pod	Seed	Rust	LLS
ICGV 93207	3.6	2.3	2.9	1.9	5	7
Control						
Malimba	0.7	0.5		0.8	9	8
JL 24	1.3	0.7	2.1	1.2	9	8
CG 7	0.9	0.6	3.9	1.8	9	7

1. Nursery 1 = Rust nursery; Nursery 2 = Late leaf spot (LLS) nursery.
2. Scored on a 1-9 scale, where 1 = no disease; and 9=81-100% foliage damaged

Table 3. Pod yield of groundnut cultivars ICGV 93207 (Sylvia) and Cabri in various trials conducted in Mauritius from 1994 to 1997.

Year	Season	No. of trials	Mean pod yield[1] (t ha^{-1}) ICGV 93207	Cabri
1994	Second season	1	4.20	2:72
1995	First season	2	2.04	1.18
1995	Second season	5	3.36	2.19.
1996	First season	4	2.35	1.87
1996	Second season	6	4.54	3.12
1997	First season	8	4.82	3.75
Overall mean (26 trials)			3.86	2.78
First season mean (14 trials)			3.71	2.85
Second season mean (12 trials)			4.02	2.70
LSD (0.05) First season			0.52	
LSD (0.05) Second season			0.66	

1. Pod yield at 8% moisture content.

Reaction to diseases and insect pests

In two trials conducted at ICRISAT, Patancheru, ICGV 93207 was rated a mean score of 4.0 for rust compared to a mean score of 7.0 for both the susceptible cultivars, JL 24 and ICGS 44 on a 1-9 disease rating scale (Table 1). For jassid or leaf hopper (*Empoasca kerri)* damage, ICGV 93207 was rated a score of 5.0 compared to 8.0 for JL 24 and ICGS 44 on a 1-9 scale (where 1 = no damage, and 9 = 81—100% foliage damaged). In the disease nurseries conducted at Chitala, Malawi, ICGV 93207 maintained its superiority over the local and improved cultivars for rust resistance (Table 2). In Mauritius, ICGV 93207 was much less susceptible to both rust and late leaf spot than the popular cultivar Cabri (MSIRI 1998).

Seed availability

The SADC/ICRISAT Groundnut Project, Malawi maintains the breeder seed of ICGV 93207. Seed of ICGV 93207 is also deposited with the ICRISAT Genebank, Patanacheru. Limited quantities of seed, without limitation on uses, will be made available on request and by signing a Material Transfer Agreement.

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PDKV Method of Own Seed Production of Groundnut

S N Deshmukh, G N Satpute, W M Dabre, and R G Deshmukh (Oilseed Research Unit, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola 444 104, Maharashtra, India)

In India, the area covered with newly released improved groundnut (*Arachis hypogaea*) varieties is very low. According to Rajan (1973), the saturation of area even with the early releases did not exceed 52% by 1973. The picture is not much different even today and the replacement rate of quality seed in groundnut is very low. It was only 1.7% in the early 1980s (Reddy 1985). The replacement situation since then has not improved. Production and distribution of high quality seed of groundnut has not caught up to the desired extent because of the low rate of multiplication and large financial investment required in procurement and distribution (Ramanamurthy et al. 1982). Therefore, at the Dr Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, India we formulated a simple method of groundnut seed multiplication (shown in Fig. 1) which can be adopted by the cultivators themselves on their own fields to meet their requirement of good quality seed of improved varieties. Continuous recycling and renovation of seed may take place on cultivators' own farms if they employ the PDKV method of own seed production of groundnut.

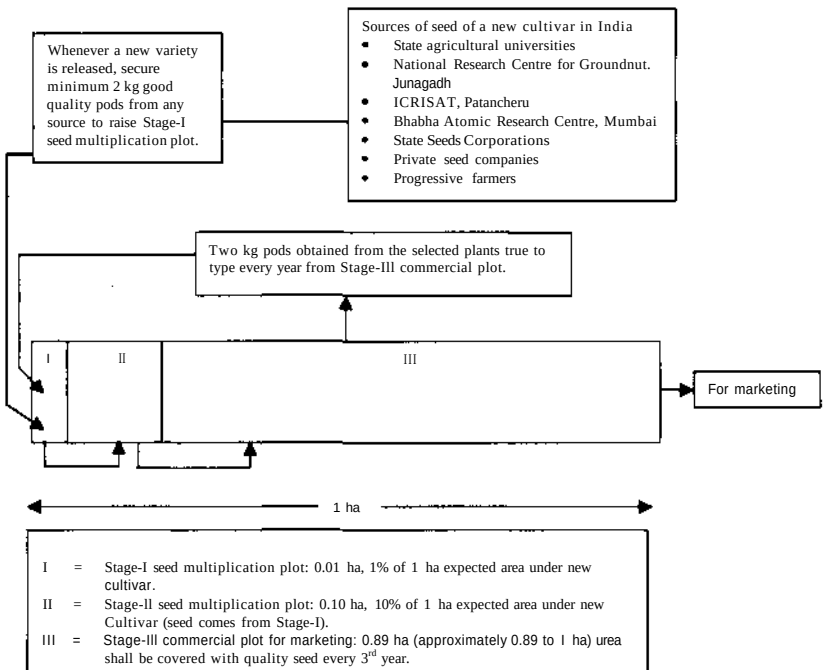

Figure 1. The PDKV method of own seed production of groundnut.

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Groundnut Seed Systems in Senegal and Niger

J Ndjeunga and B R Ntare (International Crops Research Institute for the Semi-Arid Tropics (ICR1SAT), BP 320, Bamako. Mali)

A number of groundnut *(Arachis hypogaea)* varieties have been released in both Niger and Senegal (Table 1). Recent studies in West and Central Africa have indicated that seed supply systems function poorly and therefore non-availability of seeds is a major constraint to adoption of new improved varieties. However, uptake of improved varieties and profitability of seed systems significantly differ from country to country, and according to crops.

Primary indicators of seed sector performance show that the seed sector in Senegal supplies comparatively more improved groundnut seed (28% of the total seed sown) compared to that in Niger (1%) (Table 2). The informal seed system in both these countries provides access to existing varieties by smallholder farmers. These systems supply most of the seed sown by farmers at low transaction costs and seed quality is apparently good. These systems could be strengthened by ensuring access to seed of new varieties, and possibly by improving seed flow from surplus to deficit regions after drought. Overall, adoption of improved seed by farmers is higher in Senegal than Niger. Also, seed is more efficiently produced in Senegal. There are several variables that explain the differences in seed sector performance. These include variety development and availability, seed multiplication, seed selection, storage, and seed stocks.

So far 13 groundnut varieties have been developed and released in Senegal. In Niger little emphasis was put on breeding but adaptation trials were conducted using varieties developed by the Institut de Recherche des Huiles et Oleagineux (IRHO). This led to the release of 9 varieties suitable to a range of agroecological zones. In Niger, only one groundnut variety 55-437 is widely grown while in Senegal several improved varieties are grown (Table 1).

Despite the large investments in seed multiplication and distribution projects in Niger, the formal system has consistently supplied a negligible share of total seed requirement (1%). In Senegal on the other hand, all

Table 1. Groundnut varieties released in Niger and Senegal.

Variety	Crop cycle (days)	Year of release	Institution
Niger			
55-437	90	1955	IRHO[1]
T-169-83	90	1977	IRHO
T-181-83	90	1977	IRHO
TS 32-1	90	1976	IRHO
796	90	1976	IRHO
KH 149-A	90	1973	IRHO
47-16	120	1977	IRHO
40-16	120	1940	IRHO
57-422	120	1957	IRHO
Senegal			
28-208	120	1928	IRHO
55-437	90	1955	IRHO
57-313	125	1957	IRHO
57-422	105-110	1957	IRHO
69-101	125	1969	IRHO
73-30	95	1973	IRHO
73-33	105-110	1973	IRHO
GH 119-20	110-120	1920	IRHO
73-27	120-125	1972	IRHO
756-A	125	1951	IRHO
73-28	120-125	1972	IRHO
Fleur 11	85	1988	ISRA[2]
GC 8-35	75-90	1989	ISRA

1. IRHO = Institut de Recherche des Huiles et Oleagineux.
2. ISRA = Institut Senegalais de Recherche Agricole.
Source: Ndjeunga et al. (2000).

improved groundnut varieties are multiplied and made available to farmers (28%). Overall the seed coverage for improved varieties is higher in Senegal, where the private sector such as Groupement d'Interel Economique (GIE) accounts for about 25% of the total improved groundnut seed produced (Table 3). Senegal is endowed with relatively well-developed seed distribution network than Niger. The informal seed trade is not clearly differentiated from the grain trade. In the informal seed sector, farmer-to-farmer seed exchange remains the main distribution channel.

Seed selection, storage, and quality play a significant role in the marketability of the product. Seed storage is a critical function due to perishability of groundnut seed. Inadequate seed storage results in losses of seed quality especially viability and germination rates and in higher operating costs for the seed enterprise. Results from a survey, however, indicated that performance of the seed systems in the two countries was not attributed to the quality of seed produced and distributed.

One significant difficult issue of seed systems has been on how to deal with seed security stocks. There is less incentive for private firms to maintain significant seed reserves to compensate for drought or other natural calamity, which greatly diminishes the availability of seed. Therefore, investments aimed at enhancing the capacity of local village seed systems to manage seed security stocks is warranted.

Table 2. Trends in commercialized production of groundnut seed in Niger and Senegal.

	Seed production (t)	
Year	Niger	Senegal
1990	0	10232
1991	22	16781
1992	0	15176
1993	0	22898
1994	313	11265
1995	52	9967
1996	0	6106
1997	6	15523
1998	0	na[1]
Average (1990-98)	44	15523
Average cultivated area (ha)	177526	831051
Expected national requirements' (t)	5918	27792
National government seed coverage (%)	1	55
Expected farmer seed needs (t)	4131	54353
Farmers' seed coverage[3] (%)	1	28

1. Data not available.
2. This is computed based on government recommended seeding renewal rate, while expected farmer seed needs is based on rate of market entry.
3. Average seed production/expected farmer seed need *x* 100.

Table 3. Proportion of groundnut seed sown (%) from various market sources in Niger and Senegal in 1996 and 1997.

	Niger		Senegal	
Seed source	1996	1997	1996	1997
Own stocks	89	82	54	36
Family and friends	3	4	0	1
Village markets	8	14	28	38
Formal sector	0	0	18	25

Source: Ndjeunga et al. (2000).

Conclusion

The informal seed systems still remain the main seed sources for almost all small-scale holder farmers in both Niger and Senegal. In both countries, these systems perform fairly well at supplying seed to end-users, distributing seed at relatively low cost, and maintain acceptable levels of seed viability and health. They are also able to maintain a wide access to a large range of improved varieties at low transaction cost. However, they have difficulty in meeting the needs of seed security stocks. Donors and government should invest more resources in enhancing capacity of the informal seed sector for managing seed security stocks, ensuring access to new varieties, and possibly improving seed flow from surplus to deficit regions after a poor harvest.

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A New Method for Drying Groundnut Pods for Better Seed Storability

P C Nautiyal[1], V Ravindra[1,2], and P V Zala[1]
(1. National Research Centre for Groundnut, Junagadh 362 001, Gujarat, India; 2. Present address: Indian Institute of Horticultural Research, PO Hassergatta Lake, Bangalore 560 089, Karnataka, India)

Groundnut *(Arachis hypogaea)* seed loses viability rapidly during storage. The problem of loss of viability is more serious in groundnut produced in the rabi (postrainy) season or summer crop season and about 50% viability could be lost within 4-5 months of storage in such produce (Nautiyal et al. 1990). High pod-temperatures and untimely rains during curing affect the seed quality and storability of the summer groundnut (Nautiyal and Zala 1991). Therefore, a simple, suitable, and economic drying method was developed at the National Research Centre for Groundnut (NRCG), Junagadh, Gujarat, India to avoid the exposure of pods to direct sunlight and untimely rains, while drying in the field.

Methodology

Experiments were initiated at NRCG during the summer crop season (February to June) of 1995 and 1996 to develop a simple and economic drying technology for use by farmers. Detailed trials were conducted during three summer seasons (1998, 1999, and 2000) to compare the NRCG method with three other drying methods: (1) DOR (Directorate of Oilseeds Research) method, (2) windrows, and (3) conventional heap method. Cultivar GG 2 (spanish bunch, *A. hypogaea* subsp. *fastigiata* var. *vulgaris)* with no fresh-seed dormancy was used. Immediately after harvest, plants along with the pods were kept for drying using the methods described below.

NRCG-met hod

In this method a tripod type structure (pyramid shape) was raised in the field with three bamboo poles, each about 1.5 m long (Fig. 1). A coir rope was wound around the structure starting from the bottom to the top, while maintaining a space of 15-20 cm between two loops. Immediately after harvest groundnut plants were placed on the rope of the structure with pods up and haulms hanging down. The structure was filled with groundnut plants so that the haulm of an upper ring covered the pods of the lower ring thus forming a sloping structure like the roof of a thatched house (Fig. 1). The plants

Figure 1. The NRCG method of drying groundnut pods: (top) tripod bamboo structure; and (bottom) groundnut plants arranged within the structure in inverted position.

were arranged bottom ring upwards. Groundnut pods along with the plants were allowed to dry in the bamboo structure in the field for five days,

DOR method

In the DOR method (DOR 1983) plants were tied in bundles of about 0.5 m in diameter. The bundles were then kept for drying in pairs in such a way that one bundle from each pair was placed in the field upside down and the other upright on top of the former. Thus the haulms of the upper bundle shaded the exposed pods of the inverted lower bundle from direct sunlight. Each evening the upper heap was removed and the pods in both the bundles were exposed. The heaps were returned to the inverted position the next morning. This practice was repeated for five days.

Windrows method

Plants were uprooted and left in single rows in flat position in the field for drying for five days under direct sunlight.

Conventional heap method

Groundnut pods were dried using the conventional heap method followed in the Saurastra region of Gujarat and in some other parts of India. In this method plants after harvest were heaped in a circle, about 1.5 m in diameter and 0.75 m in height for five days.

During 1998 and 1999 the crop was dried following the four methods. In 1998, however, the crop was dried in two sets. The first set was arranged on 1 June 1998 and the four drying methods were tested. The second set was arranged on 6 June 1998, where pods were dried following only the NRCG and DOR methods, and the performance of these two methods in the situation when curing/drying encounters rains was compared. The second set experienced rains on the 4^{th} day and 5^{th} day of drying in the field.

After drying for five days, the pods were picked by hand. The pods were placed as a thin layer and sundried to moisture content of 5-6.5% in 1998 and 8.7-9.5% in 1999. Pods after drying in thin layer for two to three days were packed in 10 kg capacity polyethylene-lined (0.1 mm thick) gunny bags and were stored at ambient conditions for 9 months. Germination studies were conducted before and after storage in an incubator at 30°C in rolled germination papers (between substrate). After seven days of incubation germination percentage was calculated following the rules of the International Seed Testing Association (ISTA, 1993). Root length of 10 randomly selected seedlings from each replication was measured. Seedling vigor index (SVI) was calculated following the formula given by Abdul-Baki and Anderson (1973):

SVI = germination percentage x mean root length

Seed leachate was collected by soaking five seeds in 25 ml of double distilled water for 18 h at 27°C in an incubator and electrical conductivity (EC) of seed leachate was measured. Pod moisture was calculated gravimetrically and expressed on wet weight basis.

Results and discussion

Weather during the drying period at the experimental site

Weather remained quite dry during the drying period of the first set in summer 1998. The maximum and minimum temperatures were about 39°C and 27°C, respectively. The mean atmospheric relative humidity (RH) during the morning and afternoon was 85% and 54%, respectively. There was no rainfall during the drying period; however, rainfall of about 15.8 mm was recorded after storage of the pods. Sunshine was about 9-10 h, average pan evaporation was 10 mm day^{-1}, and wind velocity was 13.0 km h^{-1} (Fig 2a). In the second set, pods experienced 15.2 mm of rain on the 4^{th} day and 16.0 mm on the 5^{th} day of drying. When the second set was being dried, the relative humidity during the morning and evening hours was around 90% and 63%, respectively. Thus the atmospheric RH during drying period was higher in second set than in the first set (Fig 2b). The weather during 1999 drying period (Fig. 2c) was humid (average RH 92%) mainly during the thin-layer drying and the mean RH during the field drying was 84% in the morning hours and 54% in the afternoon hours. Sunshine, however, was low (0-5 h) and average wind velocity was around 10.5 km h^{-1}. Thus the air temperatures, RH, sunshine hours, and wind velocity during drying period in two summer crop seasons and two drying sets in 1998 season were quite distinct.

Loss of moisture from the pods during drying

In both the years the pod moisture contents after five days of drying were in the following decreasing order, NRCG method (13.6 and 16.9), conventional heap method (9.1 and 14.6), DOR method (8.5 and 15.4), and windrows method (5.4 and 9.2) (Table 1). The impact of drying methods on the storability also followed the same order (Table 2). Pod moisture at the time of harvest generally remained at 30-45%. During drying, after moisture

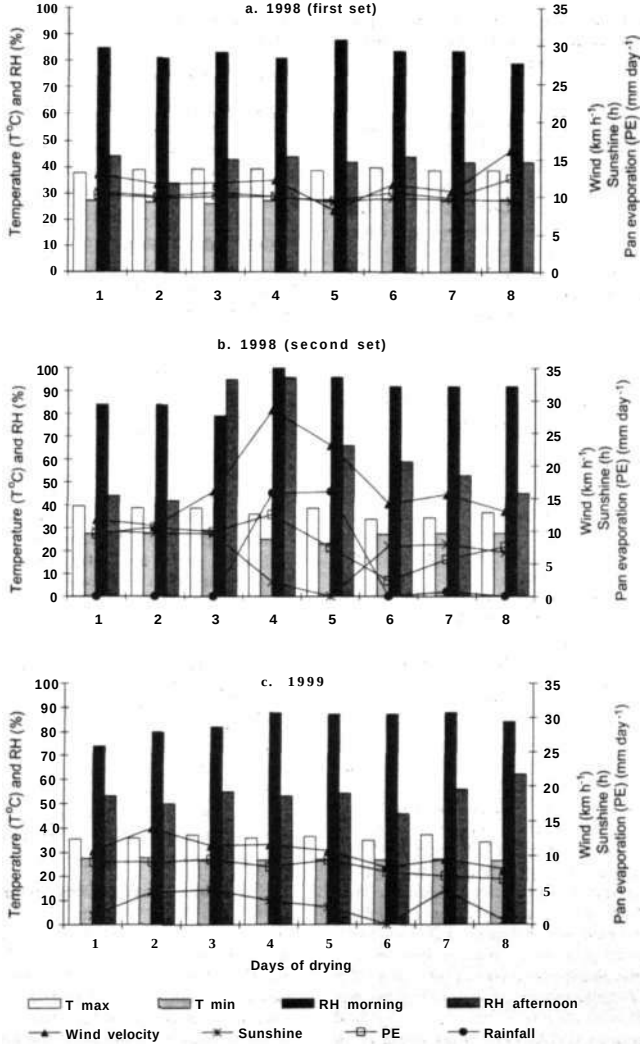

Figure 2. Weather during the drying period of groundnut in 1998 and 1999 at Junagadh, India.

Table 1. Moisture content (%) of groundnut pods during the drying process by four methods in 1998 and 1999 summer crop season[1].

Days of drying	NRCG method	DOR method	Windrows method	Conventional heap method
1998				
0	43.0 (44.3)[2]	43.7 (44.0)[2]	41.5	42.5
1	35.2 (40.2)	36.9 (41.1)	22.7	32.4
2	28.2 (35.4)	20.7 (37.5)	11.6	24.6
3	19.5 (27.1)	16.4 (30.5)	6.7	16.0
4	15.5 (22.2)	11.4(25.1)	5.5	13.5
5	13.6 (17.1)	8.5 (19.8)	5.4	9.1
At storage	5.9	6.1	5.3	5.9
1999				
0	46.4	43.9	43.8	43.8
1	39.3	41.0	34.2	39.0
2	33.7	31.3	25.9	33.8
3	22.3	21.9	13.0	21.0
4	18.9	17.1	9.7	17.1
5	16.9	15.4	9.2	14.6
At storage	9.4	9.4	8.8	10.0

1. The standard error (SE) is ± 0.89 for 1998 data and ±0.68 for 1999 data.
2. Figures in parentheses are values of pod moisture content (%) during drying in the second set (1998).

Table 2. Germination percentage and seedling vigor index (SVI) of the seeds obtained from groundnut pods dried by four methods in 1998 and 1999 summer crop season immediately after drying (0 months) and after 9 months of storage.

	Germination (%)		Seedling vigor index (SVI)		Electrical conductivity of seed leachate (µs g^{-1})	
Drying method	0	9	0	9	0	9
1998 (first set)						
NRCG	98	82	1101	548	0.031	0.070
DOR	93	66	863	450	0.032	0.099
Windrows	74	19	574	73	0.070	0.163
Conventional heap	94	59	865	327	0.038	0.105
SE±	3.18		39,13		0.005	
1998 (second set)						
NRCG	91	81	936	686	0.031	0.085
DOR	92	49	728	271	0.052	0.107
SE±	4.10		44.2		0.007	
1999						
NRCG	95	52	1037	293	0.041	0.146
DOR		42	985	185	0.043	0.158
Windrows	75	10	628	28	0.114	0.307
Conventional heap	96	35	882	132	0.072	0.180
SE±	2.47		34.96		0.009	

equalization between the seed and hull, the moisture content of the seed should reach a safe storage level of 7-8%. For marketing, the desired moisture content of shelled groundnuts is about 7.5%.

Since, the temperatures and relative humidity in two drying seasons were distinct, the rate of loss of moisture from the pods in different drying methods in two summer seasons were also distinct. In the 1999 drying season, due to high RH and low sunshine, pod moisture after five days of drying was higher (9.2-16.9%) in the four methods than that recorded in the first set in 1998 (5.4-13.6%). In ail four methods maximum loss of moisture from the pods was recorded on 3rd day of drying in both the years. Storability as marked by germination (%) after five days of drying of the seeds in 1998 was higher than in 1999 (Table 2). Thus pod moisture at the time of storage played an important role in determining the storability. Pod-temperature was also highest in the windrows method (maximum temperature around 45°C), and the lowest in the NRCG method (maximum temperature around 38°C). Higher temperatures of the pods in windrows method might have created steep moisture gradient in the seed. Based on our experiments in controlled conditions, groundnut pods dried above 40°C lose viability rapidly during storage. The suitable RH recommended in the literature for drying groundnut pods is 40-65%.

Electrical conductivity of seed leachate

Electrical conductivity of the seed leachate showed interesting results. The values of EC of seed leachate collected immediately after drying and after nine months of storage were higher in the seed obtained from the pods dried by windrows method (Table 2). The EC values of seed leachate were in general higher in 1999 than in 1998 (first set). During 1998, RH ranged between 34% and 84% in the first set, and between 60% and 90% in the second set, whereas in 1999 it ranged between 50% and 88%. Thus the prevailing weather conditions during different drying periods influenced the rate of loss of moisture from the pods, which in turn affected the seed membrane integrity (as reflected by the EC values). Similarly, slow drying in NRCG and DOR methods helped in maintaining membrane integrity. Inverse correlation between EC of the seed leachate and germination percentage has been reported in groundnut (Nautiyal and Zala 1991); the relationship in this study is also similar.

Loss of seed germinability appeared to be clearly related to the pod-temperatures during drying, especially during the first three days after digging. High rate of loss of water from the pods caused a steep moisture gradient in seed tissue, which resulted in mechanical stress and damaged seed tissue.

Seed storability

Germination studies showed that drying methods significantly influenced the storability (Table 2). Germination percentage of the seed obtained from the pods dried following the windrows method was lower than in the seed obtained from the pods dried following the DOR and the NRCG methods. Higher germination percentage in the DOR and the NRCG methods might be ascribed to the lesser pod-temperatures (around 38°C) during curing, as pods in these two drying methods were protected from direct sunlight. However, in the DOR method some peripheral pods remained exposed to sunlight resulting in 2-3°C higher temperatures than in the central pods. All the pods were covered in the NRCG method resulting in better seed germinability.

Seed quality

During summer 2000, the NRCG technology was demonstrated in farmer's fields. Pods experienced rains on 3rd day and 4th day of drying. After rains, a congenial environment for seed germination existed, and pods dried in windrows showed in situ sprouting. The quality of seed, mainly the brightness of the testa, was the best in the seed obtained from the pods dried following NRCG method than the other drying methods (data not presented). Other biochemical constituents such as sugars, proteins, and lipid composition are being analyzed.

Conclusions

The NRCG method of drying pods protects the pods from direct sunlight and rains. Seed obtained from these pods during the two summer crop seasons in 1998 and 1999 were able to maintain higher seed germinability and seedling vigor than the windrows, conventional heap, and DOR drying methods. Superiority in maintaining better seed germinability by the NRCG method was mainly due to its advantage in protecting the pods from direct sunlight. In addition the pyramid-shaped

structure with plants arranged like a thatched house allowed the rainwater to run-off quickly, which otherwise would have accumulated on the pods, and such situation prevailed during the drying in the second set in 1998. Further, the drying method does not call for any special skill in making the drying structures, and the cost involved in raising the structures is also low (Rs 200 or US$ 4.2 approx. for drying of 100 kg pods), and the same poles can be used year after year. The technology may be a boon to the small farmers, particularly those cultivating summer groundnut. Due to improper drying methodology and poor storage conditions the farmers are deprived of a chance to store their own quality produce for sowing in the next summer season. The NRCG method showed its superiority in terms of retention of seed viability and seed quality, over the other three drying methods, more specifically when pods experienced rain while drying in the field.

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Biotechnology

Molecular Diversity in *Trichoderma* Isolates with Potential for Biocontrol of *Aspergillus flavus* Infection in Groundnut

V Anjaiah, R P Thakur, and V P Rao (International Crops Research Institute for the Semi-Arid Tropics (ICR1SAT), Patancheru 502 324, Andhra Pradesh, India)

The species of the genus *Trichoderma* are known to be potential biocontrol agents for several soilborne plant pathogens (Papavizas 1985). During the past two years we have identified several *Trichoderma* isolates that have shown strong antagonism to *Aspergillus flavus* infecting groundnut *(Arachis hypogaea)* and some of these isolates have been used as potential biocontrol agents in greenhouse and field experiments (Desai et al. 2000, Anjaiah el al., in press). One of the mechanisms of biocontrol of plant pathogens with *Trichoderma* is known as mycoparasitism where *Trichoderma* recognizes and attaches to the pathogenic fungus and begins to excrete extracellular hydrolytic enzymes, such as chitinases, ß-1,3-glucanses, proteases, and lipases. These enzymes act on the cell walls of the fungi and thus cause lysis. *Trichoderma* spp are difficult to distinguish morphologically (Bissett 1991), and it is not yet well known whether the ability for biocontrol is a general property of the genus *Trichoderma* or a specific attribute of some species only. The molecular diversity among the species will help in characterizing the isolates for different modes of biocontrol ability and their deployment for effective control of plant pathogens. Using random amplified polymorphic DNA (RAPD) fingerprinting we studied genetic diversity in 17 *Trichoderma* isolates belonging to different species used in biocontrol of *A. flavus* infection in groundnut. The in vitro antagonistic characteristics of these isolates were reported earlier (Desai et al. 2000).

Genomic DNA was isolated from 17 selected isolates of *Trichoderma* species belonging to five species aggregates, *viride, hamatum, harzianum, auroviride,* and *longihrachiatum* (Desai et al. 2000) using the method described by Arisan-Atac et al. (1995). RAPD fingerprinting analysis was performed using three primers (GAGGTGGNGGNTCT, $[GACA]_4$, and $[GAG]_3$). All three primers led to the amplification of 6-10 fragments. A dendrogram (Fig. 1) based on average linkage cluster analysis, using Jaccard test was prepared using the

combined data from all three primers for the 17 isolates. The results indicated that the 17 *Trichoderma* isolates could be broadly classified into two groups. All *T. harzianum* isolates were classified into group I, and others in group II. In group I, there were minor variations, which could be related to the source of origin from different climatic zones. There were 3 subgroups in group II. Subgroup I: *T.auroviride* (T 18 Udaipur), which was different from *T.hamatum* and *T.viride.* Subgroup II: *T. hamatum* (T 5 and T 6 NRCG), *Trichoderma* spp (T 10 NRCG), *T.viride* (T 25 ICRISAT, T 17 Udaipur, and T 27 NARDI), and *T. longihrachiatum* (T 16 Udaipur). Subgroup III: *T. viride* (T 20 and T 22 Akola). It was interesting to note that all *T.hamatum* isolates were similar to *T.viride* isolates; however, *T.auroviride* (T 18) was different from others.

Molecular analysis of genomic DNA from these *Trichoderma* isolates also revealed the presence of chitinase gene in polymerase chain reaction (PCR) using primers designed in the conserved regions of the gene that often contributed to the biocontrol ability (data not shown). Some of these *Trichoderma* isolates were shown to be effective not only for reduction of seed and peg infection by *A. flavus* but also reduced *A. flavus* population in the rhizosphere of groundnut (data not shown). Selected *Trichoderma* isolates from this study are being used in field experiments to evaluate their biocontrol potential against aflatoxin contamination in groundnut. Strain typing by RAPD fingerprinting offers a quick and convenient method for screening a large number of isolates for their biocontrol potential against *A. flavus.*

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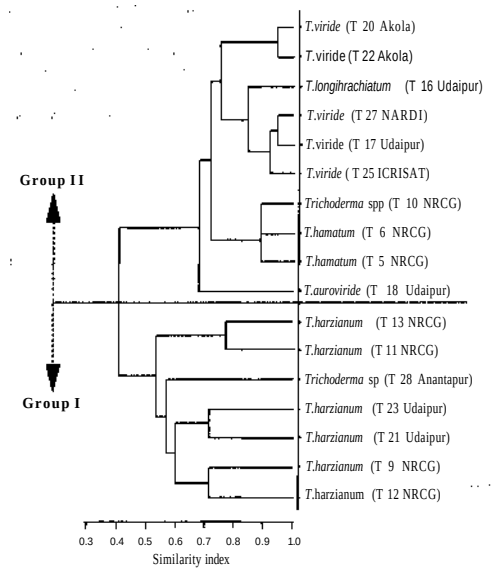

Figure 1. Dendrogram showing relative genetic similarities between strains and species of *Trichoderma,* calculated from a RAPD fingerprinting-[0/l]-data matrix including all three primers by average linkage cluster analysis using GENSTAT software.

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Pathology

Control of Foliar Diseases of Groundnut Using Inorganic and Metal Salts

G Krishna Kishore[1], S Pande[2], and J Narayana Rao[2]
(1. Department of Plant Sciences, University of Hyderabad, Hyderabad 500 046, Andhra Pradesh, India; 2. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh. India)

Late leaf spot (LLS) caused by *Phaeoisariopsis personata* and rust caused by *Puccinia arachidis* are the two major foliar diseases of groundnut (*Arachis hypogaea*) which usually occur together and significantly reduce the crop yield (Subrahmanyam et al. 1995). Desirable levels of host plant resistance against these two diseases are not available in cultivars commonly grown by farmers. Fungicidal control of LLS and rust is expensive and requires alternative strategies for management of these destructive diseases. Several inorganic and metal salts possess antifungal activity and control pre-harvest and postharvest diseases caused by pathogenic fungi (Reuveni et al. 1995, Olivier et al. 1998). These chemicals were also proved to elicit the plant defense mechanisms against invasion of pathogenic fungi (Gamil 1995). We studied the effects of 33 inorganic and metal salts on the germination of conidia of *P.personata* and urediniosporcs of *P. arachidis* under in vitro conditions and the efficacy of selected salts to reduce the incidence of LLS and rust in detached leaf bioassay.

In vitro antimicrobial assay

Inorganic and metal salts at a final concentration of 10^{-2} M and 10^{-3} M were evaluated for their inhibitory effects on germination of *P.personata* conidia and *P.arachidis* urediniospores. Conidia and urediniosporcs were taken separately onto cavity slides and mixed with respective salt solutions. The final concentration of conidia and urediniosporcs was 30,000 ml^{-1}. Conidia and urediniospores suspended in sterile double distilled water were treated as controls. Three replications were maintained for each treatment and the experiment was repeated once. The slides were incubated in a humid chamber at 23±1°C in dark. Conidia and urediniospores were observed for germination at 24 h and 8 h after incubation, respectively. In each replication, one hundred spores were observed randomly for germination and the percentage inhibition with respect to control was calculated separately for each treatment. The differences between the percentage inhibition values in two sets of experiments were not significant and hence were pooled and subjected to analysis of variance.

Of the 33 salts tested, chromium trioxide, cupric sulfate, ferric chloride, nickel chloride, and zinc chloride at 10^{-3} M concentration had significant inhibitory activity (P=0.01) against both *P.personata* and *P.arachidis.* At the same concentration sodium carbonate and sodium molybdate were effective against *P.personata* alone, and ammonium dihydrogen orthophosphate and cobalt chloride were effective against *P.arachidis* alone. Ammonium fluoride, ammonium sulfate, ammonium tartrate, borax, calcium chloride, calcium sulfate, magnesium chloride, magnesium nitrate, sodium carbonate, sodium citrate, sodium fluoride, and sodium phosphate were inhibitory to both the test fungi, only at 10^{-2} M concentration (Table 1).

Detached leaf bioassay

Chromium trioxide, cupric sulfate, ferric chloride, nickel chloride, and zinc chloride at 10^{-3} M concentration were tested to control the development of LLS and rust on detached groundnut leaves of the susceptible genotype TMV 2 (Subrahmanyam et al. 1983). Cultures of *P.personata* and *P.arachidis* were maintained on detached leaves of genotype TMV 2.

Conidia and urediniospores suspended in sterile double distilled water at a concentration of 20,000 ml^{-1}

Table 1. Percentage inhibition of in vitro germination of conidia of *Phaeoisariopsis personata* and urediniospores of *Puccinia arachidis* by various inorganic and metal salts at 10^{-2} and 10^{-3} M concentrations[1].

	Inhibition of germination (%)			
	P.personata		*P.arachidis*	
Inorganic or metal salt	10^{-2} M	10^{-3} M	10^{-2} M	10^{-3} M
Ammonium chloride	26.9	16.2	89.2	8.2
Ammonium dihydrogen orthophosphate	46.9	22.5	91.8	53.2
Ammonium fluoride	96.1	45 2	100.0	32.0
Ammonium nitrate	39.0	37.7	90.3	36.7
Ammonium sulfate	57.1	20.6	96.1	42.4
Ammonium tartrate	82.1	23.2	99.1	17.2
Barium chloride	46.8	17.5	17.4	13.6
Borax	100.0	44.9	100.0	-7.8
Calcium chloride	53.9	22.0	52.9	32.7
Calcium sulfate	47.8	20.4	58.3	24.1
Chromium trioxide	100.0	100.0	99.6	100.0
Cobalt chloride	100.0	386	100.0	100.0
Cupric sulfate	100.0	99.4	100.0	100.0
Ferric chloride	100.0	100.0	100.0	100.0
Magnesium chloride	69.8	40.2	75.9	-12.1
Magnesium nitrate	79.6	12.0	53.8	9.4
Magnesium sulfate	62.6	12.1	0.8	-10.0
Manganese chloride	89.6	45.3	41.2	31.2
Nickel chloride	99.4	987	100.0	99.1
Potassium carbonate	68.5	20.5	21.1	-0.3
Potassium chloride	47.0	273	16.2	-1.8
Potassium hydrogen phosphate	45.6	19.6	39.8	20.5
Potassium hydroxide	36.7	9.8	21.7	-21.9
Potassium nitrate	21.6	18.8	27.8	-3.1
Potassium sulfate	38.5	-9.3	50.8	-21.6
Sodium acetate	46.9	20.3	43.4	30.0
Sodium carbonate	84.2	51.3	67.4	-18.5
Sodium chloride	42.9	24.5	33.9	23.8
Sodium citrate	98.7	45.5	96.8	18.7
Sodium fluoride	61.6	35.0	61.8	41.0
Sodium molybdale	88.3	72.7	21.7	13.0
Sodium phosphate	66.2	9.6	64.0	34.0
Zinc chloride	100.0	84.5	99.0	76.2
Control	0	00		0
LSD (*P* = 0.01)	45.7		50.1	
CV (%)	33.4		37.2	

1. Data are means of six replications in two sets of experiments.

were used as inoculum. The salt solutions were sprayed onto the leaves at 24 h before pathogen inoculation and leaves sprayed with sterile double distilled water were treated as controls. Each replication consisted of ten detached leaves; three replications were maintained for each treatment and the experiment was repeated once. The lesion frequency (number of lesions cm^{-2} leaf area) was measured at 15 days after pathogen inoculation, both for *P. personata* and *P. arachidis* inoculated leaves.

None of the salts used in detached leaf bioassay were toxic to groundnut leaves. All the five salts tested significantly reduced the lesion frequency of both LLS and rust, when compared to control. Cupric sulfate and nickel chloride were effective in controlling both LLS and rust when compared to other salts (Table 2). Copper containing fungicides have been widely used against various pathogens. Nickel nitrate was effective in control of bacterial blight of rice (*Oryza sativa*) (Chandrasekaran and Vidhyasekaran 1988). These metal salts when used in combination with other fungicides or plant extracts may further enhance their disease control ability. The addition of iron to copper compounds enhanced the toxicity of copper compounds to the walnut blight pathogen *Xanthomonas campestris* pv. *juglandis,* as iron altered the physiology of the bacterium and increased the amount of free copper ions by reducing the pH (Lee et al. 1993). The efficacy of these metal salts to control LLS and rust is being verified under greenhouse and field conditions.

Table 2. Effect of metal salts at 10^{-3} M concentration on the development of late leaf spot (LLS) and rust on detached groundnut leaves as measured by lesion frequency at 15 days after pathogen inoculation[1].

	Lesion frequency (number of lesions cm^{-2} leaf area)	
Metal salt	LLS	Rust
Chromium trioxide	2.1	4.4
Cupric sulfate	1.4	3.3
Ferric chloride	2.2	5.6
Nickel chloride	1.6	3.9
Zinc chloride	2.3	4.9
Control	3.7	9.6
LSD (*P* = 0.01)	0.42	1.02
CV (%)	15.8	12.1

1. Data are means of six replications in two sets of experiments

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Groundnut Crop Loss by Pod Rot

G March[1], A Marinelli[2], C Oddino[3], M Kearney[3], S Pastor[1], S Vargas Gil', J Giuggia[2], D Remedi[2], and C Justianovich[2] (1. Institute do Fitopatologia y Fisiologia Vegetal-INTA, Cno. 60 Cuadras, km $5^1/_2$, 5119 Cordoba, Argentina; 2. Fac. Agronomia y Veterinaria, Universidad Nacional de Rio Cuarto, C6rdoba, Argentina; 3. Agencio C6rdoba Ciencia, Argentina)

Argentina is one of the largest exporters of groundnut *(Arachis hypogaea)* in the world. Since early 1990s soil-borne pathogens have become a serious problem to groundnut production. Pod rots can be a limiting factor of groundnut production (Csinos and Bell 1989). Yield losses caused by soilborne fungi such as *Sclerotinia minor, S. sclerotiorum,* and *Sclerotium rolfsii* ranged from 30 to 870 kg ha^{-1} (Marinelli et al. 1998). Groundnut pods develop below ground in close contact with soil microorganisms A number of soilborne fungi have been noted infecting pegs and pods, causing substantial pod loss during digging and drying. Several surveys have been conducted to identify fungi associated with pod rots. However, estimates of crop losses in commercial fields have been made to a limited extent.

To estimate pod rot losses, 30 groundnut fields located in the southern production region in the province of Cordoba in Argentina were selected. Majority of these fields were sown with groundnut once every two years in the past 10 years. Twenty samples were taken at uniform intervals along a diagonal. Each sample site was located at each five inverted windrows. Windrows were performed by plants lifted from four rows for the digger-shaker-inverter. The sample consisted of pods removed by hand from the surface soil within a wire ring of 500 cm^2, 3-5 days after harvest. Seeds were inspected for damage; then, damaged and non-damaged seeds were weighed, and losses estimated.

One hundred pods from each field were washed with tap water and sterilized for three minutes in sodium hypochlorite (1%). The pods were then rinsed in sterile water, transferred to petri dishes containing potato-dextrose agar medium (1%), and incubated at 25"C. The plates were observed at 6-7 days after incubation.

Seeds damaged by fungi and left on the soil ranged from 105 to 960 kg ha^{-1} (average: 462 kg ha^{-1}; 63%) and non-damaged seeds ranged from 105 to 621 kg ha^{-1} (average: 277 kg ha^{-1}; 27%) (Table 1). The average crop loss was 739 kg ha^{-1}. Furthermore, fungi were recovered from 100% of the pods, with *Fusarium* spp, *Penicillium* spp, and *Rhizopus* spp being most prevalent. *Alternariu* spp, *Aspergillus niger, Botryiis cinerea, Cladosporium* spp, *Epicoccum* spp, *Gliocladium* spp, *Macrophomina phaseoima, Papularia* spp, *Phomopsis* spp, *Pythium irregulare, P. myriotilium, Pythium* sp, *Rhizoctonia solani, Sclerotinia sclerotiorum, Sclerotium rolfsii,* and *Trichoderma* spp were isolated less frequently.

A lot of groundnut seeds may be left in the soil at harvest. Besides the crop losses, the pods that remain in the soil could provide a large reservoir of inoculum.

Table 1. Groundnut seeds (kg ha^{-1}) left in the soil in Cordoba, Argentina after harvest in 2000.

Field	DS[1]	NDS[2]	Total
1	563 (80)	141	704
2	535 (69)	244	779
3	539 (70)	233	772
4	348 (62)	217	565
5	443 (70)	188	631
6	281 (66)	144	425
7	515 (72)	201	716
8	589 (73)	217	806
9	358 (52)	325	683
10	428 (70)	185	613
11	393 (61)	248	641
12	439 (52)	413	852
13	427 (53)	372	799
14	722 (54)	617	1339
15	377 (45)	458	835
16	569 (48)	621	1190
17	105 (50)	105	210
18	441 (64)	243	684
19	262 (59)	184	446
20	960 (65)	511	1471
21	510 (53)	444	954
22	606 (82)	136	742
23	307 (67)	149	456
24	453 (76)	141	594
25	581 (71)	232	813
26	296 (61)	190	486
27	513 (75)	168	681
28	505 (73)	189	694
29	307 (58)	226	533
30	487 (46)	568	1055

1. DS = Damaged seed.
   Percentage DS values are given in parentheses.
2. NDS = Non-damaged seed.

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Prevalence of Aflatoxin Contamination in Groundnut in Tumkur District of Karnataka, India

K Vijay Krishna Kumar', R P Thakur[1], and S Desai[2]
(1. International Crops Research Institute for the Semi-Arid Tropics (ICR1SAT), Patancheru 502 324, Andhra Pradesh, India; 2. National Research Centre for Groundnut (NRCG), lvnagar Road, PB No. 5. Junagadh 362 001, Gujarat, India)

Aflatoxin contamination in groundnut *(Arachis hypogaea)* is a serious problem worldwide affecting trade and human health. Contamination of groundnut seed occurs in the field, during transportation, and in storage by *Aspergillus flavus* group of fungi. Abiotic stresses, such as end-season drought, improper drying, and moist storage conditions form the major predisposing factors for infection of groundnut seed by *A. flavus.* The National Agricultural Technology Project (NATP) "Aflatoxin contamination in groundnut: mapping and management in Gujarat, Andhra Pradesh, and adjoining areas" was launched in August 2000 in collaboration with the National Research Centre for Groundnut (NRCG) (Junagadh, Gujarat), ICRISAT (Patancheru), and the Gujarat Agricultural University to assess the extent of awareness among farmers, traders, and oil producers about aflatoxin and its associated problems, to assess the extent of pre- and postharvest aflatoxin contamination in the target districts, to determine the influence of on- and off-farm practices on the toxin contamination, and finally to evolve an integrated management strategy for combating the problem. The study reported here is a part of this project in Tumkur district of Karnataka, India.

Awareness among farmers

To assess the problem of aflatoxin awareness among farmers, traders, and oil millers, a survey was conducted at the end of the rainy season in 2000 across the four major groundnut-growing taluks of Tumkur district: Koratagere, Madhugiri, Pavagada, and Sira. Information was obtained by closely interacting with 137 farmers on the crop details, on- and off-farm practices, socioeconomic aspects of groundnut cultivation, problematic pests and diseases, and awareness on aflatoxin contamination. The survey results revealed that farmers were ignorant of the aflatoxin problem. Many farmers opined that the lack of visual indication on the seed was the major factor for their being unaware about aflatoxin contaminated seeds. *Helicoverpa armigera,* white grubs, and leaf spots were the major production constraints. Farmers thought that end-season drought was a major factor for reduced yields and bitterness in seeds. It is known that any delay in harvesting the crop under end-season drought could severely reduce yields and increase aflatoxin contamination.

Pod and soil sampling

A stratified sampling method was followed to collect one sample representing 800-1000 ha of groundnut-growing area. We collected 137 pod samples (1 kg pods per sample) and 133 soil samples from the estimated 80,000 ha groundnut area in Tumkur district during the 2000 rainy season crop.

Pod samples were collected randomly from 5 spots in each field from the mature/harvested plants in the field and bulked. The soil in the geocarposphere region from the same spots was collected and pooled to make a bulk sample (250 g per sample).

Analysis for seed infection and soil population of *A. flavus*

Pods were shelled and the seeds were surface sterilized before plating them on Czapek Dox agar (CDA) fortified with rose bengal, and incubated at 25°C for 4 days in dark for determining seed infection. For each sample, 100 apparently healthy seeds were used. Number of seeds colonized by typical *A. flavus* was counted and percentage seed infection determined. Soil samples were sieved to fine powder and serially diluted in sterilized distilled water to $10^{-3}$and 10^{-4} concentrations and plated on AFPA (*Aspergillus flavus* and *parasiticus* agar) medium (Pitt et at. 1983). The plates were incubated for two days

at 28°C in dark and typical *A.flavus* colonies were counted and population density determined as colony forming units (cfu) g^{-1} of soil.

Seed infection studies revealed that of the 137 samples, 39 had no infection, 64 had 1-5% infection, 10 had 6-10% infection, and 24 had more than 10% seed infection (Fig. 1). The results of soil analysis revealed that of the 133 samples, only 31 were free from *A.flavus* propagules, 75 samples had 1 x 10^3 to 5 x 10^3 cfu g^{-1} soil, 14 had 6 x 10^3 to 10 x 10^3 cfu g^{-1}, and 13 had more than 10,000 cfu g^{-1} soil (Fig. 1).

In general, there was no clear correlation between *A. flavus* soil population density and seed infection among samples from each taluk. However, in six villages of three taluks, there was good correlation between *A. flavus* soil populations (6 x 10^3 to 44 x 10^3 cfu g^{-1}) and seed infection (10-22%) (Table 1).

Table 1. Groundnut areas with high soil density of *Aspergillus flavus* and seed infection in Tumkur district of Karnataka, India.

Taluk	Village	*A. flavus* population (x 10^3 cfu g^{-1} soil)	Seed infection (%)
Koratagere	Agrahara Thanda	12	10
Koratagere	Arasapura	6	19
Madhugiri	Nagenahalli	7	13
Madhugiri	Bhaktharahally	26	16
Pavagada	Shilapura	44	17
Pavagada	Kotagudda	10	22

Aflatoxin in market samples

Aflatoxin contamination under market conditions was determined in 42 pod samples collected from Madhugiri (11 samples) and Pavagada (31 samples) market yards, the major oil milling centers in Tumkur district. The aflatoxin content in the collected pod samples was estimated using enzyme-linked immunosorbent assay (ELISA), a simple and quick immunoassay protocol for monitoring allatoxins (Devi et al. 1999). Seeds from all 42 samples showed aflatoxin contamination, though the levels were below 20 µg kg^{-1} seed. Anatoxin content was 8.51 (range 3-11) µg kg^{-1} seed in Madhugiri samples and 6.78 (range 5-18) µg kg^{-1} seed in Pavagada samples. The fact that all the samples contained aflatoxin is of concern because the levels could go up under humid storage conditions.

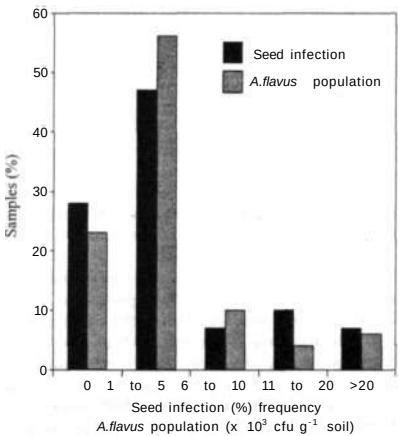

Figure 1. Extent of seed infection and soil population of *Aspergillus flavus* in groundnut samples from Tumkur district, Karnataka, India.

Conclusion

From these preliminary results six villages in three taluks of Tumkur district were identified with relatively higher population density of *A. flavus* and higher seed infection, and thus likely to be aflatoxin risk prone areas. However, these results need confirmation from pod and soil samples and aflatoxin estimation in the seed samples in 2001. An integrated management practice will be developed and on-farm evaluations will be conducted in the high-risk areas to reduce aflatoxin contamination in groundnut during the rainy season 2001.

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Biological Control of Crown Rot of Groundnut by *Trichoderma harzianum* and *T. viride*

G Krishna Kishore[1], S Pande[2], J Narayana Rao[2], and A R Podile[1] (1. Department of Plant Sciences. University of Hyderabad, Hyderabad 500 046, India; 2. International Crops Research Institute for the Semi-Arid Tropics (ICR1SAT), Patancheru 502 324, Andhra Pradesh, India)

Crown rot of groundnut (*Arachis hypogaea*) caused by *Aspergillus niger* is prevalent in warm and dry climatic zones and its incidence ranges from 2% to 14% (Pande and Narayana Rao 2(XX)). The pathogen attacks groundnut plants at all the growth stages and causes pre-emergence rotting in seeds, soft rot in emerging seedlings, and crown rot in mature plants. Thus, management of crown rot by fungicides is difficult and expensive. Biological control of plant diseases is cost effective and environmentally safe compared to fungicides. Also, the biocontrol agent once established persists in the soil for longer periods and offers disease protection even in the consecutive crop seasons (Mew and Rosales 1986). *Trichoderma* spp are antagonistic to a wide range of phytopathogenic fungi and are able to control economically important diseases in several crop plants (Papavizas 1985). *Trichoderma harzianum* and *Bacillus subtilis* AF 1 were tested to control the incidence of crown rot in groundnut and varying levels of disease control were obtained with these biocontrol agents (Lashin et al. 1989, Podile 2000). *Bacillus subtilis* AF 1 induced production of lipoxygenase and altered the phytoalexin metabolism in groundnut seedlings (Podile 2000). We report the results of the in vitro antagonistic potential of 16 *Trichoderma* isolates against *A. niger* and the efficacy of the selected isolates to control *A. niger* infection under greenhouse conditions in comparison with a fungicide.

Sixteen *Trichoderma* isolates were obtained from the rhizosphere soil of groundnut plants collected from experimental fields at the International Crops Research Institute for the Semi-Arid Tropics (ICRlSAT), Patancheru, India and these were identified into four species aggregates, *hamatum, harzianum, longibrachiatum,* and *viride. Aspergillus niger* was isolated from the groundnut plants that wilted due to crown rot infection in the experimental field at ICRISAT. The antagonistic activity of *Trichoderma* isolates against *A. niger* was determined by a dual-culture technique on potato dextrose agar (PDA) and the antagonistic potential of the strains was rated on a 1-5 scale (Bell et al. 1982). Of the 16 *Trichoderma* isolates tested, two *T. harzianum* isolates A 3 and A 11, and one *T. viride* isolate A 14 were highly antagonistic to *A. niger* and were rated 1. Among the remaining 13 isolates, 9 were rated 2, and 4 were rated 3. The production of diffusible antibiotics by the three potent antagonistic isolates was confirmed following the standard procedure of Dennis and Webster (1971).

Tolerance of biocontrol agents to commonly used fungicides is desirable for integration with the modern production practices. In addition, fungicide tolerance enhances the competitiveness of biocontrol agents in soils amended with fungicides. In this study, we tested the tolerance of *T. harzianum* isolates A 3 and A 11, and *T. viride* A 14 to thiram, the common groundnut seed dressing fungicide. This was done by amending the PDA with thiram at concentrations of 100, 200, 300, and 500 mg ml^{-1}. All the three *Trichoderma* isolates were sensitive to thiram at all the concentrations and hence cannot be used in combination with thiram.

Trichoderma harzianum A 3 and A 11, and *T. viride* A 14 were further evaluated for control of pre-emergence and post-emergence rotting under greenhouse conditions. Fifteen-day-old culture of *A. niger* grown on sorghum *(Sorghum bicolor)* grains was used as pathogen inoculum. Sorghum grain-culture was added to a mixture of *red* soil, farmyard manure, and sand (2:1:2) at 25 g kg^{-1} and mixed well. The ,*4. niger* infested soil was filled to top one-third portion of 20-cm diameter pots. The pots wvre watered, left for 48 h in the greenhouse and then were used for planting. The temperature in the greenhouse was maintained at 30 ± 2 C throughout the experimentation. Seeds of the groundnut genotype TMV 2 were coated with *Trichoderma* (10^8 conidia ml^{-1}) using 0.5% carboxy methyl cellulose (CMC). Groundnut seeds treated with thiram at 2 g kg^{-1} were used as one of the treatments. Seeds treated with 0.5% CMC served as control. For soil amendment of *Trichoderma,* 15-day-old culture grown on sorghum grain was mixed in the top layer of soil at

5 g kg^{-1} before planting. Ten seeds were planted in each pot and five pots were considered as one replication. Three replications were maintained for each treatment and the experiment was repeated twice. The pots were observed for pre-emergence rotting at 7 days after sowing, and for post-emergence rotting at 25 days after sowing. The incidence of pre- and post-emergence rotting was found insignificant between the three experiments and hence the data for the three experiments was pooled and analyzed.

The *Trichoderma* isolates were effective in reducing the pre-emergence rotting both when applied as seed treatment and soil amendment compared with control. Soil amendment of *Trichoderma* was significantly more effective than seed treatment in controling post-emergence rotting (Table 1). This could be due to the poor survival of *Trichoderma* in the soil or poor rhizosphere competence when applied as seed treatment (Papavizas 1985). When compared with *Trichoderma* isolates, seed dressing with thiram offered maximum protection to groundnut seedlings both from pre- and post-emergence rotting. Among the *Trichoderma* isolates tested, *T. viride* A 14 was effective in controlling *A. niger* infection and the disease protection obtained was comparable with that of thiram. The effectiveness of *T. viride* A 14 to control crown rot under field conditions is currently being investigated.

Table 1. Effect of antagonistic *Trichoderma* isolates on the incidence of pre-emergence and post-emergence *Aspergillus niger* infection in groundnut seedlings.

	Crown rot infection[1] (%)	
Treatment	Pre-emergence	Post-emergence
T. harzianum A 3 (seed treatment)	14.2	22.2
T. harzianum A 3 (soil amendment)	13.8	18.4
T. harzianum A 11 (seed treatment)	15.1	25.3
T. harzianum A 11 (soil amendment)	15.8	19.8
T. viride A 14 (seed treatment)	10.7	20.9
T, viride A 14 (soil amendment)	11.3	15.8
Thiram 2 g kg^{-1} (seed treatment)	9.1	13.3
Control	45.6	34.4
LSD *(P* = 0.01)	3.1	3.6

1. Data are means of nine replications in three sets of experiments.

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Identification of *Trichoderma* Species and their Antagonistic Potential Against *Aspergillus flavus* in Groundnut

P Srilakshmi[1], R P Thakur[2], K Satya Prasad[1], and V P Rao[2] (1. Department of Botany, Osmania University, Hyderabad 500 007, Andhra Pradesh, India; 2. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh. India)

Contamination of groundnut *{Arachis hypogaea)* seed by aflatoxins produced by *Aspergillus flavus* is a major problem affecting quality and trade of groundnut and its products. Among several management options, biological control can play a significant role in reducing pre-harvest

aflatoxin contamination in groundnut. Control of plant diseases by biological agents is environmentally safe and compatible with sustainable agriculture. Trichoderma spp are well-known biocontrol agents against several plant pathogens (Elad et al. 1982).

Rhizosphere soil samples were collected from major groundnut-growing areas of four districts (Anantapur, Chittoor, Cuddapah, and Kurnool) in Andhra Pradesh, and two districts (Kolar and Tumkur) in Karnataka, India under the National Agricultural Technology Project (NATP) on "Aflatoxin contamination in groundnut: mapping and management in Gujarat, Andhra Pradesh, and adjoining areas". Trichoderma spp were isolated from the soil samples. The isolates were characterized for morphological traits for speciation, and evaluated for their antagonism against Aspergillus flavus to identify highly antagonistic isolates that could be used as potential biocontrol agents for pre-harvest aflatoxin contamination of groundnut.

Isolation of Trichoderma isolates

Five hundred ml of each soil sample at 10^{-3} and 10^{-4} aqueous dilutions was spread on petri dishes containing Trichoderma specific medium (TSM: glucose 3 g, ammonium nitrate 1 g, sodium dihydrogen phosphate 0.9 g, magnesium sulfate 0.2 g, potassium chloride 0.15 g, ferrous sulfate 20 mg, zinc sulfate 20 mg, manganese sulfate 20 mg, rose bengal 30 mg, agar 10 g, and distilled water 1000 ml). After autoclaving at 121 °C for 20 min the medium was cooled to 50°C. Then 50 mg streptomycin sulfate, 50 mg chloramphenicol, 10 mg metalaxyl, and 10 mg PCNB (penta-chloro nitro-benzene) were added. Two plates were maintained for each dilution. The plates were incubated for 4 days in dark at 28°C and typical Trichoderma colonies were isolated. The colonies were white or whitish-green to green, conidiophores long and thick, with or without sterile branches, side branches mostly thick bearing short and plump phialides, phialospores globose or ellipsoidal rough or smooth walled.

Of 386 soil samples analyzed, 156 (40.4%) yielded Trichoderma, with the maximum (64.1%) Trichoderma isolates obtained from soil samples of Anantapur and the minimum (11.1 %) from the samples of Kolar (Table 1). A total of 212 isolates of Trichoderma spp were obtained (Table 1).

Evaluation for in vitro antagonism

The dual culture method (Denis and Webster 1971c) was used to study the antagonism against a highly aggressive and toxigenic strain of A. flavus (Af 11-4). Of the 212 isolates tested, 145 were antagonistic to Af 11-4. Among these, only 39 isolates showed clear inhibition zone against Af 11-4 (Fig. 1). These isolates were examined for species identification and further evaluated for antagonism, involving production of volatile and non-volatile antibiotics, and hyphal interaction with Af 11-4.

Species identification. Thirty-nine antagonistic Trichoderma isolates were identified according to the identification key (Rifai 1969) based on branching of

Table 1. Isolation of Trichoderma isolates from soil samples collected from major groundnut-growing districts of Andhra Pradesh and Karnataka, India, rainy season 2000.

District	No. of soil samples analyzed	No. of soil samples with Trichoderma isolates	No. of Trichoderma isolates obtained	Soil samples with Trichoderma (%)
Andhra Pradesh				
Anantapur	53	34	40	64.1
Chittoor	97	48	54	49.5
Cuddapah	23	11	19	47.8
Kurnool	26	15	20	57.6
Karnataka				
Kolar	72	8	35	11.1
Tumkur	115	40	44	34.8
Total	386	156	212	40.4

conidiophores, shape of the phialides, emergence of phialospores, and shape of phialospores. These isolates were identified into six species, *T. harzianum* (11), *T. hamatunt* (1), *T. viride* (9), *T. longibrachiatum* (5), *T. koningii* (9), *T. pseudokoningii* (3), and unknown species (1) (Table 2).

Production of volatile antibiotics. This study was done following the method of Dennis and Webster (1971b). The plates were incubated at 28°C for 72 h. The assembly was opened to measure colony diameter of Af 11-4 in each plate. Twenty-one of the 39 *Trichoderma* isolates showed inhibition of Af 11-4 colony by producing volatile antibiotics compared with the control. In the control plate, the colony diameter of Af 11-4 was 60 mm whereas in other plates it was 10-45 mm. Isolate T 102

Table 2. Species identification of *Trichoderma* isolates antagonistic to *Aspergillus flavus* (Af 11-4).

Trichoderma species	*Trichoderma* isolate number
T. harzianum	T 2, T 10, T 11, T 20, T 42, T 53. T 58, T 72, T 109, T 129, T 170
T. hamatum	T 47
T. viride	T 16, T 24, T 50, T 51, T 60, T 62, T 179, T 188, T 205
T. longibrachiatum	T 6, T 34, T 56, T 102, T 110
T. koningii	T 12, T 13, T 21, T 33, T 49, T 70, T 83, T 143, T 161
T. pseudokoningii	T 29, T 37, T 206
Trichoderma sp (unknown)	T 142

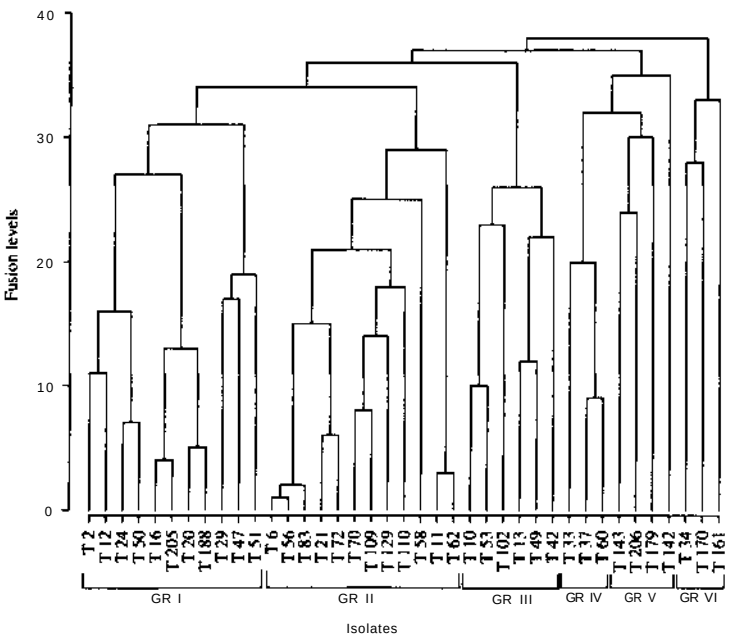

Figure 1. Dendrogram showing 39 *Trichoderma* isolates classified into six groups based on morphological traits and inhibition zone against *Aspergillus flavus* (Af 11-4).

(T.longibrachiatum) showed the maximum inhibition compared with other *Trichoderma* species.

Production of diffusible antibiotics. This study was done following the method of Dennis and Webster (1971a). The plates were incubated for two days and the colony diameter and sporulation of Af 11-4 were compared with the control. Fifteen of the 39 *Trichoderma* isolates showed inhibition of Af 11-4 colony by producing diffusible antibiotics compared with the control. Colony diameter of Af 11-4 in the control plate was 55 mm compared with 10-50 mm in plates with *Trichoderma* isolates. Isolate T 29 *(T.pseudokoningii),* T 42 *(T.harzianum),* and T 83 *(T.koningii)* showed significant inhibition of Af 11-4 growth.

Hyphal interaction. This study was done following the dual culture method (Dennis and Webster 1971c). A block of cellophane (10 mm x 20 mm) was cut from the juncture of the two colonies and mounted in trypan blue-lactophenol, and examined under microscope for hyphal interactions. Isolates T 16 (71 *viride),* T 109 *(T.harzianum),* and T 188 (T.*viride)* showed clear hyphal coiling with Af 11-4 mycelia.

The data of inhibition zone and morphological characters were subjected to average linkage cluster analysis using Euclidian distance as dissimilarity association of GENSTAT Statistical Package (Rothamsted Experiment Station, Herpenden, Herts, UK). The dendrogram prepared from the above classified the 39 *Trichoderma* isolates into six groups (Fig. 1). Further studies are in progress to determine the biological control potential of these isolates against *A. flavus.*

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Mechanisms of Resistance to Groundnut Rosette

P J A van der Merwe[1], P Subrahmanyam[1], F M Kimmins[2], and J Willekens[3] (1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), PO Box 1096, Lilongwe, Malawi; 2. Natural Resources International, Chatham, Kent, ME4 4NN, UK; 3. NRI/University of Greenwich, Chatham, Kent, ME44TB. UK)

Groundnut *(Arachis hypogaea)* is an important crop in sub-Saharan Africa (SSA) and is mostly grown by smallholder farmers as a subsistence crop under rainfed conditions. Groundnut rosette is endemic to SSA and the impact of the disease can be devastating under the conditions that favor epidemics (Subrahmanyam et al. 1991, 1997, Naidu et al. 1999a). During the 1999/2000 cropping season in Malawi, the average rosette incidence on a national scale was 21.1%, estimated to cause crop losses of nearly US$ 10 million.

The causal agents of rosette are groundnut rosette assistor virus (GRAV), groundnut rosette virus (GRV), and satellite RNA. GRAV is asymptomatic but it acts as a helper virus in vector transmission of GRV and its satellite RNA as they must be packaged in the coat protein of GRAV to form particles that can be transmitted by the aphid, *Aphis craccivora.* The satellite RNA is largely responsible for symptom expression and depends on GRV for replication while GRV depends on satellite RNA for aphid transmission. However, GRV can replicate independently. All three agents must occur together for transmission by the aphid vector and subsequent disease development. Prolonged probes by the aphid vector are

needed for the inoculation of GRAV-containing particles into the phloem, where the virus can replicate, while particles containing GRV and satellite RNA can be inoculated into mesophyll cells during short probes (Naidu el al. 1999b). Detailed studies are in progress to study the complexities of vector transmission and mechanisms of aphid resistance. GRV can be readily transmitted by mechanical inoculation and by grafting (Reddy 1985).

Methods have been investigated to manage groundnut rosette including pesticide applications to control the aphid vector and cropping practices, which enable the groundnut crop to escape or evade aphid infestation in the early stages of crop establishment. Given the economic and labor constraints of smallholder groundnut farmers in SSA, host-plant resistance is the most cost effective and environmentally-benign way to control any groundnut disease including rosette. Sources of resistance to rosette were first identified in late maturing Virginia types in West Africa. The West African sources of resistance are directed against GRV and its satellite RNA (Bock et al. 1990). Several breeding lines with field resistance to rosette were developed at ICRISAT-Malawi. One of the improved varieties, ICGV-SM 90704, was released as Serenut 2 in Uganda in 1999. It was also released in Malawi in 2000. Resistance to *A. craccivora* was first identified in the genotype EC 36892 by Padgham et al. (1990). They showed that resistance limited population increase of the aphid. Subrahmanyam et al. (2000) identified a short-duration rosette resistant genotype, ICG 12991, from the world germplasm collection. Naidu et al. (1999c) later established aphid resistance in ICG 12991. The objective of this study was to understand the differential expression of rosette resistance in some groundnut genotypes by the vector and mechanical transmission of the virus complex.

Grafting experiments

Grafting rosette-infected branches (scions) onto a healthy rooted plant (stock) can result in virus transmission without the vector. Three genotypes (ICGV-SM 90704, ICG 12991, and JL 24) were sown in pots in a glasshouse in 10 replications arranged in a randomized complete block design. Branches from rosette-infected plants (cv Malimba) were used as scions and grafted onto 23-day-old healthy stocks of the three varieties. The plants were checked daily for disease symptoms. Eighteen days after grafting all the new shoots of ICG 12991 and JL 24 stocks showed severe rosette symptoms. This indicated that the two lines were susceptible to GRV and satellite RNA, although no testing was carried out for GRAV.

These results of the reaction of ICG 12991 contradicted field trial observations in 1997-2001. Under high rosette incidence at the Chitedze Research Station in Malawi, ICG 12991 and JL 24 expressed 1% and 45% disease incidence respectively (van der Merwe and Subrahmanyam 1997) compared to the severe symptoms (100%) observed in grafting experiments. Forty days after grafting, however, only 20% of ICGV-SM 90704 plants showed mild rosette symptoms. This can be explained since ICGV-SM 90704 is resistant to GRV and its satellite RNA and the resistant reaction of this variety has been consistent under laboratory and field conditions (trials from 1994 to 1996). Across 24 sites in Malawi ICGV-SM 90704 showed 2% rosette incidence compared to the local variety Chalimbana which showed an average of 42% incidence (Chiyembekeza et al. 2000).

Aphid performance on the test genotypes

The grafting experiment showed that ICG 12991 is susceptible to GRV and satellite RNA. The differences in the rosette incidence recorded from graft transmissions and the field observations may involve resistance to *A. craccivora.* Therefore an experiment to assess vector performance on the three test genotypes was carried out.

ICGV-SM 90704, ICG 12991, and JL 24 were sown in pots in a glasshouse and 30 days after sowing, young leaves were exposed to five viruliferous *A. craccivora* alatae (winged). After inoculation each pod was covered with a crisp bag. Seven replications were arranged in a randomized complete block design. Aphids were counted 10 days after infestation (DA1) on each plant and plants were sprayed with dimethoate. Exposed plants were left in a glasshouse up to 60 days after infestation to record rosette symptoms. Results indicated highly significant differences ($P < 0.001$) in aphid population counts between the three varieties. At 10 DA1, increased numbers of aphids (alatae plus nymphs) were observed on ICGV-SM 90704 and JL 24 with an average of 93 and 96 aphids per plant respectively. In contrast aphid number on ICG 12991 fell from 5 to 3 per plant. The increased numbers of aphids on both ICGV-SM 90704 and JL 24 indicate susceptibility to aphids while the reduction on ICG 12991 is an indication of resistance to aphids. These results support the report by Minja et al. (1999). There were also significant differences in disease expression al 60 DA1 since JL 24 showed 100% disease incidence while no symptoms were noted on ICG 12991. Once again, only mild symptoms were observed on ICGV-SM 90704.

The mechanism of resistance to groundnut rosette is different in ICG 12991 compared to ICGV-SM 90704

and it is proposed that under field conditions, aphid resistance is responsible for low rosette incidence in ICG 12991, while resistance to GRV is responsible for low rosette incidence in ICGV-SM 90704.

It is difficult from the present screening trials to distinguish between virus and vector resistance because the criterion used is based on presence or absence of rosette symptoms and does not involve aphid population counts. Given the large numbers found in aphid colonies (range 2-1,000 individuals) and the relatively small size of the individual insects, such counts will not be practical, although rough estimations of colony sizes can be made (W W Page, NRI/University of Greenwich, UK, personal communication). However, genotypes with resistance to both virus and the vector are expected to be more stable than those to either one of the components. It is therefore suggested that field screening tests using disease incidence as a measure of resistance should be complemented by laboratory screening to the vector. Diagnostic methods are now available for the detection of each of the three causal agents by using reverse transcription-polymerase chain reaction (RT-PCR) (Naidu et al. 1998). RT-PCR is an efficient and specific method for detecting the asymptomatic GRAV in groundnut although it can also be detected using a triple antibody sandwich enzyme linked immunosorbent assay (TAS-ELISA) (Rajeshwari et al. 1987). Studies are also under way to identify molecular markers associated with resistance to GRV and possibly the aphid vector (L Herselman, Agricultural Research Council, South Africa, personal communication). Application of these techniques should facilitate the rapid identification of resistance to rosette or the mechanism governing the resistance.

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Entomology

Biopesticidal Effect of Neem and NPV on Production Potential and Behavior of *Rhynocoris marginatus* to Groundnut Pest *Spodoptera litura*

K Sahayaraj (Crop Protection Research Unit, Department of Zoology, St. Xavier's College, Palayamkottai 627 002, Tamil Nadu, India)

Rhynocoris marginatus is an important reduviid natural enemy of groundnut (*Arachis hypogaea)* pests (Sahayaraj 2000). It can be used in the groundnut pest management (Sahayaraj 1999). Botanicals, particularly neem products and nucleopolyhedroviruses (NPVs) are ideally suitable for integrated pest management (IPM). Generally, biopesticides are considered safe to natural enemies of the target pests. However, recent studies (Jhansilakshmi et al. 1998) have shown that biopesticides are toxic to some natural enemies. It is therefore necessary to understand the effect of biopesticides on predation potential of *R. marginatus.* This paper presents the results of laboratory experiments on the effect of biopesticides Vijayneem, Nimbicidine, and NPV (Spodoptera) [NPV(S)] were evaluated for their effect on *R. marginatus* behavior and biocontrol potential.

Both the predator and pest were collected from Tirunelveli district, Tamil Nadu, India. The predator was maintained on *Spdoptera litura* larvae. The 5. *litura* larvae were maintained on groundnut leaves under laboratory conditions (28±2°C, 70-80% relative humidity, and 11 h photoperiod) in 500 ml plastic containers. The healthy culture of 5. *litura* was maintained by following proper sanitary conditions. Two neem formulations (Nimbicidine and Vijayneem) were used in this study. The spreader Teepol (0.5%) was added to each biopesticide (Venkadasubramanian and David 1999). In all bioassays, leaves (2 g) of groundnut cv TMV 1 were used against 5. *litura.* The leaves were immersed in the biopesticide suspension and dried in shade and then used to feed *S. litura.* The glass olfactometer used to study the insect behavior consisted of a central chamber (2.5 cm upper diameter, 6.5 cm lower diameter, 6 cm height), from which two equally spaced glass tubes projected outward. A beaker of 9 cm height and 7 cm width was fitted on the terminal opening of each tube, and closed with a muslin cloth.

The biopesticide treated groundnut leaf fed *S. litura* acceptance by different stages of *R. marginatus* was evaluated by a no-choice experiment. One-day-old nymphal instars (first, second, third, fourth, and fifth) and adults of *R. marginatus* were tested for their response to biopesticide treated groundnut leaf fed *S. litura* third instar larvae. Two biopesticide treated groundnut leaf fed S. *litura* larvae were introduced in one beaker, and water treated leaf fed *S. litura* in the opposite beaker as a control. The beakers were covered with muslin cloth and the prey 5. *litura* larvae allowed to move undisturbed for five minutes. Two first instar *R. marginatus* were then introduced into the central tube and the feeding events were recorded for one hour. The successful approaching and predatory response was recorded. The predatory response was defined in terms of an Access Proportion Index (API) (Yasuda and Wakamura 1996). The API was calculated as given below.

API = NS - NC/NS + NC, where NS = number of animals choosing the sample side, and NC = number of animals chosing the control side. Each experiment was replicated fifteen times with different life stages of the predator.

In order to assess the biocontrol potential of *R. marginatus* life stages, *S. litura* third instars were allowed to feed on biopesticide treated leaves for 24 h. One-day-old first instars of *R. marginatus* were placed in a plastic container (500 ml capacity) and the biopesticide treated groundnut leaf fed *S. litura* were provided to them. After 24h, number of prey eaten by *R. marginatus* was recorded. Predatory efficiency was assessed in terms of number of prey killed and consumed in 24 h. Second, third, fourth, and fifth nymphal instars and adults were provided with four, six, eight, ten, and twelve *S. litura* larvae per day, respectively. Fifteen replications with one predator were maintained for each life stage.

Results of prey (third instar *S. litura*) acceptance by *R. marginatus* are presented in Table 1. First, second,

and third instars were highly deterred by Nimbicidine, and the results were statistically significant *(P* <0.05) compared to the other biopesticides tested. Later instars (fourth and fifth) were deterred by Vijayneem, and its effect was significant *(P* <0.05) (except fourth instars) compared to Nimbicidine and NPV(S) treatment. Since NPV(S) did not affect the predatory potential of *R. marginatus,* this can be used in groundnut IPM. Sontakke (1993) found that neem oil and synthetic-insecticide combination was toxic to the mirid bug, *Cyrtorhinus lividipennis.* The neem formulations Neemax, Neem Gold, Econeem, and azadirachtin caused less than 50% mortality, whereas other insecticidal formulations NG-4 and Achook caused more than 50% mortality in *C. lividipennis* (Jhansilakshmi et al. 1998).

Table 1. Access proportion index behavioral bioassay of *Rhynocoris marginatus* in relation to biopesticide treated *Spodoptera litura*[2].

Life stage	Vijayneem	Nimbicidine	NPV (S)[2]
First instar	-0.02 a	-0.37 b	-0.02 ac
Second instar	-0.05 a	-0.44 b	-0.03 a
Third -instar	-0.06 a	-0.46 b	-0.05 a
Fourth instar	-0.27 a	-0.17a	-0.05 c
Fifth instar	-0.37 a	-0.18 b	-0.13 c
Adult	-0.66 a	-0.06 b	-0.06 b

1. Figures followed by same letter in a row are not statistically significant at *P* = 0.05 using Duncan's Multiple Range Test (DMRT).
2. NPV(S) = nucleopolyhedrovirus (Spodoptera).

Table 2. Effect of biopesticides treated third instar *Spodoptera litura* on the predatory potential of *Rhynocoris marginatus* life stages[1].

Life stage	Control	Vijayneem	Nimbicidine	NPV(S)[2]
First instar	1.3 a	1.2 ab	1.2 abc	1.3 abcd
Second instar	2.6 a	2.4 ab	1.8 bc	2.5 abd
Third instar	3.9 a	3.1 b	2.6 c	3.1 bd
Fourth instar	5.2 a	4.8 ab	4.5 abc	5.0 abd
Fifth instar	6.7 a	5.3 b	6.1 c	6.4 cd
Adult	7.5 a	4.7 b	7.0 c	7.4 acd
Total	28.8 a	21.9b	23.7 bc	26.8 ad

1. Figures followed by same letter in a row are not statistically significant at *P* = 0.05 using Duncan's Multiple Range Test (DMRT).
2. NPV(S) = nucleopolyhedrovirus (Spodoptera).

All the life stages of this predator successfully capture and consume the third instars of *S. litura* (Sahayaraj 1994). First, second, third, fourth, and fifth nymphal instars and adults of *R. marginatus* consumed 1.3, 2.6, 3.9, 5.2, 6.7, and 7.5 *S. litura* third instars respectively. In the untreated control, the mean consumption was 28.8 *S. litura* larvae per predator. *Rhynocoris marginatus* consumed 26.3 *S. litura* larvae when treated with NPV and the value was statistically not significant when compared to the untreated control (Table 2). The predation rate was reduced in larvae fed on leaves treated with Vijayneem (21.9 prey per predator) and Nimbicidine (23.7 prey per predator) treatments respectively. Further investigations are needed, particularly under field conditions, to measure the actual predation potential.

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Agronomy

Evaluation of Weed Management Practices in Groundnut in Maharashtra, India

R T Suryawanshi, T N Narkhede, R B Patil, and S C Wadile (Oilseeds Research Station, Mahatma Phule Krishi Vidyapeeth, Jalgaon, Maharashtra, India)

A field experiment was conducted in the rainy season during 1994-97 at the Oilseeds Research Station, Mahatma Phule Krishi Vidyapeeth, Jalgaon, Maharashtra, India to find a suitable weed management practice for groundnut (*Arachis hypogaea*) for the assured rainfall zone of northern Maharashtra. Two pre-emergence herbicides, pendimethalin (at 1.0 kg ha^{-1}) and metolachlor (at 1.0 kg ha^{-1}), alone and in combination with intercultivation (IC) and hand weeding (HW) at different times were compared. The nine treatment combinations (T1 to T9) are given in Table 1. The experiment was conducted in a randomized block design with three replications. Groundnut cv JL 220 (Phule Vyas) was grown as a test crop at interrow spacing of 30 cm, and intra-row spacing of 10 cm. The experimental soil was medium black.

During the investigation, observations on weed flora, weed dry matter production, and groundnut pod and haulm yields were recorded. Weed control efficiency was also assessed. The net return and benefit-cost ratio were worked out. The results are summarized in Table 1.

Weed flora

Weeds associated with groundnut in the experimental field were *Amaranthus viridus, Parthenium histerophorus, Acalypha indica, Cyperus rotundus, Cynodon dactylon, Panicum repens, Eclipta alba,* and *Trianthema portulacastrum.* Grass weeds constituted 43% of the total weed population. Among the grass weeds *Cynodon*

Table 1. Effect of weed control treatments on weed dry matter production at harvest, weed control efficiency, groundnut yields, and net returns in the rainy season during 1994-97 in Jalgaon, Maharashtra, India.

Treatment[1]	Weed dry matter (kg ha^{-1})	Weed control efficiency (%)	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net returns[2] (Rs ha^{-1})
T_1: Pre-emergence application of pendimethalin (Stomp 30% EC) @ 1.0 kg ha^{-1}	4143	46.65	906	5881	8259	7903
T_2: Pre-emergence metolachlor (Dual 50% EC) @ 1.0 kg ha^{-1}	4152	46.54	874	6264	8428	7705
T_3: T_1 + IC at 30 and 45 DAS	3785	51.26	1000	6202	8541	9118
T_4: T_2 + IC at 30 and 45 DAS	4164	46.38	1045	6352	8708	9814
T_5: T_3 + one HW at 30 DAS	1553	78.00	1341	6829	8926	13653
T_6 : T_4 + one HW at 30 DAS	1745	77.53	1267	6986	9136	12621
T_7 : HW and 1C at 20 and 45 DAS	2622	66.24	1125	6363	8775	10534
T_8: Non-weeded check	7761		661	4977	7941	4394
T_9 : Weed-free check (3 IC at 15, 30. and 45 DAS and 2 HW at 20 and 50 DAS)	706	90.91	1432	7193	9202	14797
SE±	1790.78	5.06	52.72	344.67	47.10	689.50
CD (at 0.05)	5420.00	15.33	153.87	1006.00	142.53	2086.41

1. IC = intercultivation; HW = hand weeding; DAS = days after sowing.
2. Calculated based on price (average of 4 years): pods = Rs 1340 per 100 kg; haulms = Rs 72 50 per 100 kg.

dactyl on was predominant and *Cyperus rotundus* was predominant among sedges. *Acalypha indica* was predominant among broad-leaved weeds.

Weed dry matter production

The weed-free control had the least weed dry matter production. However, this treatment was comparable with the treatments receiving herbicides supplemented with 1C and HW (T5 and T6). All weed control treatments had significantly greater pod yield than the unweeded control. Pod yield in treatments T5 and T6 was not significantly different from that of the weed-free control (1432 kg ha^{-1}), which was the highest (Table 1).

Weed control efficiency

The weed-free check recorded the highest weed control efficiency (90.91%) followed by pendimethalin with two ICs and one HW (T5) and metolachlor with two lCs and one HW (T6).

Net returns

The weed-free check recorded the highest net returns (Rs 14797) followed by T5.

The weed-free control (3 ICs at 15, 30, and 45 days after sowing (DAS), and 2 HWs at 20 and 50 DAS] or pre-emergence application of pendimethalin 1.0 kg ha^{-1} with two ICs at 30 and 45 DAS and one HW at 30 DAS results in high groundnut pod yield and net return.

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Integrated Management of Sulfur for Groundnut on a Lateritic Soil in Orissa, India

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

Groundnut (*Arachis hypogaea)* is a major oilseed crop of Orissa, India contributing nearly 57% of the total oilseed production of the state. In Orissa the same crop is mainly cultivated in red, lateritic, and alluvial soils. Majority of these soils growing groundnut are deficient in sulfur (S) (Misra et al. 1990). Application of S through either phosphogypsum or single superphosphate (SSP) increased the pod yields by 10-25% on lateritic soils (Sahu et al. 1991). Most of the surface layers of lateritic soils are coarse textured with heavier texture in sub-soil, acidic in reaction, low in organic matter, and deficient in S (Sahu 1993). Response of oilseed crops to soil application of phosphogypsum at higher doses in these soils is reported to be less effective (Anonymous 1995).

Field trials on integration of S sources at lower doses through phosphogypsum and organics for groundnut were conducted during summer and postrainy season of 1995 and 1996 respectively at the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar, Orissa. Nine treatments were tested and these consisted of 5 S levels (20, 30, 40, 50, and 60 kg S ha^{1}) through phosphogypsum at full dose, integration of 20 kg S ha^{-1} either through farmyard manure (FYM) or poultry manure with 10 kg S ha^{-1} through phosphogypsum, 30 kg S ha^{-1} from single SSP, and one control (no S). The treatments were replicated thrice in a randomized block design.

The soil of the experimental site was sandy loam (Arenic Haplustalf) with 5.0 pH, 0.314% organic carbon,

Table 1. Integrated effect of sulfur on pod yield, shelling turnover, oil content, and S uptake during summer 1995 and postrainy season 1996 in Bhubaneswar, Orissa, India.

	Summer				Postrainy season			
Treatment/Source (S kg ha^{-1})	Pod yield (t ha^{-1})	Shelling (%)	Oil (%)	S uptake (kg ha^{-1})	Pod yield (t ha^{-1})	Shelling (%)	Oil (%)	S uptake (kg ha^{-1})
SO	0.99	63.9	31.1	2.53	0.96	63.6	31.2	2.29
S20 (phosphogypsum)	1.14	66.6	34.8	3.17	1.16	64.7	32.0	2.90
S30 (phosphogypsum)	1.19	69.7	35.3	3.53	1.28	68.7	31.5	3.48
S40 (phosphogypsum)	1.24	71.0	38.8	3.74	1.45	69.6	37.5	4.49
S50 (phosphogypsum)	1.23	71.4	37.2	3.90	1.47	69.9	37.5	4.76
S60 (phosphogypsum)	1.32	69.5	40.9	3.91	1.40	70.4	38.4	4.90
S20 (farmyard manure) + S 10 (phosphogypsum)	1.22	69.6	40.5	3.81	1.42	71.0	39.1	5.48
S20 (poultry manure) + S 10 (phosphogypsum)	1.29	70.4	42.5	4.41	1.59	71.6	40.9	6.23
S30 (single superphosphate)	1.18	69.6	42.1	3.98	1.45	69.8	41.9	5.68
CD (5%)	0.08	1.41	2.7	0.35	0.11	1.05	2.4	0.39

and low available phosphorus (P) and potassium (K). Available (0.15 $CaCl_2$ extractable) S of the soil was 4.5 mg kg^{-1}. The soil had 5.9 c mol (P+) kg^{-1} cation exchange capacity. As source of S, phosphogypsum contained 15% S, FYM contained 0.15% S, poultry manure contained 0.50% S, and SSP contained 12% S. Groundnut variety AK-12-24 was sown both in summer and postrainy season with 20 kg nitrogen (N) ha^{-1}, 17.5 kg P ha^{-1}, and 13.2 kg K ha^{-1}. Diammonium phosphate, urea, and muriate of potash were the sourcs of N, P, and K respectively. The organic manures were mixed with phosphogypsum and applied at sowing.

The data (Table 1) showed that application of S through all sources used increased the yield, shelling outturn, oil content, and uptake of S significantly. Application of S at 40 or 50 kg ha^{-1} through phosphogypsum produced significantly higher yields, shelling percentage, oil content and uptake of S than other levels of S through phosphogypsum as well as application of 30 kg S ha^{-1} through SSP. Integration of S source at 30 kg ha^{-1}, i.e., 66.5% from organic source (FYM or poultry manure) and 33.5% from phosphogypsum, indicated increase in pod yield along with other associated characters over other treatments. Maximum pod yield, shelling turnover, oil content, and uptake of S was recorded in the integrated treatment of phosphogypsum with poultry manure.

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Effectiveness of Phosphocompost Application on Groundnut in Vertisol of Central India

P K Ghosh, M C Manna, K M Hati, K G Mandal, K K Bandyopadhyay, A K Misra, A K Tripathi, R S Chaudhary, and C L Acharya (Indian Institute of Soil Science, Nabibagh, Bhopal 462 038, Madhya Pradesh, India)

Low organic matter coupled with low native soil phosphorus (P) (5.2-8.7 kg available P ha^{-1}) is a major constraint limiting the crop productivity in Vertisols in subhumid ecoregion of central India. Low input sustainable agriculture and the reduced chemical input concept focus on the reconsideration of agricultural practices in order to maintain and preserve soil organic matter level. Application of farmyard manure (FYM) is common but it is difficult to obtain adequate quantity because of increase in cropping intensity and area. In Madhya Pradesh state of India, mechanization has been increasing, and therefore low quantity of FYM is available per ha due to less number of farm animals and more area under cultivation. Besides, FYM contains very small amount of major nutrients and its cost of transportation is high. In the present era of resource management, farm residues could be used as an alternative to FYM to maintain quality of soil and to sustain crop productivity. Soybean *(Glycine max)* is one of the major cash crops in the sub-humid ecoregion of central India grown in rainy season where its residues are not used for cattle feed. During the season, cultivation of groundnut (*Arachis hypogaea)* is also picking up. In Madhya Pradesh groundnut area has increased from 25,200 ha in 1995 to 26,300 ha in 2000. Crops such as wheat *(Triticum aestivum),* Indian mustard *(Brassica juncea),* and chickpea *(Cicer arietinum)* are mainly grown during winter. Burning of wheat residue is common in this region; it hastens the decline in soil organic matter, pollutes the environment, and lowers biological activity. Residue of Indian mustard and chickpea normally is a waste as these are not used for cattle feed. Thus, it is necessary to recycle these residues for sustained production and soil quality. Moreover, groundnut being a legume crop, P management becomes imperative to realize the yield potential of groundnut. A study was, therefore, carried out at the Indian Institute of Soil Science, Bhopal, India to compare the performance of four different composts prepared from legume residue (soybean and chickpea), cereal residue (wheat), and oilseed residue (Indian mustard) and also to compare with chemical fertilizer in terms of quality of compost, improvement in physical, chemical, and biological properties, and yield of groundnut.

Phosphocompost was prepared using fresh cow-dung, soil, and residues in the ratio of 1:0.5:1 (dry weight basis). Mussoorie rock phosphate (100 mesh) at 2.2% P, pyrite [22.2% sulfur (S)J at 10%, and urea-nitrogen (N) at 0.5% were added to the mixture on dry weight basis. The materials were allowed to decompose for a period of 60 days. The chemical characteristics of matured compost, i.e., total organic carbon (C) and C/N ratio were determined and compared with the initial values. Citrate soluble-P, water soluble-P, and available N and P (Jackson 1967) were also estimated. The soil of the experimental site was medium black (Typic Haplustert) having 7.8 pH, 0.52% organic C, 620 ppm total P ha^{-1}, and 6.2 kg available P ha^{-1}. The water-holding capacity, bulk density, and porosity of the surface (0-15 cm) soil were 62%, 1.45 Mg m^{-3} and 45%, respectively. Groundnut cv G-5 was sown on 7 July 2000 at a spacing of 45 cm x 10 cm. The plot size was 4 m x 6 m. Four composts (soybean, wheat, Indian mustard, and chickpea residue) and three concentrations of inorganic P (0, 13.1, and 26.2 kg P ha^{-1}) as single superphosphate were tested in a completely randomized block design with three replications. Groundnut was harvested in the first fortnight of October. The enriched compost having 54% moisture was applied before sowing at 10 t ha^{-1}. No chemical fertilizer was applied to groundnut in the compost treated plots. However, in the inorganic P plots, N as urea and potassium (K) as muriate of potash were applied uniformly as basal at 12.5 kg ha^{-1} and 30 kg ha^{-1} respectively. The postharvest soil samples were taken from 0-15 cm depth, air-dried and analyzed for organic C by Walkley and Black rapid titration method (Jackson 1967), available N (NH_4 and NO;) (Bremner and Keeney 1966), available P by Olsen method, and total P (Olsen and Sommers 1982). The N and P concentration in seed and haulm were determined and N and P uptake were calculated. Soil microbial biomass carbon (SMBC) was estimated by the chloroform-fumigation incubation method (Jenkinson and Powlson 1976). Soil moisture content up to 30 cm soil depth was determined by gravimetric method at flowering stage when the soil was near field capacity. Total rainfall during the crop growing period was 595 mm. The crop was rainfed; however, one irrigation (6 cm) was applied 7 days before harvest for uprooting plants easily with pods intact.

There were differences in chemical composition of composts due to different crop residues used. The C/N ratio of the matured composts indicated that chickpea

residue decomposed faster in a given time followed by soybean and wheat residues (Table 1). For mustard residue, however, more time was required to obtain a similar quality of compost because mustard residue is more slowly decomposed by microorganisms. The water soluble-P was about eight- to tenfold lower than citrate soluble-P in all the composts. In general, the plots receiving composts recorded higher soil moisture compared to those treated with inorganic fertilizers. Among composts, chickpea residue compost recorded the maximum soil moisture. Though the differences in pod yield, haulm yield, N and P uptake due to different sources of compost were not significant, chickpea compost recorded the highest value of these parameters (except P uptake) followed by wheat compost (Table 2). The application of phosphocompost at 10 t ha^{-1} especially prepared from chickpea and wheat residues gave N and P uptake and yields of groundnut equivalent to inorganic P at 26.2 kg ha^{-1}. It appears that application of these two composts could maintain optimum growth and development to produce more biomass of groundnut as it contained higher soluble and total P (Table 1) and released more nutrients into the soil as was evident from organic C, and available N and P values (Table 2). The enriched phosphocompost significantly increased SMBC over chemical fertilizer. The highest SMBC was recorded in

Table 1. Quality of compost 60 days after decomposition of crop residue[1].

Chemical constituent[2]	Soybean residue	Wheal residue	Mustard residue	Chickpea residue
Organic C (%)	29.3 ± 0.9 (50.9)	26.2 ± 1.0(48.5)	32.1 ±0.6(45.7)	21.5 ±0.7 (49.7)
WSP (%)	0.062 ± 0.002	0.054 ± 0.002	0.040 ± 0.001	0.056 ± 0.003
CSP (%)	0.44 ± 0.02	0.53 ± 0.03	0.51 ± 0.04	0.54 ± 0.04
Total P (%)	4.10 ± 0.4	4.27 ± 0.5	3.30 ± 0.6	4.21 ± 0.4
Available K (%)	0.48 ± 0.04	0.38 ± 0.02	0.31 ±0.01	0.53 ±0.02
C/N ratio	22.6 ± 1.2(32.3)	23.6 ± 2.1 (49.5)	26.5 ± 1.7(46.2)	16.6 ± 1.4(35.3)

1. Data in parenlheses are initial values. The estimation of chemical parameters were made on material dry weight basis and the values given are means of three replications ± SE.
2. C = carbon; WSP = water soluble-phosphorus (P); CSP = citrate soluble-P; K = potassium; and N = nitrogen.

Table 2. Effect of phosphocompost and inorganic phosphorus (P) fertilizer on pod yield of groundnut, nutrient uptake, moisture and nutrient content in soil, and biological activities in 2000, Bhopal, Madhya Pradesh, India[1].

Treatment	TWC (mm)	OC (%)	Available N (kg ha^{-1}) NH_4^+	Available N (kg ha^{-1}) NO_3	Available P (mg kg^{-1})	Uptake (kg ha^{-1}) N	Uptake (kg ha^{-1}) P	SMBC (mg kg^{-1})	Pod yield (t ha^{-1})	Haulm yield (t ha^{-1})
P rate (kg ha^{-1})										
0 (control)	105	0.46	38.1	71.2	6.1	112.3	8.3	167	1.25	3.10
13.1	108	0.48	42.3	79.3	6.1	143.1	11.7	192	1.61	3.62
26.2	102	0.48	45.1	85.3	6.3	153.5	13.9	210	1.75	4.60
Compost[2]										
Soybean residue	116	0.49	48.3	87.5	6.2	149.3	13.3	289	1.74	4.65
Wheat residue	118	0.50	47.5	85.3	6.2	152.1	14.7	305	1.75	4.70
Mustard residue	115	0.49	46.2	87.1	6.1	141.0	11.5	282	1.65	4.47
Chickpea residue	122	0.51	47.6	88.1	6.4	155.4	14.3	317	1.78	4.71
Mean	112.3	0.487	45.01	83.4	6.2	143.8	12.5	251.7	1.64	4.26
SE±	7.0	0.04	1.8	5.4	0.18	4.3	0.41	6.1	0.092	0.67
CV (%)	17.3	5.3	7.9	6.7	10.6	12.4	13.7	5.4	21.5	23.4

1. TWC = total water content at 50 days after sowing at 0-30 cm soil depth; OC = organic carbon; N = nitrogen; and SMBC = soil microbial biomass carbon.
2. Applied at 10 t ha^{-1}.

the plots where chickpea residue compost was applied. Thus, chickpea residue compost is considered to be nutritionally superior with respect to its favorable maturity indices, nutrient content, and its effect on SMBC, nutrient uptake, and yield of groundnut followed by wheat compost and soybean compost.

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Production Potential of Rabi Groundnut as Influenced by Polythene Mulch in Northeastern India

Sanjeev Kumar and Shivani (ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok 737 102, Sikkim, India)

India is one of the leading oilseed producing countries in the world and groundnut (*Arachis hypogaea*) ranks first both in area and production among oilseed crops. Among oilseeds in India, groundnut is the largest component which occupies 45% of the total oilseeds area and 55% of the total oilseeds production (Munda et al. 1997). Still, there is a wide scope to increase both area and production of groundnut in the country by introducing the crop in areas where it has not been grown earlier especially in northeastern states. Groundnut is a very recent introduction in the northeastern region. In Meghalaya, groundnut was introduced during mid-1980s; earlier it was introduced in Tripura and Nagaland. In Assam, Mizoram, Arunachal Pradesh, Manipur, and Sikkim the crop is still to make headway. Manipur and Sikkim have about 180,000 ha and 63,200 ha of total cropped area. There is a potential production niche for groundnut in about 20% and 10% of the total cropped area respectively in these two states (Munda et al. 1997). Rice (*Oryza sativa*) is the major kharif (rainy season) crop in Manipur while maize (*Zea mays)* and rice are major kharif crops in Sikkim. During rabi (postrainy season) either mustard (*Brassica* sp) is grown or land is kept fallow in both states. The present investigation has been carried out to introduce rabi groundnut in these states as well as to increase the cropping intensity and to study the effect of polymulch on groundnut cultivation.

The field experiments were conducted on residual moisture during rabi seasons of 1997-99 and 1999-2000 at the ICAR Research Complex for NEH Region, Manipur Centre, Imphal and Sikkim Centre, Gangtok respectively. Rice and maize were grown in the same plots in kharif at Manipur and Sikkim respectively. The soil of Manipur was clay loam with pH 6.5, organic carbon 2.12%, and available NPK (67.4 kg N ha^{-1}, 6.9 kg P ha^{-1}, and 190.6 kg K ha^{-1}) while the soil of Sikkim was clay loam having pH 6.3, organic carbon 1.82%, and available NPK (53.2 kg N ha^{-1}, 5.9 kg P ha^{-1}, and 198.9 kg K ha^{-1}). The experiment was laid out in randomized block design with five replications and six treatments: broad-bed and furrow (BBF) with polymulch (T_1), broad-bed and furrow without polymulch (T_2), flat bed with polymulch (T_3), flat bed without polymulch (T_4), ridge and furrow with polymulch (T_5), and ridge and furrow without polymulch (T_6), Basal application of 2.0 t lime ha^{-1} was also made for amelioration of soil pH at both the places. Polyfilm (0.008 mm thickness and 70% light transmittance) was applied as mulch before sowing; holes were made in the polyfilm at 30 cm x 15 cm (row to row and plant to plant) intervals. Two seeds of groundnut (JL 24) were sown in each hole to ensure better germination. The crop was sown on 6 November every year in Manipur and on 3 October at Sikkim when the mean temperature of top soil was 13.2°C. Soil-moisture was measured with the help of soil-moisture meter by using gypsum blocks.

Polymulch had pronounced effect on growth and yield attributes. At Manipur, the highest groundnut pod yield was found in flat bed system with polymulch (2181 kg ha^{-1}) and the lowest was in ridge and furrow system without polymulch (433 kg ha^{-1}) while at Sikkim, highest pod yield was found in BBF system with polymulch (1882 kg ha^{-1}) and the lowest was in flat bed system without polymulch (569 kg ha^{-1}) (Table 1). The higher

Table 1. Effect of polymulch on groundnut yields in Manipur and Sikkim, India.

	Manipur (pooled data of 1997-99)					Sikkim (pooled data of 1999-2000)				
Treatment[1]	Number of pods plant^{-1}	Pod yield plant^{-1} (g)	100-seed mass (g)	Pod yield (kg ha^{-1})	Shelling (%)	Number of pods plant^{-1}	Pod yield plant^{-1}	100-seed mass (g)	Pod yield (kg ha^{-1})	Shelling (%)
T1	27.3	86.9	38.8	1602.0	72.4	35.3	122.6	42.8	1882.2	75.2
T2	29.1	48.2	34.1	875.0	61.0	24.4	70.2	37.2	1011.1	62.0
T3	38.6	125.2	47.5	2180.7	74.1	26.6	77.2	38.9	1264.7	73.9
T4	26.6	76.2	36.5	1063.0	63.1	17.6	42.6	33.6	569.2	62.9
T5	27.4	84.5	37.2	927.4	73.1	31.8	95.9	40.4	1577.7	74.9
T6	14.7	33.4	32.1	433.2	64.9	20.2	47.6	35.5	892.3	63.6
CD (0.05)	5.2	17.7	4.5	339.1	9.2	5.1	19.2	4.7	292.3	9.6
SE±	2.5	8.5	2.15	162.5	4.4	2.4	9.2	2.3	140.1	4.6
CV (%)	15.3	17.7	9.2	21.7	10.2	14.8	19.0	9.3	17.7	10.5

1. See text for details of treatments.

pod yields in treatments with polymulch compared with non-mulched treatments may be due to better soil-moisture availability and optimum soil-temperature during the crop season. Reddy and Venkatachari (1980) also reported similar results in different field crops under mulched condition. Germination, flowering, and pegging was recorded 8-10 days, 15-20 days, and 10-14 days earlier respectively, while maturity was delayed by 20-22 days with polymulch over non-mulched condition at both Manipur and Sikkim. This suggests that polymulched plots had longer reproductive period as compared to non-mulched plots which in turn must have favored higher number of pods plant^{-1}, pod yield plant^{-1}, 100-seed mass, and total pod yield (Table 1).

It was also reported that the reflection of sunlight 30 cm above the soil surface was 4.3-11.2% when polythene film was used, but only 2.4-4.0% without it and wind speed within polymulched groundnut rows was 0.01-0.03 m s^{-1} faster as compared to non-mulched plots. Faster wind speed favors air exchange and carbon dioxide movement. All these interlinked factors had increased the photosynthetic efficiency of polythene mulched groundnut and thus the yield of polythene mulched groundnut was higher than non-mulched crop. Duan Shufen et al. (1998) reported similar findings from their experiments. It was further observed that in Manipur and Sikkim polymulched plots had shown better soil-moisture (47.2% and 73.2%) throughout the crop season than non-mulched plots (28.8% and 43,2%) at 0-20 cm soil depth.

It is apparent that groundnut can be grown successfully in both the states as rabi crop under polymulched condition with appropriate sowing techniques. The technology evolved may be tested further against different fertilizer levels and moisture regimes as long-term farm research as well as in farmers' fields in Manipur. But in Sikkim it needs further study due to greater variability in environmental condition every year before making any recommendation.

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Socioeconomics

Economics of Groundnut Production in Malawi

S Ngulube[1], P Subrahmanyam[1], H A Freeman[2], P J A van der Merwe[1], and A J Chiyembekeza[1]
(1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), PO Box 1096, Lilongwe, Malawi; 2. ICRISAT, PO Box 39063, Nairobi, Kenya)

Groundnut (*Arachis hypogaea)* is an important legume crop in the smallholder agriculture in Malawi, providing approximately 25% of the agricultural income. Until late 1980s, groundnut was Malawi's fourth most important export crop product after tobacco, sugar, and tea (Babu et al. 1995). Groundnut is also important in the diet, being the major source of vegetable protein and edible fat, in rural Malawi. The haulms are a rich protein feed for livestock. The crop is a valuable component in maize *(Zea* mays)-based cropping system and improves soil fertility (Chiyembekeza et al. 1998).

Groundnut is grown mostly by smallholder farmers and almost 70% of the crop is grown in central Malawi. However, many farmers including estate farmers are now realizing the importance of groundnut, especially with the unfavorable tobacco markets. The introduction of such high-yielding groundnut varieties as CG 7 coupled with the efforts of various non-governmental organizations (NGOs) and research and development organizations in seed production and delivery have played an important role in promoting groundnut production in the country. As a result, farmers are looking for information on groundnut production costs and the financial returns to investment in groundnut production.

To provide such information, an experiment was conducted at Chitedze Agricultural Research Station near Lilongwe, Malawi during the 2000/01 crop season. The purpose of the experiment was to estimate the production costs and profitability of groundnut at three different input levels (Table 1):

1. **Low input:** Smallholder farmers with seed as the major input; all field operations are carried out manually using family labor.
2. **Medium input:** Small-scale commercial farmers where all field operations are carried out using hired labor following recommended cultural practices (seed rate, spacing, and early planting).

Table 1. Field operations and input levels for groundnut production in Malawi.

Field operation	Low input (LI)	Medium input (Ml)	High input (HI)
Land preparation[1]	Manual	Manual	Tractor
Fertilizer	None	None	Triple superphosphate (at 87 kg ha^{-1} as basal dressing)
Sowing*[1]	Late	Early	Early
Seed source	Local seed	Basic seed (treated with thiram)	Basic seed (treated with thiram)
Seed rate	Low (40 kg ha^{-1})	Optimum (80 kg ha^{-1})	Optimum (80 kg ha^{-1})
Interrow spacing	90 cm	75 cm	75 cm
Intra-row spacing[3]	20-25 cm	15 cm	15 cm
Top dressing	None	None	Gypsum (175 kg ha^{-1} at pegging stage)
Weeding[4]	Manual	Manual	Chloroacetanilide + manual
Insecticide	None	None	Lambda cyhalothrin[5]
Fungicide	None	None	Chlorothalonil[6]
Harvesting	Manual	Manual	Manual
Stripping	Manual	Manual	Manual
Shelling and cleaning	Manual	Manual	Manual

1. Land clearing and ridging was carried out using a hoe under LI and Ml. Plowing, harrowing, and ridging under HI were carried out using a tractor.
2. Sowing was done by hand with the onset of first planting rains (23 Nov 2000) in Ml and HI, and a week later (29 Nov 2000) in LI
3. Spacing between planting stations along the ridge.
4. Weeding was done twice in LI using a hoe and thrice in Ml and Hi. Hand weeding (pulling weeds by hand) was also carried out once in Ml and HI. Pre-emergence herbicide (chloroacetanilide) was applied soon after sowing in Hl.
5. One spray to control aphids at seedling stage.
6. Two sprays at 60 and 80 days after sowing to control early leaf spot.

Table 2. Cost of inputs and economic returns at three input levels for cultivation of groundnut in Malawi.

Description	Low input (LI)	Medium input (MI)	High input (HI)
Inputs (cost in MK)			
Seed[1]	1,400	6,400	6,400
Fertilizer[2]	0	0	1,606
Herbicide[3]	0	0	2,220
Insecticide[4]	0	0	780
Fungicide[5]	0	0	940
Top dressing*	0	0	2,800
Tractor cost[7]	0	0	4,744
Labor[8]	20,750	31,881	35,781
Packaging sacks	1,150	1,900	2,950
Total costs	23,300	40,181	58,221
Outputs			
Seed yield (t ha^{-1})	1.16	1.92	2.96
Haulm yield (t ha^{-1})	2.95	2.72	3.05
Returns			
Gross return (MK ha^{-1})[9]	40,689	67,150	103,419
Net return (MK)	17,389	26,968	45,198
Benefit-cost ratio	1.74	1.67	1,78

1. Cost of basic seed at MK 80 kg^{-1} for MI and HI and local seed at MK 35 kg^{-1} for LI.
2. Cost of triple superphosphate at MK 18.5 kg^{-1} in HI.
3. Cost of herbicide at MK 2,220 L^{-1} in HI at I L ha^{-1}
4. Cost of insecticide at MK I.950 L^{-1} applied in HI at 40 ml ha^{-1}
5. Cost of chlorothalonil at MK 940 L^{-1} applied in HI at 1 L ha^{-1}
6. Cost of gypsum at MK 16 kg^{-1} applied in HI at 175 kg ha^{-1}.
7. Cost of diesel and daily wages for tractor operator for plowing and ridging in HI.
8. Cost of labor in days at MK 50 day^{-1} for land preparation, ridging, planting, weeding, lifting, stripping, shelling, grading, and bagging.
9. Value of output at MK 35 kg^{-1} seed

3. High input: Large-scale estate farmers where field operations are generally mechanized following recommended cultural practices and have high level of inputs.

Three blocks, one hectare each, unreplicated, were planted to groundnut variety CG 7 to simulate the three input levels in groundnut production. Details of field operations and inputs applied in the three different input levels are presented in Table 1. Field operations, input levels, and crop management practices were carried out based on what is actually practiced by fanners in the defined input levels. Data on cost of various inputs as well as yield of pods, seed, and haulms were systematically collected.

Groundnut production costs

Production costs included costs of labor for land preparation, sowing, weeding, spraying of pesticides, lifting, stripping, shelling, grading, and bagging; chemicals (herbicides, insecticides, fungicides, fertilizers); seed; fuel for tractor; and packaging sacks. The production costs [calculated at US$ 1 = Malawi Kwacha (MK) 651 were MK 58,221 (US$ 894) in high input, MK 40,181 (US$ 617) in medium input, and MK 23,300 (US$ 359) in low input (Table 2). Chemicals and machinery were the sources of high production costs in high input level. Overall, stripping, and shelling were the major labor demanding activities in groundnut production and contributed about 40% to the total production cost at all three input levels.

Net output

Net output in high, medium, and low input levels was 2.96 t ha^{-1}, 1.92 t ha^{-1}, and 1.16 t ha^{-1}, respectively. A net output of 2.96 t ha^{-1} in high input compares well with high input systems in other groundnut-producing countries such as USA, Australia, Argentina, and Brazil where net output of 2.0 to 4.0 t ha^{-1} have been reported

(Freeman et al. 1999). The average groundnut yield among smallholder farmers using local varieties is about 0.45 t ha^{-1}. A net output of 1.16 t ha^{-1} therefore represents a yield advantage of 0.71 t ha^{-1}. This yield advantage therefore represents the benefit that farmers would get simply by replacing local groundnut varieties with improved groundnut varieties such as CG 7.

Net benefit

The net benefits in high, medium, and low input levels were MK 45,198 (US$ 695) ha^{-1}, MK 26,968 (US$ 415) ha^{-1}, and MK 17,389 (US$ 268) ha^{-1}, respectively. The value of haulms is not included in the analysis since information on prices of haulms is not available in Malawi. These results therefore represent lower bound of likely returns to farmers investing in groundnut production.

The results have shown that there are quite substantial returns to groundnut production at all input levels. The benefit-cost ratio of greater than one at all input levels simply suggests that it is worthwhile investing in groundnut production. Since 65% of Malawi's population is poor, cultivation of improved groundnut varieties can therefore play an important role in alleviating poverty in the smallholder sector.

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Groundnut Releases

New Groundnut Released in Malawi

P Subrahmanyam of ICRISAT-Lilongwe, Malawi reports that the Agricultural Technology Release Committee of the Government of Malawi has approved the release of ICG 12991 for cultivation in Malawi. ICG 12991 is a high-yielding, short-duration variety with resistance to groundnut rosette. This is the first rosette resistant short-duration variety released in the southern and eastern Africa region.

About 18% of Malawi's groundnut area is covered with 1CRISAT/DARTS developed improved varieties. With the recent releases (two in 2000 and one in 2001), and available funds from the ICRISAT/USAID Project for seed multiplication, the area under improved varieties will further increase. About US$ 0.35 million may be generated for groundnut seed production during 2001 through the revolving fund.

New Groundnut Varieties Released in Indonesia

Three groundnut varieties have been released recently for cultivation in Indonesia. Of these, ICGV 86031 and 87358 are direct introductions from ICR1SAT. In Indonesia, groundnut varieties are named after animals, so the former has been named as Kancil (mouse deer) and the latter as Turangga (horse).

Kancil is reported resistant to bacterial wilt and *Aspergillus flavus*, and tolerant to rust, leaf spot, and leaf chlorosis. It contains 50% oil and 30% protein. In the tests conducted at ICRISAT, it showed resistance to thrips, jassids, leaf miner, *Spodoptera*, and bud necrosis virus. It is also insensitive to photoperiod. Turangga is reported resistant to bacterial wilt, and moderately resistant to rust, leaf spot, and *A. flavus.* It is also tolerant to drought stress and shading. It has 47% oil content.

Sima, the third variety, is selected from a cross between ICGV 87165 and Majalengka. It is reported moderately resistant to *A. flavus* and tolerant to rust, leaf spot, drought, and acid soils. It contains *43%* oil and 22% protein. ICGV 87165 is an interspecific derivative developed at ICRISAT.

Till date, Indonesia has released six varieties of groundnut, which either originate from ICRISAT or are derived from ICRISAT-bred materials. The earlier three releases include ICG 1697 as Singa, ICG 1703 as Panter, and ICGV 86021 as Jerapah.

Groundnut Varieties Approved by the Plant Material Identification Committee (PMIC), ICRISAT during 2000–01

Original name	Genebank accession no.	Justification	Scientists/Researchers
ICGV 87354	ICG 15384	Drought tolerant and rust resistant elite germplasm	LS Reddy, SN Nigam, RC Nageswara Rao, and NS Reddy
ICGV 94361	ICG 15385	High yielding and early maturing, less susceptible to rust	HD Upadhyaya, SN Nigam, S Pande, AGS Reddy, and N Yellaiah
ICGV 86326	ICG 15386	Released in Korea as Jeokwangtangkong	Youn Sup Oh, Young Keun Cheon, Moon Soo Park, Soo Yeon Cho, SL Dwivedi, and SN Nigam
ICGV 91278	ICG 15387	Resistant to *Aspergillus flavus*, high yielding	HD Upadhyaya, SN Nigam, VK Mehan, AGS Reddy, and N Yellaiah
ICGV 91283	ICG 15388	Resistant to *A. flavus*, high yielding	HD Upadhyaya, SN Nigam, VK Mehan, AGS Reddy, and N Yellaiah
ICGV 91284	ICG 15389	Resistant to *A. flavus*, high yielding	HD Upadhyaya, SN Nigam, VK Mehan, AGS Reddy, and N Yellaiah
ICGV 92267	ICG 15390	High yielding and early maturing, less susceptible to rust and late leaf spot	HD Upadhyaya, SN Nigam, AGS Reddy, and N Yellaiah
ICGV 86143	ICG 15391	High-yielding, released as BSR 1 in Tamil Nadu, India	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, NS Reddy, N Yellaiah, and AGS Reddy
ICGV 86155	ICG 15392	High-yielding Spanish variety with 4 weeks post-maturity fresh-seed dormancy	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, AGS Reddy, N Yellaiah, and NS Reddy
ICGV 86156	ICG 15393	High-yielding Spanish variety with 4 weeks post-maturity fresh-seed dormancy	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, AGS Reddy, N Yellaiah, and NS Reddy
ICGV 86158	ICG 15394	High-yielding Spanish variety with 4 weeks post-maturity fresh-seed dormancy	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, AGS Reddy, N Yellaiah, and NS Reddy
ICGV 87378	ICG 15395	High-yielding Spanish variety with 4 weeks post-maturity fresh-seed dormancy	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, AGS Reddy, N Yellaiah, and NS Reddy
ICGV 87921	ICG 15396	High-yielding Spanish variety with 4 weeks post-maturity fresh-seed dormancy	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, AGS Reddy, N Yellaiah, and NS Reddy
ICGV 92196	ICG 15400	Early maturing, high yielding	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, AGS Reddy, N Yellaiah, and NS Reddy
ICGV 92206	ICG 15397	Early maturing, high yielding	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, AGS Reddy, N Yellaiah, and NS Reddy
ICGV 92234	ICG 15398	Early maturing, high yielding	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, AGS Reddy, N Yellaiah, and NS Reddy
ICGV 92243	ICG 15399	Early maturing, high yielding	HD Upadhyaya, SN Nigam, MJ Vasudeva Rao, AGS Reddy, N Yellaiah, and NS Reddy
ICGV 86011	ICG 15401	Spanish variety with 15 days seed dormancy, released as ALR 2 in Tamil Nadu, India	P Vindhiyavarman, A John Joel, V Mylswami, P Nagarajan, CS Raveendran, SL Dwivedi, SN Nigam, and GV Ranga Rao
ICGV 86388	ICG 15402	High yielding, moderately resistant to bud necrosis virus and thrips, resistant to jassids	SL Dwivedi, SN Nigam, DVR Reddy, GV Ranga Rao, and AS Reddy
ICGV 93470	ICG 15403	Early-maturing Spanish variety with 3–4 weeks of postharvest dormancy	HD Upadhyaya, SN Nigam, AGS Reddy, and N Yellaiah
ICGV 93382		Early maturing, high yielding, released as Sinpadetha 7 in Myanmar	HD Upadhyaya, SN Nigam, AGS Reddy, and N Yellaiah
ICGV 88438		Released as Nikoklia for cultivation in Cyprus	A Hadjichristodoulou, G Alexandrou, Chr Theodorides, M Mouzouris, SL Dwivedi, and SN Nigam
ICGV 89214		Released as Kouklia for cultivation in Cyprus	A Hadjichristodoulou, G Alexandrou, Chr Theodorides, M Mouzouris, SL Dwivedi, and SN Nigam
ICGV 99001		Source of resistance to late leaf spot	AK Singh, SL Dwivedi, S Pande, JP Moss, SN Nigam, and DC Sastry
ICGV 99003		Source of resistance to rust	AK Singh, SL Dwivedi, S Pande, JP Moss, SN Nigam, and DC Sastry
ICGV 99004		Source of resistance to rust and late leaf spot	AK Singh, SL Dwivedi, S Pande, JP Moss, SN Nigam, and DC Sastry
ICGV 99005		Source of resistance to rust	AK Singh, SL Dwivedi, S Pande, JP Moss, SN Nigam, and DC Sastry

Publications

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The world grondnut 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.

Publication from PARC

Muhammad Bashir, Zahoor Ahmad, and Nobuo Murata. 2000. Seed-borne viruses: detection, identification and control. Islamabad, Pakistan: Pakistan Agricultural Research Council. 156 pp. ISBN 969-409-129-2. Price in Pakistan Rs 200.00; other countries US$ 20.00.

About 90 percent of all food crops are attacked by devastating seed-borne pathogens. The transfer of genetic stock on a global scale, either for utilization or for conservation involves possible risks of widespread distribution of seedborne viruses. Such risks can be minimized by ensuring that imported as well as locally produced seeds are virus-free. The book covers all aspects related to seedborne viruses in seven chapters: characteristics of seedborne viruses; mechanism of seed transmission; seed health testing; serology in virus detection; quarantine and genetic resources; viruses of quarantine significance; and control of seed-borne viruses. More than 300 seed-borne viruses (including groundnut viruses) with their geographical distribution and percent seed transmission have been listed in the book.

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Groundnut publications

Akasaka, Y., Daimon, H., and Mil, M. 2000. Improved plant regeneration from cultured leaf segments in peanut *(Arachis hypogaea* L.) by limited exposure to thidiazuron. Plant Science 156:169-175.

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Information for IAN contributors

Publishing objectives

The International *Arachis* Newsletter is published annually by the International Crops Research Institute for the Semi-Arid Tropics (1CR1SAT), 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?

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

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

How to format contributions?

- Keep the items brief - remember, IAN is a newsletter and not a primary journal. About 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 tons instead of kg). Every table should fit within the normal type-written area of a standard upright page (not a 'landscape' page). Do not use the table-making feature of the word processing package; use simple tab set to prepare tables.
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- 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.
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Africa and Asia

IAN Scientific Editor
ICRISAT
Patancheru 502 324
Andhra Pradesh, India

Fax +9140 3241239
E-mail newsletter@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

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