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Publishing objectives

The *International Arachis Newsletter* (IAN) is published annually by ICRISAT, in cooperation with 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. An illustrative list is given here.

- Personal news (new appointments, awards, promotions, change of address, etc.)
- Reports of field days, meetings, tours, surveys, network activities, recently launched or concluded projects, etc.
- Short reports on recently held workshops, conferences, symposia, etc.
- Details of recent publications, with full bibliographic information and 'mini reviews' whenever possible.
- Results of recently concluded experiments, newly released varieties, recent additions to germplasm collections, etc.

How to format the 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).
- Black-and-white photographs and drawings (prepared in dense black ink on a white card or a heavy-duty tracing paper) are welcome–photocopies, color photographs, and 35-mm slides are not. Please send disk-files (with all the data) whenever you submit computer-generated illustrations.
- Keep the list of references short—not more than five references, all of which should have been seen in the original by the author. Provide all the details such as author/s, year, title of the article, full title of the journal, volume, issue, and page numbers (for journal articles), and place of publication and publishers (for books and conference proceedings) for every reference.
- Express all the quantities only in SI units.
- Spell out in full every acronym you use.
- Give the correct Latin name of every crop, pest, or pathogen at the first mention.
- Type the entire text in double spacing. Whenever possible, please send a file, which should match the printout, on a double-sided/high density IBM-compatible disk. WordPerfect 5.1 files are preferred; if that is not possible, send an ASCII file instead.

We will carefully consider all submitted contributions and will include in the Newsletter those that are of acceptable scientific standard and conform to requirements. The language of the Newsletter is English, but we will do our best to translate articles submitted in other languages. Authors should closely follow the style of the reports in this issue. Contributions that deviate markedly from this style will be returned for revision, and could miss the publication date.

If necessary, we will edit communications so as to preserve a uniform style throughout the Newsletter. This may shorten some contributions, but particular care will be taken to ensure that the editing will not change the meaning and scientific content of the article. Wherever we consider that substantial editing is required, we will send a draft copy of the edited version to the contributor for approval before printing.

Contributions should be mailed to:

Southern and Eastern Africa
P Subrahmanyam
Groundnut Coordinator (SADC)
SADC/ICRISAT Groundnut Project
Chitedze Agricultural Research Station
P O Box 1096
Lilongwe, Malawi

West Africa
B R Ntare
Groundnut Coordinator (ISC)
ICRISAT Sahelian Center
B P 12404
Niamey (via Paris)
Niger

Rest of the world
S N Nigam
Groundnut Coordinator (IAC)
ICRISAT Asia Center
Patancheru 502 324
Andhra Pradesh
India

Requests for inclusion in the mailing list should be addressed to:

The Editor
International Arachis Newsletter
ICRISAT Asia Center
Patancheru 502 324
Andhra Pradesh
India

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Contents

News and Views

Editorial 1
Golden Groundnut from Black Soils 1
Regional Groundnut Workshop for Western and Central Africa 1
Groundnut Production Technology Training Course 2
News from CLAN
Working Group Meeting on Groundnut Viruses 3
Training Course on Groundnut Viruses 3
Workshop on Achieving High Groundnut Yields 4
Training Workshop on On-farm Adaptive Research 5
Geographic Information Systems 5
Book Review – "Sustainability in Oilseeds" 5
New ICRISAT Publications 6

Research Reports

Hybridization Between Wild Species and Cultivated Varieties in Genus *Arachis* 9
Stability of Pod Yield in Foliar Disease-Resistant Groundnut Varieties 9
Release of Cultivar Zhonghua 117 in China 11
Birsa Bold 1, a Promising New Confectionery Variety of Groundnut 12
Brazilian Growers have a New Groundnut Cultivar 12
BSR 1 (ICGV 86143), a High-Yielding Spanish Bunch Groundnut Variety for the Western Zone of Tamil Nadu 13
Utilization of Residual Genetic Heterogeneity in a Phenotypically Homogenous Population of Groundnut Variety RSB 87 14
Performance of Groundnut Varieties at the Agricultural Research Station, Bhavanisagar 15
Diversity in the Australian Groundnut Germplasm Collection 15
Chemical Characteristics of Argentinean Groundnut Cultivars 17
Performance of Groundnut Varieties in the Postrainy/Summer Seasons in the Alluvial Tract of West Bengal 18
Stability of Some Spanish Groundnut Varieties 20
Tapioca Pearls—A Potential Substitute for Agar in Microbiological Media 21
Survey of Groundnut Diseases in Northern Malawi 22
Toward Standardization of a Laboratory Screening Technique for Early Leaf Spot Resistance in Groundnut 24
Comparison of Whole-Plant and Detached-Leaf Methods for Studying Components of Rust Resistance in Groundnut 25
Variation in the Sensitivity of Groundnut Rust to Tridemorph in Central Maharashtra 28
Temperature Sensitivity of Sclerotium Stem Rot Resistance in Groundnut 30
Resistance to Rust and Leaf Spots in ICRISAT Groundnut Lines in Eastern Sri Lanka 31
Effect of Humidity on Conidial Morphology of *Phaeoisariopsis personata* 33
Assessment of Losses in Groundnut Due to Early and Late Leaf Spots 34
Evaluation of Elite Bunch Entries for Productivity and Resistance to Late Leaf Spot in the Transitional Tract of Karnataka 36
Evaluation of Foliar Disease-Resistant Mutants in Groundnut 38
Reaction of Some ICRISAT Groundnut Varieties to Bacterial Wilt Disease in China 40
Identification of Sources of Resistance to Bacterial Wilt in Groundnut Germplasm Under Southern Vietnamese Conditions 41

Aflatoxin-Producing Potential of Various Strains of *Aspergillus flavus* from Groundnut Fields in Different Soil Types 42
Host Races of *Meloidogyne javanica*, with Preliminary Evidence that the 'Groundnut Race' is Widely Distributed in India 43
Preliminary Investigation of a 'Peg Drying' Problem of Groundnut 45
Bioefficacy of *Paecilomyces lilacinus* in Controlling *Meloidogyne javanica* (Pathotype 2) on Groundnut 46
Groundnut Virus Identity Problem? 47
Evaluation of an Aphid-Resistant Groundnut Genotype (EC 36892) in China 49
Survey of Groundnut Virus Diseases in Pakistan 51
Confirmation of the Effects of Plant Density and Irrigation on Peanut Bud Necrosis Disease Incidence 52
Improved Diagnosis and Control of Peanut Stripe Virus—Progress and Future Directions of an ACIAR-Funded Project Involving Australia, Indonesia, and China 53
Effect of Simulated Rainfall on Eggs and Larvae of the Groundnut Leafminer, *Aproaerema modicella* 55
Bio-efficacy and Development of a Reduviid Predator, *Rhinocoris marginatus*, on *Spodoptera litura* 56
Developmental Stages and Biocontrol Potential of a Reduviid Predator, *Acanthaspis pedestris*, against Termites on Groundnut 57
Screening Promising Groundnut Varieties Against Termite Damage at Bhubaneswar, Orissa, India 59
Effectiveness of Soil-Applied Insecticides Against Foliage- and Pod-Feeding Arthropod Pests in Burkina Faso 60
Current Status of Synthetic Pyrethroid Resistance in *Helicoverpa armigera* Populations on Groundnut 62
Recent Developments in the Groundnut Industry in Zimbabwe 63
Groundnut Production on the Coast of Oaxaca, Mexico 64
Possibility of Groundnut Cultivation in a Subtropical Area of Ethiopia 65
Collaboration Between the Institut National de la Recherche Agricole du Bénin and ICRISAT Sahelian Center 67
Effect of Transparent Polythene Mulch during the Reproductive Stages of Groundnut 68
Bioenergetic Considerations in Increasing Groundnut Yield 69
Performance of Spanish Groundnut TG 26 Under Varying Plant Density 71
Plant Population Dynamics of Groundnut/Mustard Intercropping 72
Effect of Different Irrigation Schedules and Methods of Sowing and Irrigation on Yield, Economics, and Water Saving in Summer Groundnut 73
Response of Groundnut Varieties to Fertilizer Nitrogen in Medium Black Soils of the Konkan Region of Maharashtra, India 76
Response of Erect Bunch Groundnut Genotypes to Nitrogen Fertilizer 77
Response of Groundnut to Boron With and Without Molybdenum and Lime in Lateritic Soils (Aeric Haplaquept) in Orissa, India 79
Influence of Organic Amendments on Groundnut Pod and Oil Yields in *Theri* Soils (Typic Ustipsamments) 81
Farming Situation Based Extension Approach for Groundnut 82
Yield, Water-Use Efficiency, and Moisture Extraction Pattern of Summer Groundnut under Different Irrigation Schedules, Row Spacings, and Seed Rates 83
Effect of Irrigation, Interrow Spacing, and Seed Rate on Quality and Economics of Summer Groundnut 85
Effect of 'Green Gold Plus' Application on Groundnut Yield 86
Effects of Crop Residue Burning and Calcium Supply on the Growth of Groundnut Cultivars in a Sandy Clay Soil in Congo 87

News and Views

Editorial

This issue of the *International Arachis Newsletter* contains papers from Argentina, Australia, Benin, Brazil, China, the Republic of Congo, Ethiopia, India, Malawi, Mexico, Sri Lanka, Vietnam, and Zimbabwe, and news of recent developments in Israel and training courses and workshops in Asia and Africa. They provide evidence of rapidly improving research capabilities throughout the semi-arid tropics, and of close cooperation among national programs, developmental agencies, nongovernmental organizations, international research institutes, and funding agencies.

The *Newsletter* continues to grow in scope and in readership. Along with this growth, we would like to see a shift in emphasis. This is primarily a vehicle for exchanging information on groundnut, rather than a formal research journal—long-term results (e.g., several years' data) deserve publication and wide dissemination in refereed journals. Research results (usually preliminary results) will continue to form the bulk of the contents, but future issues will contain more 'news' items—reports on workshops and meetings, examples of successful technology transfer, and information on farming systems in which groundnut has been introduced.

Please bear this in mind when you send contributions for issue no. 16, to be published in 1996. Articles must reach Groundnut Coordinators (see inside cover) by April 1996, to allow us sufficient time for review and publication.

Drs L J Reddy and G V Ranga Rao, editors for the previous issue, have left the *Newsletter* in good shape; and with help from readers and contributors, we will ensure that it continues to disseminate information quickly and effectively, and promote greater cooperation between groundnut workers worldwide.

S N Nigam

Golden Groundnut from Black Soils

Groundnut is one of the more important irrigated crops in Israel; about 24 000 t of pods are produced from 4500 ha each year. About 60% of the produce is intended for export in shell to European markets. Annual exports amount to 14 000 t, worth approximately US$ 15 million. Pod yield levels in Israel are 5–6 t ha^{-1}; with a national average close to 5.5 t ha^{-1}, the possibility for further improvement still exists.

A sophisticated new technique has been implemented on heavy black soils (and organic black soils) to produce golden in-shell groundnut for export markets, where it is extremely popular. The new technique was developed after intensive experiments on drip irrigation and bed shape, conducted in northern Galilea. Farmers have adopted the new method, and yields—and profits—have jumped.

The lighter soils in Israel are already fully exploited. To increase groundnut production, the challenge was to develop technologies to extend cultivation to heavy black soils. These results show that this challenge can be successfully met.

Shimon Dar
Chief Peanut Specialist, Ministry of Agriculture
P O Box 7054, Hakirya, Tel Aviv
Israel

Regional Groundnut Workshop for Western and Central Africa

The Fourth Regional Workshop for Western and Central Africa was held at ICRISAT Sahelian Center (ISC) in Niger from 29 Nov to 2 Dec 1994. The Workshop was organized within the framework of the NARS/ICRISAT consultation process for effective collaboration. It was cosponsored by ICRISAT, the Conférence des responsables de la recherche agronomique africains (CORAF), and Peanut CRSP—testimony to the cooperation between ICRISAT and other agencies operating in the region. Participants came from Benin, Burkina Faso, the Central African Republic, Congo, Côte d'Ivoire, France, Ghana, Guinea, India, Madagascar, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo, Chad, and the USA. The papers presented at the Workshop will be published as a Summary Proceedings. Several recommendations were made to improve and stabilize groundnut production in western and central Africa:

- ICRISAT should continue to support and assist NARS in establishing their own screening facilities and to enable groundnut breeders within the region to benefit from each other's experience and skills.
- National programs should collect and characterize local germplasm using their resources, and deposit duplicate samples with ICRISAT for preservation, pending the operationalization of the germplasm center for western Africa.

- National programs were encouraged to utilize the diverse breeding material from ICRISAT. In order to minimize duplication of effort, national programs should focus not just on yield trials but also on the evaluation of advanced lines. ICRISAT should concentrate on germplasm distribution, and accumulation and dissemination of information on new elite sources (with resistance to diseases, drought, insects, etc). Selected nurseries for specific purposes (e.g., disease evaluation) should be established on a regional basis.
- ICRISAT should offer more specialized training in different disciplines to allow scientists and technicians to improve their skills, for long-term improvement of NARS research capabilities.
- The formation of an Aflatoxin Task Force was endorsed, and it was recommended that this approach be extended to such other crop protection issues as foliar diseases and viruses.
- Due to the uneven dissemination of information on nematode damage and management, it was strongly recommended that efforts be made to share information and technology on the subject among NARS.
- There is a need for integrated surveys of soil pests and diseases across the region to diagnose problems and prioritize future research activities. This should be done within a farming systems framework.
- Regional study tours should be held between regional workshops. This would enable specialists from linked disciplines to exchange information more effectively.
- Scientists were encouraged to inform public officials about the seriousness of health hazards caused by aflatoxin contamination in groundnut. It would be useful to produce a brochure on the subject.
- Protocols for regional trials should include an evaluation of the economic value of crop protection measures, in the context of integrated pest and disease management.
- The availability of improved seed remains a major constraint. The germplasm project elaborated under the auspices of the Food and Agriculture Organization of the United Nations (FAO) can make a positive contribution; the group recommended that this project should not be limited to germplasm conservation, but should include seed multiplication and distribution of foundation seed of released varieties, studies on postharvest problems, and assistance to NARS in these areas.
- There is a need to characterize groundnut production systems and environments to better understand the factors limiting production.
- Technologies developed must be based on farmers' needs and resources, and should address the socioeconomic constraints they face. The importance of socioeconomics is still not fully appreciated by research teams; all institutions involved in groundnut research should redouble their efforts in this area.
- Research on postharvest technology is a weak link in many research programs. This area should receive more attention, and research results should be widely disseminated.
- Research results can help increase groundnut production only if the agronomic plan is well organized, and logistical and socioeconomic factors are considered. Researchers should be familiar with market trends, producers' constraints, and consumer demands. These domains should constitute an important component of research programs in close collaboration with farmers' organizations, nongovernmental organizations, and the private sector.
- The workshop reiterated the negative impact of aflatoxin on the economy and on human and animal health, and approved of the initiative taken by ICRISAT, Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), and Peanut CRSP to prepare a multidisciplinary project on the control of aflatoxins in groundnut. A working group led by Dr V K Mehan of ICRISAT was charged with the task of preparing this project.

Groundnut Production Technology Training Course

The Southern African Development Community (SADC)/ICRISAT Groundnut Project based at the Chitedze Agricultural Research Station, Malawi, organized a training course on Groundnut Production Technology from 1 to 10 Mar 1995. Twenty-one research technicians (including nine women) participated, representing 10 SADC countries—Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe. The course was coordinated by Dr Pala Subrahmanyam, ICRISAT Country Representative.

The training course was inaugurated by Dr A S Kumwenda, Deputy Chief Agricultural Research Officer, Ministry of Agriculture, Government of Malawi. In his inaugural address, Dr Kumwenda observed that groundnut production in the region had declined in recent years. Yields are low (400–700 kg ha^{-1}, in marked contrast to 4 t ha^{-1} on research stations and commercial farms), largely due to diseases, insect pests, and the lack of suitable varieties. Where improved cultivars are available, nonavailability of seed and difficulties in seed multiplication have contributed to the low production levels.

Groundnut production technology course—participants visit a farmer's field in Namwera, Malawi. The cultivar is CG 7 (ICGMS 42).

The 10-day course covered a range of subjects:

- Groundnut production, constraints, and research in the SADC region
- Groundnut varietal improvement in the SADC region
- Improved cultural practices
- Management of diseases and insect pests
- On-farm research methodologies
- Seed production at smallholder and commercial levels
- Socioeconomic survey methodologies.

News from CLAN

Working Group Meeting on Groundnut Viruses

The International Working Group Meeting on Groundnut Viruses in the Asia Pacific Region was held during 13–15 Mar 1995 at Khon Kaen University, Khon Kaen, Thailand. The Working Group consists of scientists from 12 Asian countries (Bangladesh, Cambodia, China, India, Indonesia, Laos, Myanmar, Nepal, Pakistan, Sri Lanka, Thailand, and Vietnam), and from Australia, Belgium, Netherlands, UK, and USA. The purpose of the meeting was to review progress made on detection, identification, characterization, and management of the major groundnut viruses in the Asia Pacific region.

Country representatives summarized the status of research on groundnut viruses in their countries, which varied from substantial information (India, China, Thailand, Indonesia) to very limited knowledge of viruses (Laos, Cambodia, Vietnam, Myanmar). Although work on the integrated management of groundnut viruses is in progress, it was agreed that a more consolidated effort was needed. Various components—resistance (conventional and non-conventional), cultural practices, biological control of vectors, variation in virus, use of virus-free seed, and possibly the strategic use of insecticides—were considered as potential components of an integrated virus management strategy.

Training Course on Groundnut Viruses

A training course on Identification and Detection of Viruses of Legumes with Special Emphasis on Groundnut was held from 27 Feb to 11 Mar 1995 at Khon Kaen University, Thailand. The 2-week course, conducted for research scientists and plant quarantine officers from Asia, was organized jointly by the Cereals and Legumes Asia Network (CLAN)/ICRISAT, the Noble Foundation, Peanut CRSP, and FAO. Thirteen participants from Bangladesh, Cambodia, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Pakistan, Sri Lanka, Thailand, and Vietnam attended.

They received hands-on training in virus detection methods such as nucleic acid hybridization using non-radioactively labeled cDNA probes, and on PCR and other molecular biology techniques. The participants also presented overviews of their work and reported on the status of research on groundnut viruses in their respective countries.

Workshop on Achieving High Groundnut Yields

An International Workshop on Achieving High Groundnut Yields was held during 25–29 Aug 1995 at Laixi, China. The Workshop was cosponsored by the Chinese Academy of Agricultural Sciences, Beijing, Shandong Academy of Agricultural Sciences, Jinan, and ICRISAT. The schedule comprised a 2-day visit to farmers' fields around Laixi in Shandong province, followed by 3 days of presentations and discussions. During the field visit, participants saw groundnut fields where farmers use high-yield technologies to obtain average yields of around 4 t ha^{-1}. Farmers practice intensive cultivation with adequate inputs, including optimum plant populations, up to 50 t ha^{-1} of manure, plus chemical fertilizers, herbicides, growth hormones, and pesticides. Over 90% of the farmers used polythene film mulching, which extends the effective growing season by raising soil temperatures. This substantially improves conditions for seed germination and initial seedling growth in the spring season, when temperatures are low.

Reports were presented on the status of high-yield technologies in nine countries; there were also thematic papers, papers on technology transfer in China, plus 20 contributed papers from Chinese participants. The Workshop Proceedings will be published by ICRISAT, and will include abstracts in both English and Chinese.

Some of the major recommendations of the Workshop were:

- Breeding strategies for regions/countries should consider the balance/trade-off between high yield on the one hand and resistance and improved quality parameters on the other.
- Exchange of germplasm and breeding material among countries should be increased.
- Constraints to production should be categorized separately for regions with different productivity levels (e.g., high, medium, and low productivity) and research planned accordingly, rather than using a broad-brush approach for constraint alleviation.
- Drought, soil-related problems (fertility, acidity, alkalinity, nutrient deficiencies, etc.), low temperature, drainage, pests, diseases, weeds, and the non-availability of good seed were the major management-related constraints.
- The need for information exchange among groundnut scientists (informal means, newsletters, networks, working groups, meetings, etc.) was emphasized.
- Several constraints, needs, and opportunities for technology transfer were identified in the countries represented, and suggestions were made as to how to facilitate technology transfer.
- Participants strongly recommended an exchange program (allowing scientists from one country to work in another) to strengthen technology exchange.

Farmers in Laixi province enjoy bumper yields, achieved with a combination of high inputs and innovative cultural practices.

Training Workshop on On-farm Adaptive Research

An In-country Training Workshop on On-farm Adaptive Research (20–21 Jun 1995) was jointly organized by CLAN/ICRISAT and the Department of Agriculture, Sri Lanka, at the In-Service Training Institute, Gannoruwa, Kandy. Participants were drawn from the Department of Agriculture and Provincial Agricultural Offices involved in extension and on-farm research. The course covered needs for on-farm adaptive research (OFAR), concepts and techniques in OFAR, problem identification and prioritization, planning and implementation, and adoption and impact assessment of improved technologies.

Geographic Information Systems

CLAN/ICRISAT helped to orgaize two meetings on geographic information systems (GIS) in Thailand this year. A workshop on the 'Role of GIS in developing and transferring sustainable agriculture technologies in the tropics' was held at the Asian Institute of Technology, Bangkok, from 20 Feb to 7 Mar 1995. There were 27 participants from China, India, Indonesia, South Korea, Laos, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand, Vietnam, Ecuador, and the USA. The focus of discussions was the use of GIS for analyzing ecoregional multisectoral data to identify factors that limit the sustainability of agriculture in the tropics. Participants worked with georeferenced relational databases and presented case studies (prepared during the Workshop) on rice-wheat cropping, sorghum-pigeonpea systems in rainfed agriculture, and crop diversification through the introduction of legumes.

A subsequent 'Meeting of decision and policy makers to discuss the present status and future needs of GIS databases and remote sensing for developing plans for sustainable agricultural development' was held at the same location during 6–7 March. Senior research administrators from India, Nepal, and the Philippines attended. Case studies prepared by participants at the earlier workshop were presented. It was suggested that the available hard-copy datasets be transformed into readily usable form through GIS; they would then become a useful tool for making policy decisions on food security and agricultural research planning and investment.

Book Review – 'Sustainability in Oilseeds'

Prasad, M.V.R., Kalpana Sastry, R., Raghavaiah, C.V., and **Damodaram, T.** (eds.). 1994. Sustainability in oilseeds. Rajendranagar, Hyderabad 500 030, India: Indian Society of Oilseeds Research, Directorate of Oilseeds Research. 612 pp. Price Rs 500 (India), US$ 50 (other countries).

This publication is a compilation of 137 papers presented at the National Seminar on Oilseeds Research and Development in India: Status and Strategies, held during 2–5 Aug 1993 at Hyderabad, India. The Seminar was organized by the Indian Society of Oilseeds Research and cosponsored by 11 national and international organizations. There were five sessions—Genetic enhancement of oilseed crops, Sustainability of oilseed production systems, Postharvest processing technology, Vegetable fat in the human diet, and Development scenario and strategies—and a panel discussion on market interventions and policy support.

The papers on genetic enhancement cover germplasm evaluation, conservation, and utilization in nine annual oilseed crops (groundnut, rapeseed/mustard, soybean, sunflower, sesame, linseed, safflower, castor, and niger) and palms and minor oil-bearing species. Various breeding strategies (conventional, mutation, and biotechnological approaches) are discussed, and there is plenty of useful information on techniques and methodologies.

Another section focuses on ways to achieve sustainability in production, with an emphasis on economic sustainability and expansion of oilseeds cultivation into new areas. The reviews on postharvest technologies discuss methods to reduce harvest losses and improve quality. Other papers discuss fat intake patterns, nutritional and quality aspects, and the demand/supply situation in India.

A number of suggestions are made on how to ameliorate production constraints; the suggestions relate to the role of the Technology Mission on Oilseeds, extension strategies in macro- and micro-level planning, the supply of critical inputs and services, and the role of the private sector. The panel on market intervention and policy support recommended that market intervention be strengthened by involving the National Dairy Development Board and oilseeds cooperatives, to achieve stability in prices.

This publication is highly informative. Copies are available with the General Secretary, Indian Society of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad 500 030, India.

P S Reddy

New ICRISAT Publications

Mehan, V.K., and **McDonald, D.** 1995. Techniques for diagnosis of *Pseudomonas solanacearum*, and for resistance screening against groundnut bacterial wilt: a manual. Technical Manual no. 1. 68 pp. ISBN 92-9066-315-4. Order code TME 001. Price US$ 7.42 (LDC[1]), US$ 14.52 (HDC), Rs 114.50 (India).

This publication, the first in a new ICRISAT series, presents techniques for detection, isolation, and identification of all variants of *Pseudomonas solanacearum*, the pathogen that causes bacterial wilt, a widespread and destructive disease of groundnut. The use of enzyme-linked immunosorbent assay (ELISA) to detect the bacterium in plant tissues, seed, and soil is emphasized. DNA-based diagnostics for *P. solanacearum* are described, as are an infectivity titration technique to determine the virulence of the wilt pathogen, and several inoculation techniques used in evaluating host-plant resistance.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1995. Food from Thought. No. 1. Integrated management of a groundnut pest on India's eastern coast. 8 pp. Order code FTE 001. Single copies free.

This is the first of a series of narratives on the practical application of research conducted by ICRISAT and its collaborators. It describes methods used successfully by farmers in Andhra Pradesh to control the armyworm *Spodoptera litura.*

Mehan, V.K., Mayee, C.D., Brenneman, T.B., and **McDonald, D.** 1995. Stem and pod rots of groundnut. Information Bulletin no. 44. 28 pp. ISBN 92-9066-314-6. Order code IBE 044. Price US$ 4.23 (LDC), US$ 9.03 (HDC), Rs 79.60 (India).

Stem and pod rots caused by *Sclerotium rolfsii* affect groundnut crops in many countries, reducing yields by 10–25%. Pod yield losses can reach over 80% in heavily infested fields. This publication summarizes the considerable progress that has been made in understanding the epidemiology of the diseases. Effective greenhouse- and field-screening techniques have been developed, sources of resistance identified, and some resistant cultivars bred. Options for disease management are discussed, and an integrated approach is advocated.

1. LDCs = less developed countries. HDCs include Australia, Canada, European countries, Iran, Iraq, Japan, Kuwait, Libya, New Zealand, Saudi Arabia, South Africa, and USA. All prices include postage.

Subrahmanyam, P., McDonald, D., Waliyar, F., Reddy, L.J., Nigam, S.N., Gibbons, R.W., Ramanatha Rao, V., Singh, A.K., Pande, S., Reddy, P.M., and **Subba Rao, P.V.** 1995. Screening methods and sources of resistance to rust and late leaf spot of groundnut. Information Bulletin no. 47. 24 pp. ISBN 92-9066-319-7. Order code IBE 047. Price US$ 3.83 (LDC), US$ 7.83 (HDC), Rs 65.60 (India).

Rust and late leaf spot are the most serious fungal diseases of groundnut worldwide, and can cause devastating yield losses when they occur together. This Bulletin describes simple and effective field screening methods to identify genotypes with resistance to these diseases. Production of inoculum, sowing and inoculation of test genotypes, and disease assessment in the field are discussed. These methods were used to evaluate ICRISAT's world collection of over 12 000 groundnut accessions. Several reliable sources of resistance to rust and/or late leaf spot were identified, and are listed.

Johansen, C., Lee, K.K., Sharma, K.K., Subbarao, G.V., and **Kueneman, E.A.** (eds.). 1995. Genetic manipulation of crop plants to enhance integrated nutrient management in cropping systems—1. Phosphorus: proceedings of an FAO-ICRISAT Expert Consultancy Workshop, 15–18 Mar 1994, ICRISAT Asia Center, India. 184 pp. ISBN 92-9066-296-4. Order code CPE 094. Price US$ 12.67 (LDC), US$ 31.07 (HDC), Rs 286.20 (India).

This Workshop forms part of an overall endeavor to establish a global consortium of researchers focusing their efforts on improving the ability of crop plants to acquire phosphorus, particularly through sources from which it is only sparingly available. These sources include bound forms of soil phosphorus and such fertilizers or amendments as rock phosphate. This volume explains the overall procedures followed, presents the formal papers prepared for the Workshop, and highlights the outcome of the deliberations in the form of a preliminary draft proposal for a global project. A background paper covers the possibilities of favorably manipulating phosphorus acquisition. Position papers examine in detail the prospects for favorable manipulation of specific components of phosphorus acquisition.

Buiel, A.A.M., Parlevliet, J.E., and **Lenné, J.M.** (eds.). 1995. Recent studies on peanut bud necrosis disease: proceedings of a Meeting, 20 Mar 1995, ICRISAT Asia Center, India. 1995. 80 pp. ISBN 92-9066-318-9. Order code CPE 100. Price US$ 6.37 (LDC), US$ 14.37 (HDC), Rs 127.90 (India).

The current status of research on peanut bud necrosis disease caused by the peanut bud necrosis virus and its vector *Thrips palmi* is reviewed. Recent advances in the genome structure, host range, transmission, and spread of tospoviruses with emphasis on the peanut bud necrosis virus are discussed. The epidemiology of the disease and resistance to both the vector and the virus are reviewed in detail. Agronomically acceptable varieties with resistance to the vector and/or the virus are now available.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1995. ICRISAT Report 1994. 80 pp. ISSN 1017-9933. Order code IRE 005. Price US$ 18.58 (LDC), US$ 48.98 (HDC), Rs 462.20 (India).

Presents a digest of major events at ICRISAT and the Institute's achievements during 1994. Contents include an introduction by the Director General and the Chairman of the Governing Board, sections on the year's highlights, financial summaries, technology exchange, plant material releases, and a list of senior staff.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1995. ICRISAT Publications Catalog. 94 pp. Order code GAE 009. Single copies free.

Lists current and microfiched out-of-print publications from the Institute, supplemented with brief descriptions of their contents.

Bantilan, M.C.S., and **Joshi, P.K.** (eds.). 1994. Evaluating ICRISAT research impact: summary proceedings of a Workshop on Research Evaluation and Impact Assessment, 13–15 Dec 1993, ICRISAT Asia Center, India. 148 pp. ISBN 92-9066-302-2. Order code CPE 091. Price US$ 14.30 (LDC), US$ 36.50 (HDC), Rs 345.20 (India).

Research evaluation and impact assessment (REIA) at ICRISAT is recognized as an important part of research planning, and serves several functions: to quantify the impact of research products on their final clientele; to improve research planning and priority setting, given limited research resources; to develop an information and decision-support system for scientists and research managers; and to establish greater accountability with donors and funding agencies.

The workshop was attended by scientists of various disciplines (from ICRISAT and several other research institutions) and by representatives from the seed sector. This summary proceedings discusses the various research outputs from ICRISAT research, impact indicators, and other socioeconomic factors relevant to REIA. The workplans for implementing REIA, recommended at the Workshop, are also recorded.

Rupela, O.P., Kumar Rao, J.V.D.K., Wani, S.P., and **Johansen, C.** (eds.). 1994. Linking biological nitrogen fixation research in Asia: report of a meeting of the Asia Working Group on Biological Nitrogen Fixation in Legumes, 6–8 Dec 1993, ICRISAT Asia Center, India. 140 pp. ISBN 92-9066-297-2. Order code CPE 092. Price US$ 13.21 (LDC), US$ 33.31 (HDC), Rs 313.20 (India).

Reports from Bangladesh, Nepal, Thailand, and India on the on-farm use of rhizobial inoculants are presented. Other topics covered include the status of soybean *Bradyrhizobium* research in India, the influence of cropping systems and other factors on population of cowpea rhizobia, improvement of biological nitrogen fixation (BNF) in groundnut by host-plant selection, expectations of research administrators and breeders from BNF research, intra-varietal variability in nodulation in chickpea and pigeonpea, the role of legumes in cropping systems, and iron chlorosis in groundnut. Details are given of experiments on rhizobial inoculants and on host-plant selection for high BNF. Working Group workplans are outlined.

Sharma, S.B., and **McDonald, D.** 1994. International agricultural research on diseases caused by nematodes—needs and constraints: summary and recommendations of a satellite meeting of the International Congress of Plant Pathology, 6 Aug 1993, Montreal, Canada. 24 pp. ISBN 92-9066-300-6. Order code CPE 093. Price US$ 3.09 (LDC), US$ 6.69 (HDC), Rs 60.30 (India).

In conjunction with the International Congress of Plant Pathology (28 Jul to 6 Aug 1993) in Montreal, Canada, a satellite meeting was organized by ICRISAT to discuss the role of international agricultural research centers in alleviating the constraints that nematode diseases impose on the production of food crops, especially in developing countries. Twenty scientists from 10 countries and two international centers participated. This publication provides a background to the meeting, a record of discussions on research strategies, priorities, and collaborative activities, and recommendations for future research.

Mehan, V.K., and **McDonald, D.** (eds.). 1994. Groundnut bacterial wilt in Asia: proceedings of the Third Working Group Meeting, 4–5 Jul 1994, Oil Crops Research Institute, Wuhan, China. 160 pp. ISBN 92-9066-308-1. Order code CPE 095. Price US$ 11.29 (LDC), US$ 27.29 (HDC), Rs 250.20 (India).

The current status of research on bacterial wilt of groundnut in Asia is reviewed. Particular emphasis is given to recent advances in serological and molecular techniques for identification and differentiation of races, biovars, and strains of the wilt pathogen, *Pseudomonas solanacearum*. Recommendations are made for further collaborative research, and the need to interest potential

donors in promoting the Group's activities is emphasized. The publication includes country papers summarizing the status of the disease in China, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam. Each paper includes abstracts in both Chinese and English.

Ndunguru, B.J., Hildebrand, G.L., and **Subrahmanyam, P.** (eds.). 1994. Sustainable groundnut production in southern and eastern Africa: proceedings of a Workshop, 5–7 Jul 1994, Mbabane, Swaziland. 162 pp. ISBN 92-9066-309-X. Order code CPE 096. Price US$ 11.39 (LDC), US$ 27.59 (HDC), Rs 253.20 (India).

Sustainable agricultural practices are essential if the natural resource base is to be conserved while improving productivity. Thirty-three delegates from 11 countries in southern and eastern Africa (including South Africa), and from ICRISAT and the Southern African Centre for Cooperation in Agriculture and Natural Resources Research and Training (SACCAR), participated in this Workshop. Recent research on groundnut was reviewed, through presentations that discussed the role of four broad disciplines—genetic enhancement, crop protection, agronomy, and technology transfer—in sustainable groundnut production. The Workshop recommendations are summarized; priority areas include characterization of drought-prone environments, establishment of drought nurseries, surveys on pests, diseases, and aflatoxin contamination, on-farm trials, and more effective technology transfer.

Publications in other languages

Several previously published titles have been translated into different languages, and are now available. All prices given below include postage.

- A groundnut insect identification handbook for India (Information Bulletin no. 39) is available in Telugu (order code IBL 039), Marathi (order code IBM 039), and Tamil (order code IBT 039). Price US$ 6.18 (LDC), US$ 15.78 (HDC), Rs 152.30 (India).
- Web blotch disease of groundnut (Information Bulletin no. 43) is available in Portuguese (order code IBP 043). Price US$ 3.64 (LDC), US$ 7.44 (HDC), Rs 63.60 (India).
- Peanut stripe virus (Information Bulletin no. 38) is available in French (order code IBF 038). Price US$ 2.68 (LDC), US$ 5.28 (HDC), Rs 45.30 (India).

Research Reports

Hybridization Between Wild Species and Cultivated Varieties in Genus *Arachis*

Ronghua Tang, Hanqun Zhou, and **Tsai Chi-Yeh** (Research Institute of Economic Crops, Guangxi Academy of Agricultural Science, Nanning, Guangxi 530007, People's Republic of China)

Wild *Arachis* species were introduced into China in 1981. Soon after their introduction, work began on hybridization between wild species and cultivated varieties. Various pathways to hybridization were followed. This paper summarizes the progress made in China during 1981–91 in interspecific hybridization using different approaches.

Triploid pathway. Eighteen crosses were made, of which only three (Huoyue no. 1 × *A. correntina*, Guangliu × *A. villosa*-1, Liuzhouzhenzhudou × *A. cardenasii*) produced hybrid progenies. Some triploids produced seeds, spontaneously changing their ploidy level. In early generations of these triploids, most of the plants were runner types, vigorous, and highly resistant to rust and leaf spot like their wild parents. Erect plants were observed in the F_5 generation, and the progenies became stable in F_9 or F_{10}. There were more two-seeded pods in advanced generations. High-yielding lines with superior seed quality and moderate resistance to rust and late leaf spot (mid-parent scores) have been obtained from the progenies of triploid hybrids. The seeds of some of these lines contain up to 59% oil.

Hexaploid pathway. One hundred and twenty-seven crosses were made using wild species (e.g., *A. stenosperma, A. correntina, A. villosa*-1) as male parents. The female parents were cultivated varieties (Xilong no. 6, Shanyou no. 14, Fuhuasheng, Silihong, Liuzhouzhenzhudou, Yueyou no. 116, etc). The central spikes in stems of triploid plants were treated with 0.25% hydrotropic solution of Colchicine to produce hexaploids. At present, in the self-pollinated progenies of hexaploid plants, there are 31 lines (F_3 to F_{10}) from 15 crosses. Before the F_6 generation there was too much segregation in progenies; most of them were runner types with many branches. A few erect plants observed before the F_7 generation were sterile. Similar to their wild parents, most of the runner derivatives have high resistance to leaf spot and rust. Stable, erect plants began to emerge in the F_7 generation. The pod characters of advanced-generation derivatives are similar to those of cultivated varieties. There are also lines in which the seeds have oil contents of up to 59%.

Autotetraploid pathway. Autotetraploids of *A. stenosperma* were produced, and 20 crosses were made with the autotetraploid as the male parent. The female parents were Huoyue no. 1, Yueyou no. 116, EC 76446, and Liuzhouzhenzhudou. Only one hybrid produced pods. Most pods were produced in the F_2 generation. F_5 progenies were sterile; in addition, the autotetraploid reverted to a diploid after four generations.

Tetraploid pathway. Sixteen crosses were made with *A. monticola* as the male parent. No superior lines were identified from this exercise.

Synthetic amphidiploid pathway. The amphidiploid of *A. correntina* × *A. batizocoi* was obtained with the pollen mentor method. Five crosses between the amphidiploid as the male parent and six cultivated varieties (Yueyou no. 223, Yueyou no. 116, Shanyou no. 523, Shanyou no. 27, Zhonghua no. 2, Liuzhouzhenzhudou) as female parents were made, but the hybrids were sterile.

Stability of Pod Yield in Foliar Disease-Resistant Groundnut Varieties

L J Reddy, S N Nigam, and **A G S Reddy** (ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

Significant genotype × environment (G × E) interactions have been reported by several workers both for pod yield and yield components in groundnut (Tai and Hammons 1978, Wynne and Coffelt 1980, Shorter and Hammons 1985, Vindhiya Varman and Raveendran 1989). Groundnut varieties that show small G × E interactions are desirable because their performance is stable across a wide range of environments.

Rust (*Puccinia arachidis*), early leaf spot (*Cercospora arachidicola*), and late leaf spot (*Phaeoisariopsis personata*) are major fungal pathogens on groundnut worldwide. These, together with other biotic and abiotic stresses, contribute to instability in pod yields across locations and years. Foliar disease-resistant varieties can help improve yield stability in groundnut. This paper presents results from a study of pod yield stability in rust and late leaf spot resistant varieties developed at ICRISAT Asia Center.

Table 1. Mean pod yield and stability parameters of foliar disease-resistant groundnut varieties.

Variety	Mean pod yield (kg ha^{-1})	b_i	s^2d
ICGV 87155	1479	1.101	−21951.750
ICGV 87156	1697	1.155	12749.547
ICGV 87157	1619	1.012	−31339.750
ICGV 87158	1444	1.050	−30648.152
ICGV 87159	1327	0.745	41219.195**
ICGV 87160	1252	0.324**	308743.188
ICGV 87161	1266	0.949	−35002.152
ICGV 87162	1271	0.793	−28055.652
ICGV 87163	1299	0.872	117466.242**
ICGV 87164	1455	0.969	50451.547**
ICGV 87165	1481	0.683*	−26511.703
ICGV 87166	1564	0.970	−37459.852
ICGV 87167	1431	0.978	−15363.551
ICGV 87168	1337	0.958	2673.445
ICGV 87169	1822	1.255	−14413.453
ICGV 87170	1407	1.149	149816.750**
ICGV 87171	1460	1.259	119483.742**
ICGV 87172	1010	0.209**	260562.969**
ICGV 87173	1699	1.247	−32104.051
ICGV 87174	1439	1.118	−26817.652
ICGV 87175	1718	1.171	33405.352**
ICGV 87176	1577	0.777	7561.852
ICGV 87177	1709	1.190	−16544.250
ICGV 86022	1530	0.874	−4426.250
ICGV 87178	1214	0.876	−19535.551
ICGV 87179	1655	1.042	154361.656**
ICGV 87180	1613	1.070	130080.742**
ICGV 87181	1601	1.053	−9069.551
ICGV 87182	1724	1.393*	39009.148
ICGV 87183	1880	1.117	141832.250**
ICGV 87184	1600	1.306*	12929.945
ICGV 86021	1449	0.934	53335.750**
ICGV 87185	1594	0.934	63335.750**
Controls			
NC Ac 17090 (resistant)	1667	1.106	20486.445**
JL 24 (susceptible)	1875	1.307*	283800.969**
Grand mean	1519		
SE	±135		

* Significant at 5% probability level, ** significant at 1% probability level

Thirty-three groundnut varieties tolerant of rust and late leaf spot, along with a resistant germplasm line ICG 1697 (NC Ac 17090) and a susceptible cultivar JL 24, were tested in seven environments in an International Foliar Diseases Resistance Groundnut Varietal Trial. These environments included Yezin, Myanmar (1987, 1988), Magwe, Myanmar (1988), Philippines (1989), Sudan (1988), and the Republic of Guinea (1987, 1988). Plot size in the trial was 5.0 × 1.2 m^2; there were three replications in a randomized block design. No fungicides were used, thus facilitating the natural occurrence of foliar diseases. Late leaf spot incidence was scored on a 1–9 field scale, where 1 = no disease and 9 = 50% foliage damaged. At maturity, dry pod yields were recorded for each plot, and pod yield stability was estimated following the method suggested by Eberhart and Russell (1966).

Late leaf spot incidence was low across the test environments; mean scores for the resistant varieties ranged from 3.3 to 5.3, compared to 6.0 for the susceptible variety JL 24. Analysis of variance revealed significant differences among genotypes and environments, but G × E (linear) interaction was not significant. Hence the stability parameters were not calculated for disease incidence.

Analysis of variance for pod yield revealed highly significant differences among genotypes and environments. G × E interaction was also highly significant. The linear component of G × E interaction was highly significant against the pooled deviations, suggesting the possibility that most of the variation could be predicted.

Mean pod yields of 35 varieties, regression coefficients (b_i), and deviations from regression (s^2d) are shown in Table 1. On the basis of the three stability parameters—mean performance across environments, linear regression, and deviation from the regression—ICGV 87169 was found to be both stable and high-yielding. ICGV 87183 and JL 24 were high-yielding but unstable, with significant deviations from regression. However, ICGV 87183, with a nonsignificant regression value close to unity, was more stable than JL 24. Many foliar disease-resistant varieties including ICGVs 87166, 87169, 87173, 87177, 87157, and 87181 had above average pod yields and good stability, with b_i values close to unity and low nonsignificant negative deviations from regression. Some other foliar disease-resistant varieties (ICGVs 87155, 87161, 87167, 87168, 87174, and 87178) were stable but had below average yields. Such varieties can be utilized in a breeding program for transferring stability characteristics into high-yielding cultivars.

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Release of Cultivar Zhonghua 117 in China

Tang Guiying, Wang Yuying, Liao Boshou, Li Dong, and **Xia Xinming** (Oil Crops Research Institute, Chinese Academy of Agricultural Sciences, Wuhan, Hubei 430062, China)

Zhonghua 117, a spanish groundnut cultivar, was developed at the Oil Crops Research Institute (OCRI) of the Chinese Academy of Agricultural Sciences (CAAS). It was bred from a multi-way cross (Ehua 4 × Taishan Sanlirou) F_2 × (Ehua 3 × Xiekangqing) F_2 using the modified pedigree method. It was released in 1993 by the Guangxi and the Hubei Provincial Crops Variety Committees and in 1994 by the National Committee.

In various yield trials in central and southern China during 1985–92, Zhonghua 117 outyielded the local cultivars by 10–46%. Under natural conditions it showed moderate resistance to rust (scored 4.5 on a 1–9 scale, where 1 = no damage, and 9 = 81–100% foliage damaged). Moderate resistance to rust was also confirmed under artificial inoculation. Zhonghua 117 is also moderately resistant to bacterial wilt and tolerant of the acid soils in southern China.

Zhonghua 117 contains 51% oil and 30% protein. It has uniform pods and seeds, with 72% shelling, 100-pod mass of 151 g, and 100-seed mass of 65 g. It matures in about 125 days when sown in spring and in 110 days when sown in summer in central China. It is adapted to various cropping systems in central and southern China.

Birsa Bold 1, a Promising New Confectionery Variety of Groundnut

M H Rahman[1], **P K Sinha**[1], and **M S Basu**[2] (1. Department of Plant Breeding and Genetics, Birsa Agricultural University, Kanke, Ranchi 834 006, Bihar, India. 2. Project Coordinating Unit, National Research Centre for Groundnut, Junagadh 362 001, Gujarat, India)

About one-third of the total world groundnut production is used for confectionery purposes (Dwivedi et al. 1988), for which bold-seeded types are preferred. India, being the largest producer, has immense potential for exporting bold-seeded groundnut. However, the lack of suitable varieties with aflatoxin load within permissible limits has restricted the scope for exports. We report here the development of a confectionery variety, Birsa Bold 1, that was recently released for cultivation in India.

Birsa Bold 1 (also known as BAU 13) is derived from a three-way cross (Asiriya Mwitunde × BG 1) × M 13. It belongs to the alternately branching group and has large red seeds. In three seasons (1990–92) of trials conducted under the All India Coordinated Research Project on Oilseeds (AICORPO), Birsa Bold 1 gave a pod yield of 2.2 t ha^{-1} and seed yield of 1.4 t ha^{-1} (Table 1). It was superior to the control cultivar M 13 by about 11% in pod/seed yield and 15% in 100-seed mass. Shelling percentages were similar in M 13 and Birsa Bold 1, but the latter had a higher proportion of sound, mature seeds.

Reference

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Brazilian Growers have a New Groundnut Cultivar

Roseane Cavalcanti dos Santos (Empresa Brasileira de Pesquisa Agropecuaria, EMBRAPA-CNPA, CP 174, Campina Grande, PB Brazil CEP 58107-720)

Groundnut is a crop of great economic importance in Brazil, and is grown in all the regions of the country. The seeds are consumed directly or used in confectionery. In 1994, production was over 140 000 t of groundnut in shell. The northeastern region accounts for about 9% of the total groundnut area in Brazil. This was not a traditional groundnut area, but production has expanded because the crop is profitable and markets are growing. However, yields are low—the region accounts for only 5% of the national production. Yields are low partly because farmers use low-quality seed, purchased in free markets or obtained from the previous harvest.

Table 1. Performances of Birsa Bold 1 (BAU 13) and the best control, M 13, All India Coordinated Trials (HPS Varietal Trial), 1990–92 rainy seasons.

	Pod yield[1] (t ha^{-1})					100-seed		Days
Variety	1990	1991	1992	Average	Shelling percentage	mass (g)	SMS[2] (%)	to maturity
Birsa Bold 1	2.01	2.01	2.56	2.19	63	70	83	125
M 13 (national control)	1.86	1.61	2.48	1.98	64	61	80	129
SE	±0.048	±0.118	±0.051					
CV (%)	9.2	9.9	8.4					

1. Pod yields averaged across 6 locations in 1990, 5 locations in 1991, and 4 locations in 1992.
2. Sound mature seeds.

Table 1. Characteristics of groundnut cultivars BR 1 (newly released) and Tatu, Brazil.

Characteristic[1]	BR 1	Tatu
Maturity duration (DAE[2])	89	99
Days to flowering (DAE)	22	25
Pods plant^{-1}	27	18
100-pod mass (g)	148	140
100-seed mass (g)	48	42
'Pops' (%)	12	15
Perfect seeds (%)	84	84
Pod yield (t ha^{-1})	1.7	1.2
Seed yield (t ha^{-1})	1.3	0.8
Shelling percentage	72	70
Oil content (%)	45	49
Protein content (N × 6.25) (%)	38	35

1. Average of data from 11 trials over 3 rainy seasons.
2. Days after emergence.

BR 1 is a bunch type cultivar released in 1994 by the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA). It was released principally for its high yield potential, earliness, and seed characteristics. BR 1 was selected from a bulk composed of three local cultivars grown by farmers in the northeastern region. These cultivars, which were designated as CNPA 29 AM, CNPA 95 AM, and CNPA 96 AM in the groundnut germplasm bank, have high diversity for maturity duration, yield, and seed characteristics.

In preliminary yield tests in five states of the Brazilian northeast, BR 1 averaged 42% higher yields and flowered earlier and more uniformly than Tatu, a traditional groundnut cultivar in Brazil. Plant characteristics of BR 1 and Tatu are similar (Table 1). BR 1 matures earlier than Tatu under some field conditions, and is more tolerant of early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Phaeoisariopsis personata*). No significant damage due to either pod rot (*Pythium myriotylum*, *Rhizoctonia solani*) or rust (*Puccinia arachidis*) was seen on BR 1. As to nutritional aspects, BR 1 has a lower oil content and higher protein content than Tatu. Although BR 1 was developed for the northeast, its plant type and seeds are acceptable to growers and consumers in different parts of Brazil.

BSR 1 (ICGV 86143), a High-Yielding Spanish Bunch Groundnut Variety for the Western Zone of Tamil Nadu

D Sudhakar, K Ganesan, N Sundaram, W M Alikhan, A Gopalan, A Mohamed Ali, K Pillayarsamy, and **V S Shanmugasundaram** (Agricultural Research Station, Bhavanisagar 638 451, Tamil Nadu, India)

Groundnut is one of the major oilseed crops grown in the western zone of Tamil Nadu (comprising the districts of Coimbatore and Periyar, and parts of Salem, Dindigul, Anna, and Madurai), where it occupies 210 000 ha. The currently recommended spanish bunch varieties (Co 2, VRI 2, VRI 3, TMV 2, etc.) are non-dormant types. BSR 1, a dormant spanish bunch type, has been developed from material supplied by ICRISAT.

BSR 1 matures in 100–105 days and has moderate resistance to late leaf spot and rust diseases. It also has fresh seed dormancy up to 21 days. Other features are listed in Table 1.

Seed of ICGV 86143 was originally received from ICRISAT in 1986. It was tested from 1987 to 1993 at the Agricultural Research Station, Bhavanisagar, which represents the western zone of Tamil Nadu. ICGV 86143 was found to be a stable, high-yielding variety in a previous study conducted at this research station. It was evaluated in multilocational trials (1991/92), on-farm trials (1991/92), and adaptive research trials (1992–94).

At the Bhavanisagar research station, ICGV 86143 gave a mean dry pod yield of 2.85 t ha^{-1}, 17.6% higher than VRI 2 (mean of 13 trials in both rainy and postrainy seasons). In multilocational trials conducted at research stations in the western zone, ICGV 86143 gave 2.86 t ha^{-1} of dry pod yield, 8.6% higher than VRI 2. It also per-

Table 1. Characteristics of spanish bunch groundnut variety BSR 1.

Parentage	ICGS 44 × (Robut 33-1 × NC Ac 2821)
Leaf color and size	Small to medium and dark green
Pods	Medium with moderate constriction, normally two-seeded
Seed	Bold with rose testa
Shelling percentage	70.3
100-seed mass (g)	38.5
Oil content (%)	49.5

formed well in farmers' fields, with 2.05 t ha^{-1} of dry pod yield, 11.5% higher than VRI 2.

This variety was accepted by the State Variety Release Committee for release as BSR 1 in Jan 1994. It is recommended for general cultivation in the rainy (Jun-Jul) and postrainy/summer (Dec-Jan) seasons in the western zone of Tamil Nadu. This variety is also in the advanced stages of testing (AVT I) under AICORPO (All India Coordinated Research Project on Oilseeds) Coordinated trials in zone II and zone III of the country.

Acknowledgment. The authors are grateful to ICRISAT for the supply of seed material.

Utilization of Residual Genetic Heterogeneity in a Phenotypically Homogenous Population of Groundnut Variety RSB 87

D K Saxena (Agricultural Research Station, Durgapura, Jaipur 302 015, Rajasthan, India. Present address: Agricultural Research Station, Fatehpur-Shekhawati 332 301, District Sikar, Rajasthan, India)

A base population of a phenotypically homogenous cultivar may have some amount of genetic heterogeneity which, if utilized, could lead to improvement in yields. Plant selection for high pod yield is thus an important part of the procedure to develop high-yielding groundnut genotypes.

This study was initiated in a large-scale breeder seed production plot of groundnut variety RSB 87. RSB 87 was developed by pure line selection of an exotic collection received from Brazil. Single plants were selected randomly at harvest, dried, and pod yields recorded. The plants were grouped in five categories (treatments) depending on pod yield. The number of plants in each bulk varied from 23 to 36. Average pod yields in these selected bulks were 201 g $plant^{-1}$ in Bulk 1, 155 g in Bulk 2, 118 g in Bulk 3, 80 g in Bulk 4, and 67 g $plant^{-1}$ in Bulk 5. An unselected bulk of 50 plants from the breeder seed plot was used as control. This bulk gave a pod yield of 110 g $plant^{-1}$. Individual plants from each category were thoroughly mixed and a representative sample drawn for yield trials conducted during two rainy seasons (1987 and 1988).

The trial was sown in a randomized block design on 18 Jun 1987 (plot size 7.5 m^2) and 17 Jun 1988 (plot size 10.5 m^2). Fertilizer @ 20 kg ha^{-1} N and 40 kg ha^{-1} P_2O_5 was applied. Total precipitation was 264 mm in 1987 and 538 mm in 1988. Life-saving irrigation was provided in both seasons.

Treatments 1 and 2 significantly outyielded the unselected bulk (control) in 1987. In 1988, Treatments 1–3 significantly outyielded the control (Table 1). On an average Treatments 1, 2, and 3 produced 58%, 39%, and 24% higher pod yields than the control. The higher yield in 1988 was probably due to the relatively high, uniformly distributed precipitation that season.

The study thus indicates that it is necessary to make cyclic selections every few years in order to maintain high yields and the genetic purity of cultivated groundnut varieties. This could lead to significant genetic improvement in terms of yield.

Table 1. Yield and yield components of selected bulks of groundnut variety RSB 87, Agricultural Research Station, Fatehpur, Rajasthan, 1987 and 1988 rainy seasons.

Treatment	Pod yield (t ha^{-1}) 1987	1988	Average	Days to maturity	Shelling percentage	100-seed mass (g)
1	3.34	4.48	3.91	130	74	62
2	2.87	4.03	3.45	128	73	55
3	2.61	3.52	3.06	130	74	52
4	2.27	2.77	2.52	131	72	50
5	2.04	2.66	2.35	130	70	50
6 (control)	2.32	2.63	2.47	130	72	53
SE	±0.142	±0.214				
CV (%)	10	14				

Performance of Groundnut Varieties at the Agricultural Research Station, Bhavanisagar

D Sudhakar, N Sundaram, W M Alikhan, A Gopalan, and **V S Shanmugasundaram** (Agricultural Research Station, Bhavanisagar 638 451, Tamil Nadu, India)

Groundnut is an important oilseed and cash crop in Tamil Nadu. The Agricultural Research Station at Bhavanisagar has been testing groundnut varieties received through collaborative projects between ICRISAT and the Tamil Nadu Agricultural University. This paper describes the performance of seven groundnut varieties, including three from ICRISAT, tested using a completely randomized block design in different seasons during 1989–92. The varieties were ICGS(E) 22, ICGV 86014, ICGV 86143, CO 2, VRI 1, VRI 2, and VRI 3. Stability parameters were worked out using the mean plot yield obtained over seasons and the statistical model suggested by Eberhart and Russell (1966).

The mean squares due to varieties and environments were significant, indicating that there was adequate variability among varieties and diversity in the study environments. The significant mean squares due to G × E interaction indicated that the genotypes responded—and ranked—differently in different environments.

Genotypes with regression coefficient (b_i) close to unity and low deviation from regression (s^2d) are stable and widely adapted (Eberhart and Russell 1966). An 'ideal' genotype would have high mean yield, $b_i = 1$, and $s^2d = 0$. Results from the trials (Table 1) indicate that ICGV 86014 was stable, with almost unit response to changes in environment as indicated by nonsignificant b_i and s^2d values. ICGV 86143, VRI 1, and VRI 2 had high mean yields and were responsive to specific environments (ICGV 86143 and VRI 1 to favorable environments, VRI 2 to poor environments), as reflected by significant b_i values.

Based on these results, ICGV 86014 and ICGV 86143 were entered in Adaptive Research Trials in farmers' fields in the western zone of Tamil Nadu. Subsequently, ICGV 86143 was released as BSR 1 for general cultivation in this zone. It has also performed well in AICORPO trials across the country. In addition, both these varieties have been used extensively in hybridization programs at Bhavanisagar.

Table 1. Mean pod yield and stability parameters of 7 groundnut varieties tested across 6 environments, Agricultural Research Station, Bhavanisagar, Tamil Nadu, 1989–92.

Variety	Mean plot yield (kg)	b_i	s^2d
ICGS (E) 22	1.661	0.309*	0.07
ICGV 86014	2.113	1.309	0.15
ICGV 86143	2.404	1.542*	0.03
CO 2	1.676	1.126	0.06
VRI 1	1.959	1.209*	0.00
VRI 2	2.021	0.607*	0.04
VRI 3	1.804	0.897**	0.02
Mean	1.948		

* significant at 5% level, ** significant at 1% level.

Acknowledgment. The authors are grateful to ICRISAT for the supply of seed material.

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Diversity in the Australian Groundnut Germplasm Collection

B D Harch[1], P K Lawrence[2], A Cruickshank[3], J Tonks[3], K E Basford[1], I H DeLacy[1], and **C M McLeod[4]**
(1. Department of Agriculture, The University of Queensland, St Lucia, Australia. 2. Australian Tropical Field Crops and Genetic Resource Centre, Biloela, Australia. 3. J. Bjelke-Petersen Research Station, Kingaroy, Australia. 4. Previously at Agricultural Chemistry Laboratories, Indooroopilly, Australia)

The Australian Tropical Field Crops Genetic Resource Centre (ATFCGRC) has been collecting, storing, characterizing, evaluating, and distributing groundnut germplasm since its establishment in Oct 1988. The ATFCGRC is located at Biloela, Queensland, and is operated by the Queensland Department of Primary Industries (QDPI).

This report provides information on the variability in the Australian groundnut collection in terms of the range of accessions and their origin. Comparisons are also made to the variation available in the world groundnut collection, which is held at ICRISAT Asia Center.

The Australian groundnut germplasm collection used in this study consisted of 835 accessions, of which 693 were cultivars and advanced breeding lines and 142 were landraces. All accessions were grown in 1990/91 at the J Bjelke-Petersen Research Station at Kingaroy (26°35'S, 151°50'E), Queensland, in a single-replicate, completely randomized design with grid-plot checks. The accessions were grown on Euchrozem soils, fertilized with 15 kg ha^{-1} each of P_2O_5 and K_2O, with supplementary irrigation to avoid moisture stress. Plots were single 5 m rows, with 90 cm between rows and 12 cm between plants.

The type of characterization and evaluation data maintained in the Australian groundnut database has been determined by international guidelines and the requirements of the main users of the database. In this paper, the Australian collection is compared with 12 160 accessions (194 wild species, 5146 landraces, 320 cultivars, 4553 breeding lines, and 1947 others) from the world collection.

Origin of accessions. Most of the accessions in the Australian collection originated from North and Central America and from Asia, whereas accessions in the world collection originated from Asia and Africa (Table 1). The Australian collection has a greater percentage of accessions from North and Central America and Oceania, while the world collection has a greater percentage of accessions originating from South America, Africa, Asia, Europe, and the CIS (formerly USSR) (Table 1).

Table 1. Percentage of the Australian and world groundnut germplasm collections originating from seven major regions as defined by FAO (1991).

Origin	Australian groundnut collection (%)	World collection (%)
Africa	18.4	28.8
North and Central America	36.8	15.9
South America	3.9	14.2
Asia	29.9	34.5
Europe	0.2	0.6
Oceania	6.2	0.5
CIS (formerly USSR)	0.4	0.5
Unknown	4.1	5.0

Qualitative descriptors. Groundnut accessions in both the Australian and world collections are dominated by alternate and sequential branching patterns, absence of stem pigmentation, presence of purple peg pigmentation, non-variegated seed coat color, slight or moderate pod beaks, moderate pod constriction, and slight or moderate pod reticulation. The world collection has a greater range of representation across the categories for the descriptors, plant habit, pod beak, pod constriction, and pod reticulation. Other points of interest are that accessions in the world collection are dominated by erect plant habits, whereas the Australian collection has fewer erect habits, and consists mainly of accessions with decumbent-3 type plant habit. These differences may be a consequence of the different perceptions evaluators have in assigning accessions to particular categories.

Quantitative descriptors. The frequency distributions for each of the quantitative descriptors for the Australian collection were investigated, along with three comparable quantitative descriptors taken from the world collection.

The frequency distribution for oil content in the Australian collection is normal ($P>0.01$), while distributions for plant height and shelling percentage are left-skewed, and distributions for plant width, number of seeds per pod, and seed mass are right-skewed. In the world collection, the frequency distributions for the number of seeds per pod and seed mass (in the postrainy season) are right-skewed, whereas the distribution for shelling percentage is left-skewed. The seed mass and shelling percentage in both collections have the same ranges of variability.

The fatty acid frequency distributions from the Australian collection indicate that linoleic and lignoceric acid percentages have normal distributions ($P>0.01$), while the remaining distributions are all right-skewed, with palmitic and oleic acids approaching bimodal distributions. Most simple correlation coefficients between the quantitative descriptors in the Australian collection were statistically significantly different from zero ($P\leq0.05$). There were large negative correlations between oleic and linoleic acids (−0.92) and palmitic and oleic acids (−0.83), and a large positive correlation between stearic and arachidic acids (0.86). Seed mass was negatively correlated with behenic acid (−0.46) and palmitic acid (−0.42), and positively correlated with oleic acid (0.48). Overall, the Australian and world collections appear to have the same range of representation in the descriptors mentioned. Methodologies to statistically evaluate or describe the diversity in germplasm collections are currently being investigated.

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Chemical Characteristics of Argentinean Groundnut Cultivars

Nelson R Grosso[1] and **Carlos A Guzmán**[2]
(1. Facultad de Ciencias Agropecuarias (UNC), Cat. Química Biológica, Avda Valparaíso s/n, 5000 Córdoba, Argentina.
2. Facultad de Ciencias Exactas Físicas y Naturales (UNC), IMBIV-CONICET, Avda Velez Sarsfield 299, 5000 Córdoba, Argentina)

About 98% of the groundnut in Argentina is cultivated in the province of Córdoba. Florman (runner type), Colorado Irradiado (valencia type), and Virginia Manfredi 5 (virginia type) are the main cultivars used by industry. However, the chemical quality of these cultivars had not been previously studied. This study focused on the seed chemical characteristics of these cultivars.

Sound mature seeds of Colorado Irradiado, Virginia Manfredi 5, and Florman from the 1992 and 1993 crop years were provided by the Instituto Nacional de Tecnología Agropecuaria (INTA) in Córdoba. The oils were extracted for 16 h with petroleum ether (boiling range 30–60°C) in a Soxhlet apparatus. Oil content was calculated by the difference in weight before and after extraction. Ash content was determined by incineration in a muffle furnace at 525°C (AOAC 1980, method 31.012). Nitrogen content estimated by the Kjeldahl method (AOAC 1980, method 2.057) was converted to protein content using a conversion factor of 5.46. Fatty acid methyl esters were prepared by transmethylation with a 3% solution of sulfuric acid in methanol (Jellum and Worthington 1966). The fatty acid methyl esters were analyzed on a Shimadzu GC-R1A gas chromatograph equipped with a flame ionization detector (FID). An AT-WAX Superox II capillary column (30 m × 0.25 mm inner diameter) was used. The column temperature was programmed from 180°C (held for 10 min) to 240°C (4°C per min). Iodine values (IV) were calculated from fatty acid percentages using the formula: IV = (% oleic × 0.8601) + (% linoleic × 1.7321) + (% eicosenoic × 0.7854). Sterols of the unsaponifiable matter (after saponification with alcoholic 1 N potassium hydroxide) were purified by preparative thin-layer chromatography (TLC). TLC was performed on silica gel 60 G (20 × 20 cm, 0.5 mm layer thickness) using chloroform-diethyl ether (9:1 v/v) as the developing solvent. The corresponding band of 4-desmethylsterols was scraped off the plate and extracted with chloroform (Gaydou et al. 1983). Purified sterols were analyzed on a Shimadzu CBP1 capillary column (25 m × 0.25 mm inner diameter). The column temperature was programmed from 200°C to 300°C (4°C per min). The injector temperature was 320°C. Standard fatty acids and sterols were run in order to use retention times for identifying sample peaks. Fatty acid and sterol levels were reported as a relative proportion of the total fatty acid composition and the total sterol composition, respectively.

Data shown in Table 1 are mean values from triplicate analysis. Colorado Irradiado showed higher protein and lower oil content than the other two cultivars. Palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2), arachidic (20:0), eicosenoic (20:1), behenic (22:0), and lignoceric (24:0) acids were detected. Oleic acid was predominant in Virginia Manfredi 5 and Florman, while linoleic acid was the major component in Colorado Irradiado.

Oleic to linoleic (O/L) ratio and iodine value are both indicators of oil stability and shelf-life (Ahmed and Young 1982). Virginia Manfredi 5 had the highest O/L ratio and the lowest iodine value, closely followed by Florman (Table 1), indicating that these cultivars have better oil quality than Colorado Irradiado.

The following 4-desmethylsterols were found (Table 1)—cholesterol, campesterol, stigmasterol, β-sitosterol, Δ^5-avenasterol, Δ^7-stigmasterol and Δ^7-avenasterol. β-sitosterol was prominent in all three cultivars. The sterol composition was within the ranges previously reported by Padley et al. (1986).

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Table 1. Oil, ash, and protein contents, iodine value, oleic to linoleic acid ratio, and fatty acid and sterol composition of three Argentinean groundnut cultivars.

Chemical characteristics	Cultivars: Colorado Irradiado	Virginia Manfredi 5	Florman
Oil (%)	45.2	49.7	50.1
Protein (%)	30.2	26.1	26.7
Ash (%)	2.5	2.6	2.5
Iodine value	110	103	104
O/L ratio	0.94	1.23	1.22
Fatty acid composition (%)			
16:0	10.0	10.1	9.9
18:0	2.0	2.4	2.0
18:1	40.3	44.9	45.2
18:2	43.0	36.5	37.0
20:0	1.2	1.2	1.0
20:1	0.9	1.4	1.4
22:0	1.8	2.3	2.3
24:0	0.7	1.0	1.0
Sterol composition (%)			
Cholesterol	0.6	1.2	0.9
Campesterol	15.1	14.6	14.5
Stigmasterol	9.7	10.6	10.5
β-sitosterol	59.8	60.8	61.5
Δ^5-avenasterol	12.7	10.9	10.1
Δ^7-stigmasterol	1.3	0.6	1.1
Δ^7-avenasterol	0.7	1.0	1.2

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Performance of Groundnut Varieties in the Postrainy/Summer Seasons in the Alluvial Tract of West Bengal

R C Samui and **A K M Minajur Ahasan**
(Department of Agronomy, Bidhan Chandra
Krishi Viswavidyalaya, P O Mohanpur,
Nadia 741 252, West Bengal, India)

Rapeseed and mustard are the principal oilseed crops cultivated in West Bengal. Postrainy/summer groundnut is gaining popularity in the state, particularly for cultivation after the potato crop; no fertilizer is needed and

Table 1. **Performance of 15 groundnut varieties in the alluvial tract of West Bengal, postrainy/summer seasons (mean of 1989, 1990, and 1991).**

Variety	Maturity duration (days)	Pod yield (t ha^{-1})	Oil content (%)	Shelling percentage	Oil yield (t ha^{-1})
TG 23	105	2.21	45.0	70	0.69
ICGS 11	105	1.92	45.0	71	0.61
ICGS 5	105	1.91	44.7	74	0.63
JL 24	115	2.25	45.0	70	0.73
TGS 2	115	1.68	49.0	73	0.60
Girnar 1	120	2.40	47.0	69	0.78
CGC 3	120	1.83	42.0	72	0.55
MH 2	120	1.83	40.0	74	0.54
TG 9	120	1.75	44.4	72	0.56
SB XI	120	1.61	44.5	70	0.51
ICGS 44	125	2.92	49.4	65	0.94
NRGS (E_2)	125	1.96	44.9	70	0.62
J 11	125	1.51	44.2	69	0.46
TG 19A	126	2.65	52.3	65	0.90
ICGS 65	126	1.86	49.3	73	0.67
SE		±0.0107			±0.0034

yields are high. The crop is also grown in rice fallows. Where water is scarce, groundnut is also replacing summer rice (*boro* paddy). However, there is a need for short-duration groundnut varieties that mature in 100–105 days during this season, so that the crop can be harvested before the onset of the monsoon.

Fifteen groundnut varieties were evaluated in a field experiment conducted at the Bidhan Chandra Krishi Viswavidyalaya farm, Kalyani, during the 1989–91 postrainy/summer seasons. The soil of the experimental field was alluvial in texture, with 0.69% total N and 0.74% organic carbon, and a pH of 7.3. The crop was sown on 9 Feb in 1989 and 1990 and 25 Feb in 1991, at a spacing of 30 × 15 cm. A common fertilizer dose of N 20, P 60, K 40 kg ha^{-1} in the form of urea, single superphosphate, and muriate of potash was applied during final land preparation. Results from the trials are shown in Table 1.

Varieties with maturity duration 100–105 days. Summer groundnut is generally grown in Hooghly, Burdwan, and Howrah districts after the potato harvest. In Midnapore district postrainy-season groundnut is cultivated after the harvest of rainy-season rice. In Nadia, 24 Parganas, Birbhum, and Burdwan districts it is cultivated after winter crops (rape, mustard, etc.) are harvested. The short-duration varieties TG 23, ICGS 5, and ICGS 11 can be successfully cultivated during this season, replacing JL 24. However, farmers will have to sacrifice some amount of yield. TG 23 gave the highest pod and oil yields in this group of varieties.

Varieties with maturity duration 115–120 days. This group included TGS 2, TG 9, JL 24, SB XI, MH 2, CGC 3, and Girnar 1 (Table 1). Girnar 1 gave the best pod and oil yields, followed by JL 24.

Varieties with maturity duration >120 days. Five varieties matured in 125–126 days (Table 1). Among these varieties, ICGS 44 gave the highest yield, followed by TG 19A; the latter had the highest oil content.

Conclusions. It can be concluded that TG 23 could be selected for postrainy-season cultivation, to avoid the monsoon rain at harvest. If sowing can be advanced by 15–20 days, then ICGS 44 could replace JL 24 in this region.

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Stability of Some Spanish Groundnut Varieties

G J Patra (Department of Plant Breeding and Genetics, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar 751 003, Orissa)

Groundnut is an important oilseed crop in Orissa, where it is cultivated in all the districts in three seasons, rainy (kharif), postrainy (rabi), and summer. The districts of Cuttack, Sambalpur, Dhenkanal, and Ganjam account for about 70% of the total production in the state. Yields fluctuate from year to year, partly because of poor adaptation or lack of yield stability in the available varieties. This study was undertaken to test the stability of new varieties that could replace the popular variety AK 12-24.

Released varieties developed by the Orissa University of Agriculture and Technology and ICRISAT were tested at the Central Research Station, Bhubaneswar, along with a pre-release variety (OG 52-1) and two controls. The studies were conducted during the rainy and postrainy/summer (irrigated) seasons for 5 consecutive years from 1989, at different research stations in the important groundnut-growing districts of Orissa. In addition, varieties were also tested on farmers' fields for two postrainy/summer seasons under residual moisture and irrigated conditions.

Research station trials. Pod yield data for different varieties are shown in Table 1. The new varieties generally performed better during the rainy season (all outyielded the control) than during the postrainy/summer season, when only one variety, Kisan, significantly outyielded the control. Rainy-season yields, averaged over 5 years, were highest in OG 52-1 (41% higher than the control) and ICGS 11 (32% higher).

Trials in adaptive research stations and farmers' fields. In order to test these varieties under conditions that are closer to real farming situations, trials were con-

Table 1. Pod yields of five groundnut varieties at research station trials, Orissa, 1989–93.

	Rainy season[1]		Postrainy/summer season[2]	
Variety	Pod yield ($t\ ha^{-1}$)	Increase over best control (%)	Pod yield ($t\ ha^{-1}$)	Increase over best control (%)
OG 52-1	0.70	41	1.49	–9
ICGS 11	0.65	32	1.50	–8
Kisan	0.61	25	1.75	7
Jawan	0.60	22	1.64	1
ICGS 44	0.60	22	1.34	–18
Controls				
GG 2	0.49		1.02	
AK 12-24	0.49		1.63	

1. Average of 2 replications, 5 seasons, 1989–93.
2. Average of 5 seasons: 1989/90, 1990/91, and 1991/92 postrainy; 1990/91 and 1992/93 summer.

Table 2. Pod yield ($t\ ha^{-1}$) of ICGS 44 at adaptive research stations in 4 districts of Orissa, 1986–93.

Puri[1]	Cuttack[2]	Sambalpur[3]	Balasore[4]	Mean (12 trials)
2.32 (62)	2.13 (49)	2.56 (8)	1.01 (100)	1.77 (38)

Figures in parentheses show percentage increase over AK 12-24 (control).
1. Three postrainy seasons, 1987/88, 1988/89, 1992/93.
2. 1987/88 and 1992/93 under varying conditions; rainy season, postrainy season (rainfed, irrigated, residual moisture, and irrigated+lime amendment).
3. Three postrainy seasons, 1986/87, 1987/88, 1989/90.
4. Postrainy season 1988/89.

ducted at adaptive research stations located in four districts—Puri (3 seasons), Cuttack, Sambalpur (3 seasons), and Balasore (1 season). The best performer in these trials was ICGS 44, which was evaluated in 12 such trials; data are shown in Table 2. ICGS 44 was also tested in farmers' fields at three locations during the 1992/93 postrainy season, under residual moisture and irrigation. Pod yields in farmers' fields were 1.59 t ha^{-1} under residual moisture (vs 1.71 t ha^{-1} for AK 12-24), and 3 t ha^{-1} under irrigation.

Stability of performance is a crucial factor in assessing the suitability of new varieties. The stability of all the test varieties (and of four others) in this study was estimated using the method suggested by Eberhart and Russell (1966). Pooled analysis of variance indicated that genotypes (G), environments (E), and G × E interactions were highly significant for pod yield when tested against pooled error, whereas E and E + G × E were significant when tested against pooled deviation. The stability parameters show that OG 52-1 is stable with respect to pod yield (regression coefficient b = 0.98, deviation from regression s^2d = 10.96), while ICGS 11 is stable for seed yield (b = 1.00, s^2d = 2.14), pod yield (b = 1.08, s^2d = –0.14), 100-seed mass (b = 1.01, s^2d = 1.98), and oil content (b = 1.06, s^2d = –0.06). Both varieties are likely to be suitable for cultivation in all seasons. ICGS 44 is stable for shelling percentage (b = 1.05, s^2d = 0.63) and oil content (b = 1.02, s^2d = 1.15), but shows some resistance to environmental changes and is hence better adapted to rainy-season cultivation. It can be also grown with good management in the postrainy/summer season. AK 12-24, the control variety, is sensitive to environmental changes and has below average stability for pod yield (b = 1.40, s^2d = –0.36), although it is stable for oil content (b = 0.96, s^2d = 0.76). It is therefore better adapted to the postrainy/summer season. Similarly, Kisan and Jawan (below average stability for pod yield, stable for shelling percentage, seed index, and oil content) are better suited to high-yielding environments (postrainy/summer season), although they can be grown during the rainy season with proper management, even in drought-prone areas.

The new varieties generally combine high yields with stability in shelling percentage and seed size. They are therefore likely to be good replacements for AK 12-24, and can help stabilize oilseeds production in Orissa.

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Tapioca Pearls—A Potential Substitute for Agar in Microbiological Media

Y L Nene and **V K Sheila** (ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

Agar is an expensive gelling agent that is extensively used in microbiology and pathology laboratories all over the world. It is a complex polysaccharide obtained from marine algae. We tested a range of starch products and identified small-grained, granulated tapioca or tapioca 'pearls' as a cheap substitute for agar in microbiological media.

Two media, chickpea-dextrose-tapioca (CDT) [chickpea *dhal* flour 5 g, dextrose 20 g, granulated tapioca (*Motidana*, no. 2 quality) 150 g, distilled water 1000 mL] and potato-dextrose-tapioca (PDT) [potatoes 200 g, dextrose 20 g, granulated tapioca (*Motidana*, no. 2 quality) 150 g, distilled water 1000 mL] were prepared as described by Nene and Sheila (1994). The effectiveness of the two media was tested with fungal pathogens of groundnut and was also compared with potato-dextrose-agar (PDA), the commonly used medium for most fungi.

Cercospora arachidicola, which causes early leaf spot of groundnut, was successfully isolated from infected leaves on CDT, PDT, and PDA. In growth studies, the three media supported excellent mycelial growth of *Rhizoctonia bataticola* and *Sclerotium rolfsii*, which are important fungal pathogens of groundnut (Fig. 1). However, sclerotial production by the two fungi differed in the media tested. Fewer sclerotia of *S. rolfsii* were produced on CDT and PDT than on PDA (Fig. 2); more sclerotia of *R. bataticola* were produced on PDT than on PDA.

Aflatoxin contamination of groundnut seeds due to colonization by aflatoxigenic strains of *Aspergillus flavus* is a worldwide problem. Czapek Dox agar and its modified formulations have been widely used as routine culture media for *Aspergillus* spp (Raper and Fennell 1977). In laboratory screening tests, groundnut genotypes with resistance to seed infection by *A. flavus* were identified by plating seeds on Czapek Dox-Rose Bengal-streptomycin-agar medium (Mehan and McDonald 1984, Mehan et al. 1986, Mehan 1989). Using the same medium, Mehan et al. (1986) also detected seed infection by *A. niger* in several groundnut genotypes. We tested *A. flavus* and *A. niger* on CDT and PDT. The two media supported as good growth of the fungi as did PDA; however, sporulation of *A. flavus* and *A. niger* was less on CDT and PDT than on PDA. Colonies of *A. flavus* and *A. niger* were observed on modified Czapek Dox tapioca medium (Nene and Sheila 1994). Our studies indicate that granulated tapioca can be used instead of agar to detect seedborne infection by *Aspergillus* spp.

Tapioca-based media can be used to isolate fungi and bacteria, and for the maintenance and short-term preservation of fungal cultures (Nene and Sheila 1994). The media can also be used in seed pathology studies. Attempts are being made to use granulated tapioca instead of agar in tissue culture media for callus induction in grain legumes.

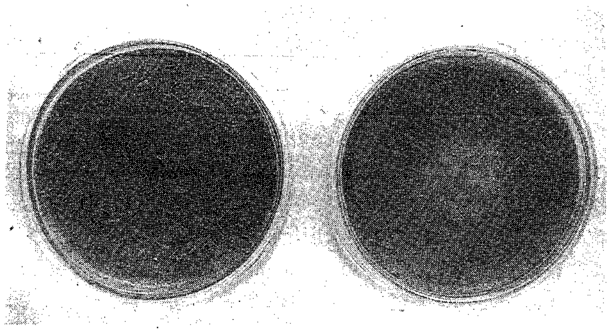

Figure 1. Growth of *Rhizoctonia bataticola* after 4 days on chickpea-dextrose-tapioca (left) and potato-dextrose-agar (right).

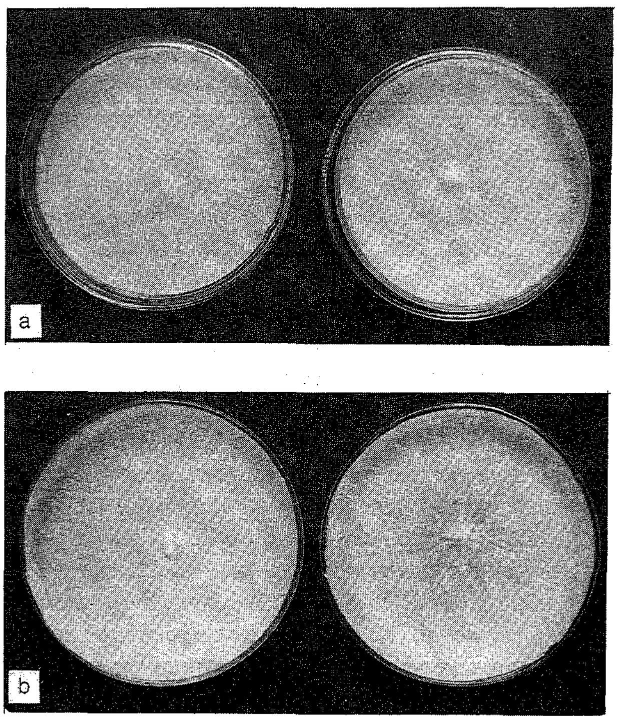

Figure 2. Growth of *Sclerotium rolfsii* after 4 days on: (a) chickpea-dextrose-tapioca (left) and potato-dextrose-agar (PDA) (right); and (b) potato-dextrose tapioca (right) and PDA (left).

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Survey of Groundnut Diseases in Northern Malawi

P Subrahmanyam[1] and
A J Chiyembekeza[2]
(1. SADC/ICRISAT Groundnut Project, PO Box 1096, Lilongwe, Malawi.
2. Chitedze Agricultural Research Station, PO Box 158, Lilongwe, Malawi)

Groundnut is the most important leguminous crop grown in Malawi. In the smallholder sector, groundnut is the second most important crop after maize, and provides a supplementary source of income. Until recently, groundnut was Malawi's fourth most important export crop after tobacco, tea, and sugar. However, yields are very low, averaging 700 kg ha^{-1} (unshelled). Diseases are a major constraint to groundnut production in Malawi.

In collaboration with the Malawi Ministry of Agriculture, a survey was carried out in Apr 1993 to assess the distribution and relative importance of various groundnut diseases in farmers' fields in Mzuzu and Karonga Agricultural Development Divisions (ADDs) of northern Malawi. A total of 54 groundnut fields were surveyed (Fig. 1).

Mzuzu ADD. In Mzuzu ADD, 34 groundnut fields were visited—14 fields in the central and southern areas of Mzimba (Chasula, Kamatawo, Chafisi, Embangweni, Mbawa, Chitaya, Njebwa, Chimutu, Chiswa, Mathandani, Eswazini, and Emoneni); 17 in the Rumphi and northern Mzimba areas (Njakwa, Gumbo, Ruviri, Kamphenda, Kazuni, Mpherembe, and Malidade); and 3 fields in the Nkhata Bay area. Most of the fields were sown late in these areas. Plant population was low in many fields. The majority of the fields surveyed were sown to a mixture of varieties Chalimbana, Kalisere, and Mwitunde. A number of fields surveyed around the Ruviri area were sown to a mixture of Malimba (locally known as Kasawaya) and an unknown red-seeded valencia type. In the Nkhata Bay area, most of the fields surveyed were sown to Malimba.

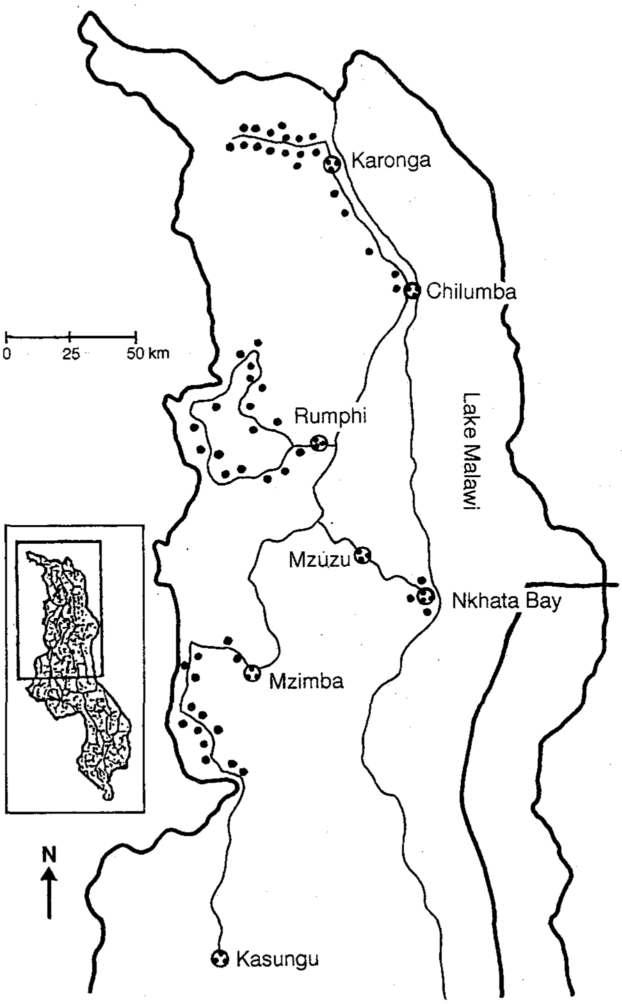

Figure 1. Areas in Malawi surveyed for groundnut diseases.

Early leaf spot (*Cercospora arachidicola*), late leaf spot (*Phaeoisariopsis personata*), and rust (*Puccinia arachidis*) were very common. However, late leaf spot and rust were particularly severe, causing extensive damage to the crop. Early leaf spot was serious only in the Ruviri and Mpherembe areas. *Darluca* sp was commonly found associated with groundnut rust pustules in fields near Chitaya. Groundnut rosette (chlorotic form) was observed in almost all fields, but the incidence was surprisingly low in spite of late sowing and poor plant stand in several fields. The average incidence of groundnut rosette in this ADD was about 3%. Other diseases recorded were leaf scorch (*Leptosphaerulina crassiasca*), web blotch (*Phoma arachidicola*), phyllosticta leaf spot (*Phyllosticta arachidis-hypogaea*), anthracnose (*Colletotrichum* sp), and groundnut streak necrosis disease (sunflower yellow blotch virus). However, the severity of these diseases was low, and they did not appear to cause any appreciable damage to the crop. Plants showing symptoms of witches' broom (bushy plants with reduced leaf size and pegs showing negative geotropism) were observed in several fields, but disease incidence was negligible. Witchweed (*Alectra vogelii*) was observed in almost all fields surveyed in Mzuzu ADD, but again the incidence was negligible.

Karonga ADD. In Karonga ADD, the survey was limited to the Karonga Rural Development Project. In this area, 20 groundnut fields around Majiga, Chikangawa, Lupembe, Katili, Baka, Malungo, Gwepe, Mwenitanga, and Nthora were surveyed. Crop management in these areas was very good. Malimba was the most common variety in these areas. Although some late-sown fields were noticed, most fields had been sown in time (early Dec 1992). This was evident from the fact that some farmers were already harvesting their crop.

The disease spectrum in Karonga ADD was similar to that in Mzuzu ADD. Late leaf spot and rust were the most important diseases; in many fields only withered stems were observed due to severe attack by these diseases. Groundnut rosette was observed for the first time in the Malungo, Gwepe, Mwenitanga, and Nthora areas of Karonga ADD.

Conclusions. Groundnut is an important crop in Mzuzu and Karonga ADDs. Late leaf spot and rust were the most predominant and destructive groundnut diseases in these areas, and the introduction of genotypes with resistance to these diseases should prove useful in northern Malawi. Groundnut rosette was observed for the first time in Karonga ADD.

Toward Standardization of a Laboratory Screening Technique for Early Leaf Spot Resistance in Groundnut

J Narayana Rao, S Pande, M V Reddy, D McDonald, and **D R Butler** (ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

Field screening for early leaf spot resistance in groundnut is not always successful because of fluctuations in weather conditions over seasons. Recent research (Butler et al. 1994) has indicated that duration of leaf wetness and temperature are important factors in disease development. The detached leaf culture technique developed by Melouk and Banks (1978) has many advantages, but the disease reactions may not always correspond with those shown on leaves still attached to plants. A laboratory screening technique was therefore developed, using whole plants held in a dew/growth chamber. We present the results of investigations on the effect of inoculum concentration on the efficiency of such a screening system using cultivars with varying levels of resistance to *Cercospora arachidicola.*

Plant material. Three genotypes (ICGs 9294, 10920, and 7892) with varying levels of resistance to early leaf spot and two susceptible genotypes (J 11 and TMV 2) were used in this study. Four seeds of each genotype were sown in each of twelve 15 cm diameter plastic pots containing autoclaved Alfisol and farmyard manure (4:1 ratio) in a greenhouse. Two plants were retained in each pot after germination. The temperature of the greenhouse was maintained at 25–30°C. The experiment was arranged in a randomized block design with four replications for each conidial concentration. Two fully opened quadrifoliate leaves (third and fourth from top) on each plant were inoculated when the plants were 30 days old.

Preparation of inoculum. Conidia were collected from sporulating lesions on the susceptible cultivar TMV 2 using a cyclone spore collector, and stored in small glass vials held at 4°C. Conidial inoculum was prepared

Table 1. Reaction of three known early leaf spot resistant and two susceptible groundnut genotypes 30 days after inoculation with the ICRISAT isolate of *Cercospora arachidicola* in dew/growth chamber, ICRISAT Asia Center, 1993/94.

	Number of lesions cm^{-2} leaf			Lesion diameter (mm)			Number of conidia per lesion			Percentage leaf area damaged			Percentage defoliation		
Genotype	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Resistant															
ICG 7892	0.05	0.22	0.55	2.9	3.1	2.6	1250	1350	1100	0.8	2.3	4.3	2	19	41
ICG 9294	0.10	0.80	1.73	4.8	4.2	3.2	1300	1300	1400	4.0	10.9	17.2	2	45	72
ICG 10920	0.10	0.70	1.27	4.9	5.0	4.1	1550	1463	1525	1.5	11.0	14.6	0	19	49
Susceptible															
J 11	0.18	0.60	1.22	7.0	6.6	4.5	5000	5300	5300	2.3	9.4	15.8	6	45	72
TMV 2	0.10	0.49	1.26	5.7	5.6	4.3	3250	2800	3000	1.2	5.0	13.1	11	49	83
	SE	LSD		SE	LSD		SE	LSD		SE	LSD		SE	LSD	
Concentration × Genotype	±0.15	0.42		±0.3	0.85		±42.5	1215		±1.4	4.0		±8.3	23.7	
CV (%)		46.4			13.6			32.8			39.0			47.7	

T1 = 100 conidia per mL of inoculum, T2 = 500 conidia per mL of inoculum, T3 = 1000 conidia per mL of inoculum.
All LSDs at 5% probability level.

by suspending the conidia in sterilized water to which Tween 80® was added at the rate of 10 mL L^{-1}. Three conidial concentrations, 100 mL^{-1} (T1), 500 mL^{-1} (T2), and 1000 mL^{-1} (T3) were prepared by serial dilutions.

Inoculation. All the cultivars were arranged into three sets for inoculation with the three conidial concentrations. Using an atomizer, the tagged leaves were sprayed with inoculum to the point where run off occurred on both the sides of the leaf. This was done in the evening. Immediately after inoculation, the plants were placed in dew chambers (Clifford 1973) at 23°C to ensure wetness of the leaf surface, and held for 16 h in the dark.

Post-inoculation treatments. The plants were removed from the dew chamber on the morning of the following day and placed before a fan for about 30 min until the foliage had dried. They were then returned to the growth chamber and kept at 25°C for 8 h during the day (Butler et al. 1994). The plants were then returned to the dew chamber for 16 h. This alternate wet and dry period treatment was repeated for 5 days. The plants were then held in the growth chamber with 25°C constant temperature and relative humidity of 52–55% until the end of the experiment.

Observations. Observations on six parameters—number of lesions per leaf, total leaf area, lesion diameter, number of conidia per lesion, percentage leaf area damaged, and percentage defoliation—were recorded from 6 to 30 days after inoculation. Percentage defoliation was again recorded 45 days after inoculation.

Results. Disease symptoms appeared on the tagged leaves of all genotypes within 6 days after inoculation. Analysis of variance for the resistance components was done. Significant differences were found between the conidial concentrations for most of the components studied. In general, number of lesions, percentage leaf area damaged, and percentage defoliation were higher with the highest conidial concentration (1000 conidia mL^{-1}) used (Table 1). Number of conidia per lesion was significantly higher in susceptible genotypes than in resistant genotypes (Table 1). This parameter can be used to screen for early leaf spot resistance using a dew/growth chamber. Any of the three conidial concentrations would be satisfactory for laboratory screening based on components of resistance. The lower concentrations could be best for the study of lesion diameter, whereas the higher concentration could be more effective when measuring leaf area damage and defoliation.

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Comparison of Whole-Plant and Detached-Leaf Methods for Studying Components of Rust Resistance in Groundnut

V K Mehan, P M Reddy, D McDonald, and **K Vidyasagar Rao** (ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

Groundnut rust caused by *Puccinia arachidis* is a serious problem worldwide, causing substantial losses in crop yield in many groundnut-growing regions (Subrahmanyam et al. 1985, Ghughe et al. 1981). The use of rust-resistant, high-yielding cultivars is the best means of reducing yield losses due to the disease. Research on host-plant resistance to rust has received increasing attention over the past 15 years, and many rust-resistant groundnut genotypes have been reported (Subrahmanyam et al. 1995). A few studies have reported components of rust resistance, using either the detached-leaf or whole-plant inoculation method (Subrahmanyam et al. 1983, Liao et al. 1990). The objective of this study was to compare the two methods for estimating components of rust resistance in selected genotypes.

Components of resistance were studied in 40 rust-resistant groundnut genotypes and one susceptible cultivar TMV 2, using the whole-plant and detached-leaf methods described by Subrahmanyam et al. (1983) and Liao et al. (1990). Five components were studied—infection frequency (number of pustules cm^{-2} leaf area), percentage of leaf area damaged, lesion diameter, incubation period (time taken for the appearance of 50% of the total pustules from the time of inoculation), and sporulation index (on 1–5 scale, where 1 = no sporulation, 2 = 1–25% lesion area covered with spores, 3 = 26–50% lesion area

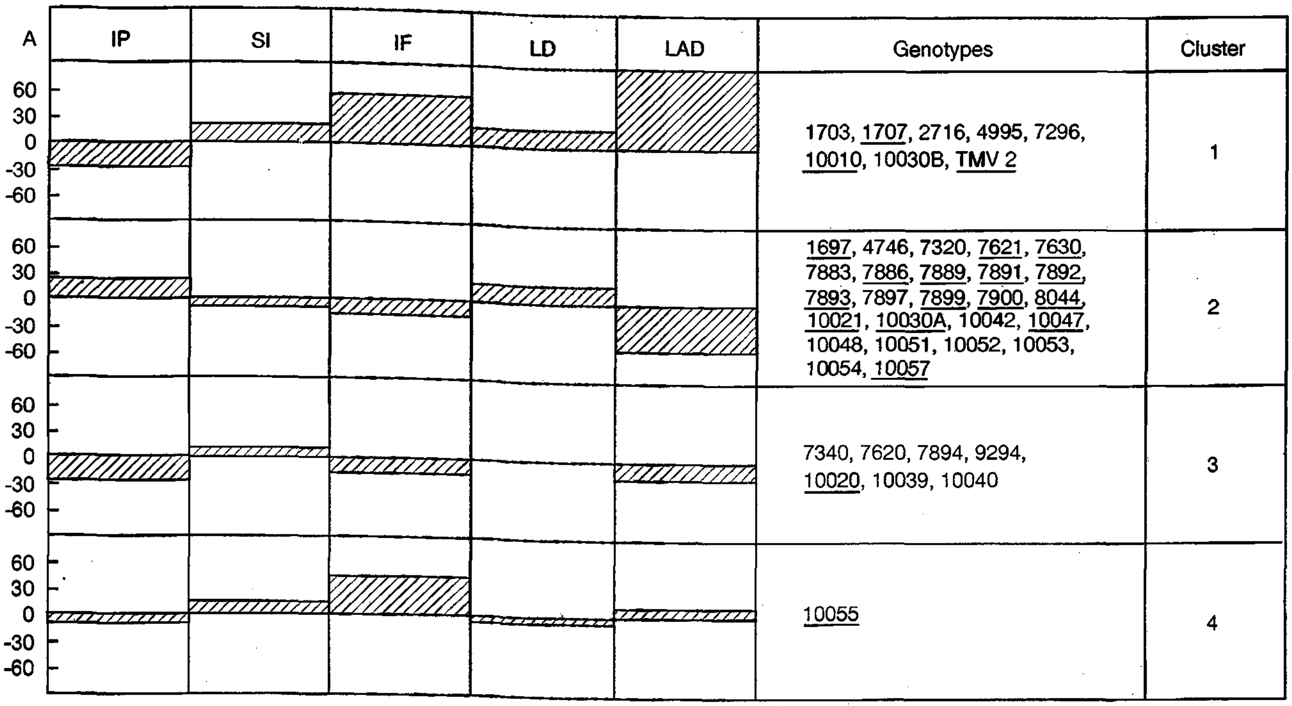

Figure 1. Deviation (%) of cluster means from the grand mean for five components of rust resistance in the detached-leaf method.

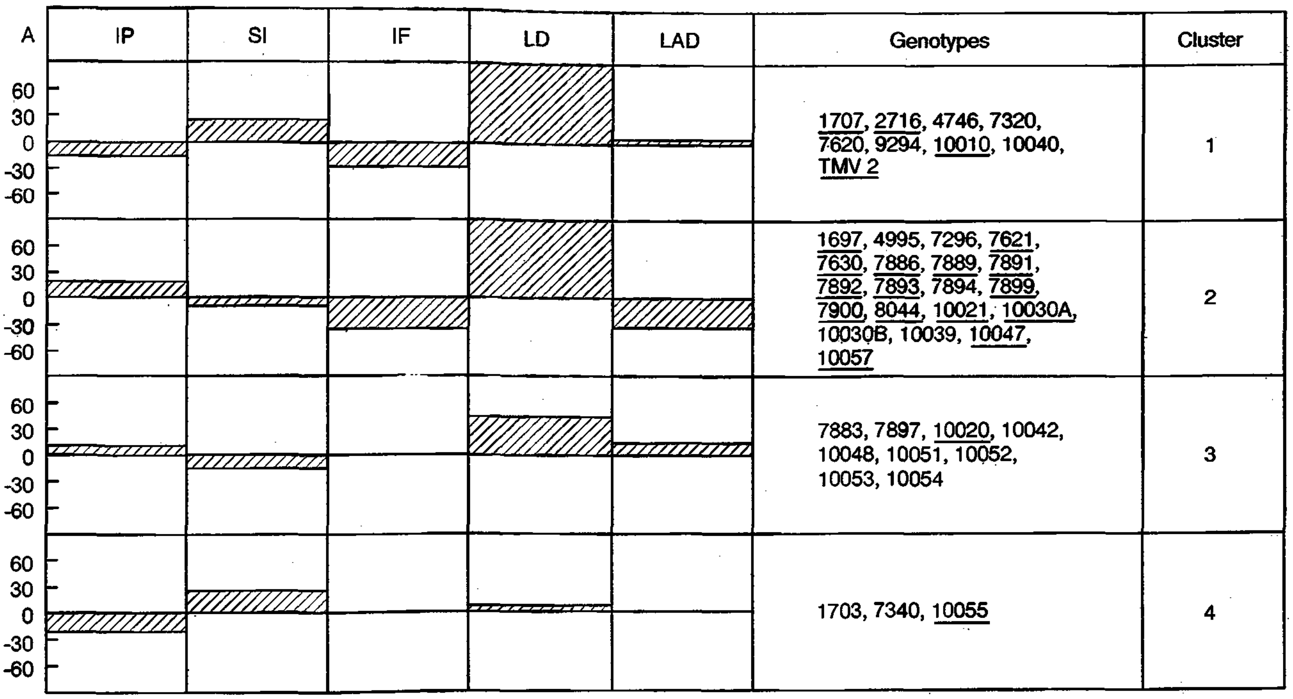

Figure 2. Deviation (%) of cluster means from the grand mean for five components of rust resistance in the whole-plant method.

A = deviation (%) from grand mean, IP = incubation period, SI = sporulation index, IF = infection frequency, LD = lesion diameter, LAD = percentage leaf area damaged. Underlined genotypes were grouped in the same cluster in both methods.

Table 1. Comparison of whole-plant and detached-leaf methods for studying components of rust resistance in groundnut.

Component	Whole plant method[1]	Detached leaf method[1]	Paired 't' value
Incubation period	14.5	13.9	1.63
Infection frequency	3.7	6.9	6.11**
Lesion diameter	0.3	0.3	0.15
Leaf area damaged (%)	4.0	7.2	3.02**
Sporulation index	3.1	3.1	0.57

1. Mean values for 41 genotypes.
** significant at P<0.01, df=40.

covered with spores, 4 = 51–75% lesion area covered with spores, and 5 = 76–100% sporulation).

Differences between the two methods for different components were tested by the paired 't' test (Table 1). The methods did not differ significantly for incubation period, lesion diameter, and sporulation index, but differed significantly for infection frequency and percentage of leaf area damaged. Levels of incubation period were similar in 29 (71%) genotypes in both methods. In the other 11 genotypes, minor differences in incubation period were observed between the methods. However, the genotype ICG 7296 showed a large variation in incubation period (19 days in the whole-plant method vs 9 days in the detached-leaf method).

Table 2. Correlations among components of rust resistance in groundnut in the detached-leaf and whole plant methods.

Components[1]	Correlations: Whole-plant method	Correlations: Detached-leaf method
LAD and IF	0.65**	0.64**
and LD	0.31*	0.37*
and IP	−0.35*	−0.52*
and SI	0.28	0.23
IF and LD	−0.09	0.20
and IP	−0.10	−0.39
and SI	0.03	0.17
LD and IP	−0.57**	−0.35
and SI	0.49**	0.40**
IP and SI	−0.38*	−0.16

* significant at 5%, ** significant at 1%
1. LAD = percentage of leaf area damaged, IF = infection frequency, LD = lesion diameter, IP = incubation period, SI = sporulation index.

Genotypes were clustered based on their similarity in levels of components in each method, using Ward's minimum variance method (Ward 1963). Figures 1 and 2 show clusters of genotypes and their deviation percentage from the grand mean. In both methods the largest number of genotypes (15) were in cluster 2 (Figs. 1 and 2). This cluster had genotypes with longer incubation period (positive deviation) and lower sporulation index (negative deviation) than the grand mean. This is important as these two components play a major role in slowing down rust epidemics. In both methods the susceptible control cultivar TMV 2 was grouped in cluster 1, along with genotypes showing low incubation period and moderate to high sporulation index levels.

Correlations among the components of rust resistance (except for infection frequency and sporulation index) in each method were also very similar in both direction and magnitude (Table 2). This is in agreement with the findings of Subrahmanyam et al. (1983) and Liao et al. (1990).

The results of this study clearly indicate that either method can be used to study resistance components. However, in view of space limitations and the difficulties of maintaining temperature and humidity in the greenhouse, the detached-leaf method is preferable to the whole-plant method.

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Variation in the Sensitivity of Groundnut Rust to Tridemorph in Central Maharashtra

B M Kareppa[1] and **L V Gangawane**[2]
(1. Department of Botany, D S M College, Parbhani 431 401, Maharashtra, India.
2. Soil Microbiology and Pesticides Laboratory, Department of Botany, Dr B A M University, Aurangabad 431 004, Maharashtra, India)

Rust (*Puccinia arachidis*) is a serious disease of groundnut worldwide (Subrahmanyam et al. 1980). Different fungicides including tridemorph are effective against rust and other foliar diseases of groundnut in India (Mayee 1979, Shastry et al. 1985, Subrahmanyam et al. 1985).

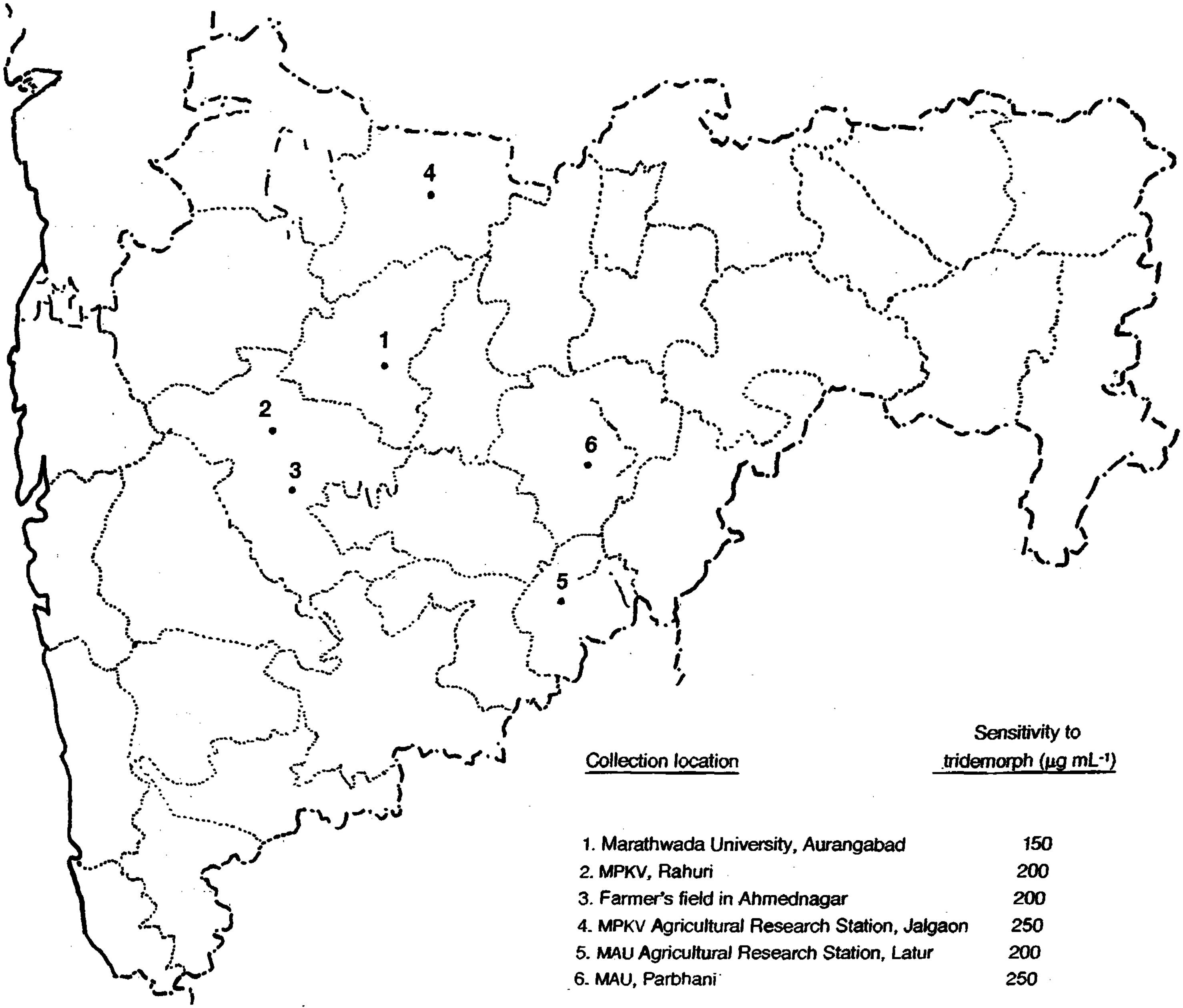
The simple leaf detached technique (SDL) was used to test isolates of the rust pathogen for sensitivity to the fungicide tridemorph. Groundnut variety SB 11 was used for the study. Fully expanded leaves from the lower, middle, and upper portions of the plants were detached, and washed 10 times with sterile distilled water. These leaves were dipped in different concentrations of tridemorph for 2 min. Uredospore suspension of the Aurangabad isolate (3×10^4 mL^{-1}) was applied to the leaves with the help of a brush, and the inoculated leaves were placed on glass rods in moist plates. The petioles touched the lower surface of moist filter paper. The plates were incubated in the laboratory at 26±3°C, and moistened from time to time to maintain the required moisture and turgidity of pathogen and host.

With an increase in tridemorph concentration there was a decrease in the number of pustules. The minimum inhibitory concentration (MIC) for rust was found to be 150 µg mL^{-1} (Table 1). The latent period was delayed by

Table 1. Number of rust pustules on leaves of groundnut cv SB 11 treated with tridemorph at various intervals, studied using the simple detached leaf technique.

Concentration of tridemorph (µg mL^{-1})	Number of rust pustules at various stages (days after inoculation)															
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Control	92.50[1]	110.00	122.75	138.25	152.66	167.25	182.00	190.33	199.50	204.50	208.00	211.50	214.00	216.00	217.00	218.00
10	3.00	6.00	9.50	12.00	16.00	20.00	21.50	25.50	28.25	30.75	32.50	33.00	33.33	34.00	34.00	34.00
50	1.00	1.25	4.25	9.75	11.50	13.50	14.75	16.25	18.00	19.66	20.85	21.66	22.00	23.00	23.00	23.00
100	0.00	0.00	1.50	2.50	4.50	6.00	7.33	8.00	11.00	12.50	13.25	14.00	14.50	15.00	15.00	15.00
150	0.00	0.00	0.00	1.00	2.00	3.33	4.40	5.50	6.00	6.30	7.00	7.60	8.00	8.60	8.60	8.60
200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1. Average of five replications



Collection location	Sensitivity to tridemorph (µg mL^{-1})
1. Marathwada University, Aurangabad	150
2. MPKV, Rahuri	200
3. Farmer's field in Ahmednagar	200
4. MPKV Agricultural Research Station, Jalgaon	250
5. MAU Agricultural Research Station, Latur	200
6. MAU, Parbhani	250

Figure 1. Locations in central Maharashtra from where groundnut rust samples were collected, and sensitivity of rust isolates to tridemorph.

3, 4, 5, and 6 days respectively on leaves treated with 10, 50, 100, and 150 µg mL^{-1}. At 200 µg mL^{-1} concentration, rust was completely inhibited. During initial testing, the MIC for the rust isolate from the Marathwada University farm, Aurangabad, was found to be 150 µg mL^{-1}. Hence, concentrations of 150–500 µg mL^{-1}, i.e., above this MIC level, were used for this study to determine the sensitivity of isolates collected from different locations in Maharashtra during the 1986 rainy season (Fig. 1).

Puccinia arachidis appears to be sensitive to tridemorph. Uredospore-infected samples from different locations showed variation in the MIC of this fungicide. Isolates from the Marathwada University Botanic Garden showed lower sensitivity than the isolate from the Marathwada Agricultural University (MAU), Parbhani, and the Mahatma Phule Krishi Vidyapeeth (MPKV) Agricultural Research Station (250 µg mL^{-1}). Other isolates showed an intermediate MIC of 200 µg mL^{-1} (Fig. 1). The Aurangabad isolate had not been previously treated with tridemorph. However, variation in MIC (150–250 µg mL^{-1}) was also recorded among the isolates obtained from different fields in Maharashtra. The increase in MIC shows the development of fungicide resistance in the rust pathogen.

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Temperature Sensitivity of Sclerotium Stem Rot Resistance in Groundnut

J Narayana Rao, S Pande, M V Reddy, and **D McDonald** (ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

Three hundred and fifty groundnut accessions originating from different geographic regions were evaluated in pots in a greenhouse for resistance to stem rot caused by *Sclerotium rolfsii.* Seven-day old potted seedlings were inoculated with 15-day old mycelial propagules. These propagules were covered with dried groundnut leaf debris (Pande et al. 1994). The ambient temperatures in the greenhouse during the period of the experiment (Jan 1993) ranged from 16–18°C (minimum) to 28–31°C (maximum). The number of dead plants was recorded every fourth day after the appearance of the first dead plant (killed by stem rot). The final mortality was recorded 30 days after inoculation, by which time the susceptible control cultivar showed 90–100% mortality. Eleven accessions (7 cultivated, 3 wild *Arachis* spp, and 1 interspecific derivative) showed less than 20% stem rot incidence, compared to 100% incidence in the susceptible control, Robut 33-1 (Table 1).

The 11 genotypes were retested in the same greenhouse during May 1993 using the same inoculation technique. The ambient temperatures during this experiment ranged from 23–26°C (minimum) to 27–36°C (maximum). All the test entries developed 100% disease incidence within 30 days after inoculation, indicating that sclerotium stem rot resistance in groundnut could be temperature sensitive.

The 11 genotypes were again tested in the greenhouse in Jan 1994, when temperatures ranged from 15–17°C (min) to 27–32°C (max). Nine entries showed less than 20% mortality, compared to 100% in the susceptible control.

A laboratory experiment was also conducted in Mar 1994 with three resistant and three susceptible genotypes, using incubators. The temperature regimes tested in this experiment were; 15–30°C (15° night, 30° day), 20–30°C (20° night, 30° day), 25–30°C (25° night, 30° day), and 30°C (30° night, 30° day). The three resistant lines were resistant only at 15–30°C (15° night, 30° day) and susceptible at higher temperatures, confirming the temperature sensitivity of sclerotium stem rot resistance in these genotypes (Table 2).

The fact that some genotypes are resistant at low temperatures but susceptible at high temperatures suggests either changes in the physiology of the groundnut plant that alter the plant's reaction to *S. rolfsii*, or changes in the pathogenicity of *S. rolfsii* as a result of increased oxalic acid production; oxalic acid levels play an important role in pathogenesis, as has been reported in carrot and sugar beet (Punja et al. 1985).

Table 1. Reactions of 12 groundnut genotypes to stem rot (*Sclerotium rolfsii*) in pot screening in three greenhouse tests, ICRISAT Asia Center, 1993–94.

	Percentage mortality due to stem rot[1]		
Genotype	Jan 1993[2]	May 1993[2]	Jan 1994[2]
ICG 407	13	100	40
ICG 494	7	100	8
ICG 500	0	100	0
ICG 563	13	100	0
ICG 605	7	100	12
ICG 2279	7	100	12
ICG 2837	13	100	0
ICG 4983	0	100	0
ICG 13172	0	100	0
ICG 13177	0	100	0
ID no. 2256 (*A. hypogaea* × *A. cardenasii*)	0	67	60
Robut 33-1	100	100	100
SE	±4.9	±1.9	±4.7
CV (%)	64.0	3.4	58.3

1. Average of 3 replications (5 plants per replication in one 15 cm plastic pot).
2. Temperature range: Test 1, minimum 16–18°C, maximum 28–31°C. Test 2, min 23–26°C, max 27–36°C. Test 3, min 15–17°C, max 27–32°C).

Table 2. **Reactions of six groundnut genotypes to stem rot (*Sclerotium rolfsii*) under different temperature regimes in incubators, ICRISAT Asia Center, Mar 1994.**

	Percentage mortality due to stem rot[1]			
	Temperature in incubators (°C)			
Genotype	Min 15 max 30	Min 20 max 30	Min 25 max 30	Min 30 max 30
Resistant				
ICG 494	7	87	100	100
ICG 500	15	100	93	100
ICG 2837	7	100	100	100
Susceptible				
ICGS 76	100	100	93	100
TMV 2	100	100	100	100
Robut 33-1	100	100	100	100
SE	±5.3	±2.7	±4.0	0.0
CV (%)	16.8	4.8	7.2	0.0

1. Average of three replications

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Resistance to Rust and Leaf Spots in ICRISAT Groundnut Lines in Eastern Sri Lanka

N Rabeendran and **V Arulnandhy**
(Faculty of Agriculture, Eastern University, Chenkalady, Sri Lanka)

In the eastern region of Sri Lanka, groundnut crops often suffer from leaf spots caused by *Cercospora arachidicola* and *Phaeoisariopsis personata*, and rust caused by *Puccinia arachidis*. Control measures against these diseases have not been effective in Sri Lanka. In order to identify resistant genotypes, short- to medium-duration lines, received from ICRISAT, were screened during in 1994 (mid April to late Aug) under field conditions in eastern Sri Lanka. The lines were sown at 30 × 10 cm spacing and managed in accordance with recommended practices (Anonymous 1990). No fungicides were sprayed. All lines were randomly sown in rows of 6 m length; every fifth row was an infector row of a local susceptible genotype (unnamed). Ten randomly selected plants in each line were scored for disease reactions on a 1–9 scale (Subrahmanyam et al. 1995).

The crop received a total rainfall of 91.5 mm during growth and development. Conditions during the experimental period (mean relative humidity 73%, mean temperature 29°C) were conducive to the proliferation of leaf spot and rust fungi, resulting in effective disease evaluation. Table 1 gives a summary of the results.

Severity of leaf spots ranged between 0 and 26.5%. Four groundnut lines, ICGVs 86928, 87883, 88248, and 87387, did not show leaf spot symptoms and were identified as resistant. Rust severity ranged between 0 and 41.8%. Six genotypes with 0–0.5% severity were considered as resistant—ICGVs 87391, 87817, 87281, 87282, 87334, and 88330. Groundnut lines with resistance to leaf spots and rust have great potential for cultivation in the eastern region of Sri Lanka. They can also be used as resistant parental materials in breeding programs to develop disease-resistant cultivars adapted to local conditions.

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Table 1. Disease reactions to leaf spots and rust in 39 groundnut genotypes, eastern Sri Lanka, 1994.

Genotype	Leaf spots Severity (%)	Leaf spots Disease score[1]	Rust Severity (%)	Rust Disease score[1]
Local control (unnamed)	100.0	9	6.5	3
ICGV 88311	26.5	5	6.5	3
ICGV 87867	18.8	4	0.6	2
ICGV 87334	14.5	4	0.3	1
ICGV 87160	13.0	4	0.6	2
ICGV 87817	10.8	4	0.3	1
ICGV 87206	10.3	3	0.9	2
ICGV 87108	10.0	3	7.1	3
ICGV 86885	9.9	3	9.9	3
ICGV 87232	9.4	3	4.1	2
ICGV 87242	9.3	3	11.7	4
ICGV 87281	9.1	3	0.3	1
ICGV 87350	8.3	3	0.6	2
ICGV 87282	6.5	3	0.3	1
ICGV 87074	6.4	3	0.9	2
ICGV 87288	6.2	3	2.2	2
ICGV 88347	6.2	3	41.8	7
ICGV 88330	5.7	3	0.0	1
ICGV 88335	5.2	2	38.0	6
ICGV 87885	4.7	2	32.5	6
ICGV 86023	3.9	2	2.8	2
ICGV 87884	3.3	2	3.5	2
ICGV 88336	3.2	2	7.4	3
ICGV 87391	2.7	2	0.3	1
ICGV 86168	2.3	2	19.8	4
ICGV 88348	2.0	2	17.4	4
ICGV 88329	1.9	2	3.6	2
ICGV 88322	1.8	2	2.3	2
ICGV 88338	1.7	2	4.3	2
ICGV 90064	1.7	2	3.9	2
ICGV 87378	1.6	2	15.9	4
ICGV 88342	1.4	2	1.7	2
ICGV 88345	0.6	2	5.5	3
ICGV 90068	0.3	1	4.3	2
ICGV 87983	0.3	1	13.9	4
ICGV 89318	0.3	1	0.6	2
ICGV 86928	0.0	1	4.9	2
ICGV 87883	0.0	1	4.7	2
ICGV 88248	0.0	1	5.7	3
ICGV 87387	0.0	1	2.2	2
Mean	5.62		10.48	
SD	±5.60		±9.94	

1. Scored on a 1–9 scale, where 1 = disease-free, 9 = 81–100% foliage destroyed

Effect of Humidity on Conidial Morphology of *Phaeoisariopsis personata*

K D R Wadia and **D R Butler** (ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

During the course of sporulation studies on the late leaf spot pathogen *Phaeoisariopsis personata*, diseased groundnut plants were placed in single plant chambers with controlled humidity (Butler et al. 1995). All chambers were kept at 25°C, and constant humidities of 96%, 98.5%, and 100% relative humidity (RH) were maintained. Conidia from lesions on attached leaves were collected using a suction spore sampler (Woolacott and Ayres 1984) after 24 h, and at 100% RH after 48 h and 72 h. Microscopic examination showed distinct differences in the morphological characters of conidia which developed at various humidity levels (Table 1, Fig. 1).

Table 1. Morphological characters of *Phaeoisariopsis personata* conidia at different relative humidities (RH).

	Length (µm)		Breadth (µm)		Number of septa	
Treatment	Mean	SE	Mean	SE	Mean	SE
96.0% RH (24 h)	38 d	±0.9	6.0 c	±0.10	2.5 c	±0.1
98.5% RH (24 h)	50 c	±1.9	6.0 c	±0.09	3.5 bc	±0.2
100% RH (24 h)	84 b	±4.0	6.2 bc	±0.08	10.5 a	±0.6
100% RH (48 h)	108 a	±4.0	6.1 c	±0.09	11.2 a	±0.4
100% RH (72 h)	115 a	±6.0	6.4 b	±0.06	11.0 a	±0.5
Burkard spore trap catches	42 cd	±1.9	7.0 a	±0.18	4.5 b	±0.3
LSD (5%)	9.31		0.29		1.06	

Mean and standard error values are for 100 determinations. Means followed by the same letter are not significantly different at $P<0.05$.

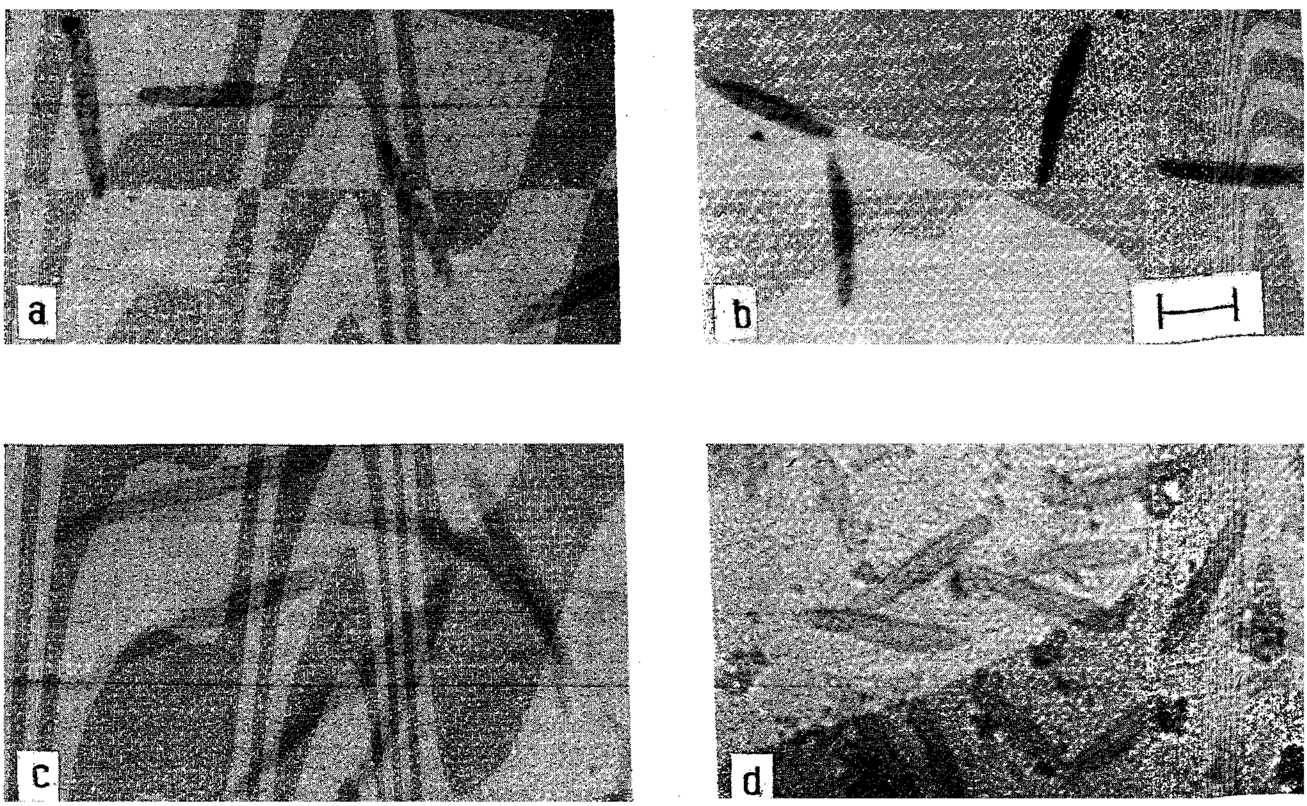

Figure 1. Photomicrographs of *Phaeoisariopsis personata* conidia collected after 24 h exposure to (a) 96% RH, (b) 98.5% RH, (c) 100% RH, and (d) Burkard spore trap catches. Bar represents 20 µm.

After 24 h, mean length of conidia ranged from 84 μm at 100% RH to 38 μm at 96% RH, and there were more than 10 septa at 100% rh compared to 2–3 septa at 96% RH. There were significant differences ($P<0.05$) in both mean conidial length and number of septa between all humidity treatments. A further significant increase in conidial length occurred after 48 h exposure to 100% RH, but there were no equivalent increases in the number of septa. There was no obvious trend in conidial breadth. Usually, conidial dimensions from spore catches in the field in the rainy season (Fig. 1d) are similar to those at the lower humidities (96%–98.5% RH).

Both the conidial length and number of septa at 100% RH reported here are very different to earlier reports for *P. personata* (Deighton 1967). Variability of morphological characters of fungal isolates of the same species collected from different geographical locations is commonly attributed to different pathotypes. The effect of environment on morphological characters can be large and should not be overlooked.

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Assessment of Losses in Groundnut Due to Early and Late Leaf Spots

S Das and **T K Roy** (Department of Plant Pathology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur 741 252, West Bengal, India)

Early leaf spot caused by *Cercospora arachidicola* and late leaf spot (*Phaeoisariopsis personata*) cause serious damage to groundnut crops in many areas. Leaf spots can cause up to 53% losses in pod yield and 27% losses in seed yield (Patel and Vaishnav 1987). In susceptible genotypes, combined attacks of rust and leaf spot can reduce seed yields by as much as 70% (Subrahmanyam et al. 1980). However, most of these reports are not correlated with repeated disease severity measurements. Therefore, it is not possible to use such data to construct mathematical models of the relationships between disease severity and yield loss. A clear knowledge of such relationships is important for effective disease management.

As a prerequisite to finding such correlations, differential epidemics must be achieved on experimental plots. This can be done by repeated recording of disease in different fields where disease levels are different. An indirect method was used (Van der Graf 1981). Differential epidemics were generated by using different numbers of fungicidal sprays and staggering the timing of sprays, while a disease-free plot was developed by blanket spraying of fungicides.

Groundnut cultivar JL 11 (susceptible to early and late leaf spots) was sown in 2 × 2 m plots during three rainy seasons from 1990 to 1992. The experiment was conducted in a randomized block design with three replications. Tridemorph was used to control rust and carbendazim to control leaf spots. Up to six sprays were applied every 10–15 days; some plots received fewer sprays than others, to generate differential epiphytotics. Tridemorph @ 0.2% was sprayed at 15-day intervals on 10-day old plants to inhibit rust infection, and this treatment did not interfere with leaf spot development (Das and Raj 1992). Similarly, up to six sprays of carbendazim (0.05%) were applied to generate differential levels of leaf spot. A rust-free condition was maintained by using blanket sprays of tridemorph and carbendazim even before appearance of the disease. In another control, no carbendazim was applied.

In each season, artificial epiphytotics were created by inoculating plants with *Cercospora* conidia. Spores were collected from severely infected groundnut leaves from the nearby early-sown fields. Approximately 20 g of infected leaves were blended in one liter of distilled water, and filtered through cheesecloth to remove extraneous debris. The filtrate was centrifuged at 3000 rpm for 15 min, decanted, and the pellet material containing spores was diluted with distilled water to provide a concentration of approximately 2000 spores mL^{-1}. Using a hand sprayer, 25-day old plants were sprayed with the inoculum immediately after it was prepared, till the point of run off in the evening. Spots appeared 15 days after inoculation. Disease severity on individual plants was rated using a 1–6 scale (Lewin et al. 1973) 10 days before harvest and computed as:

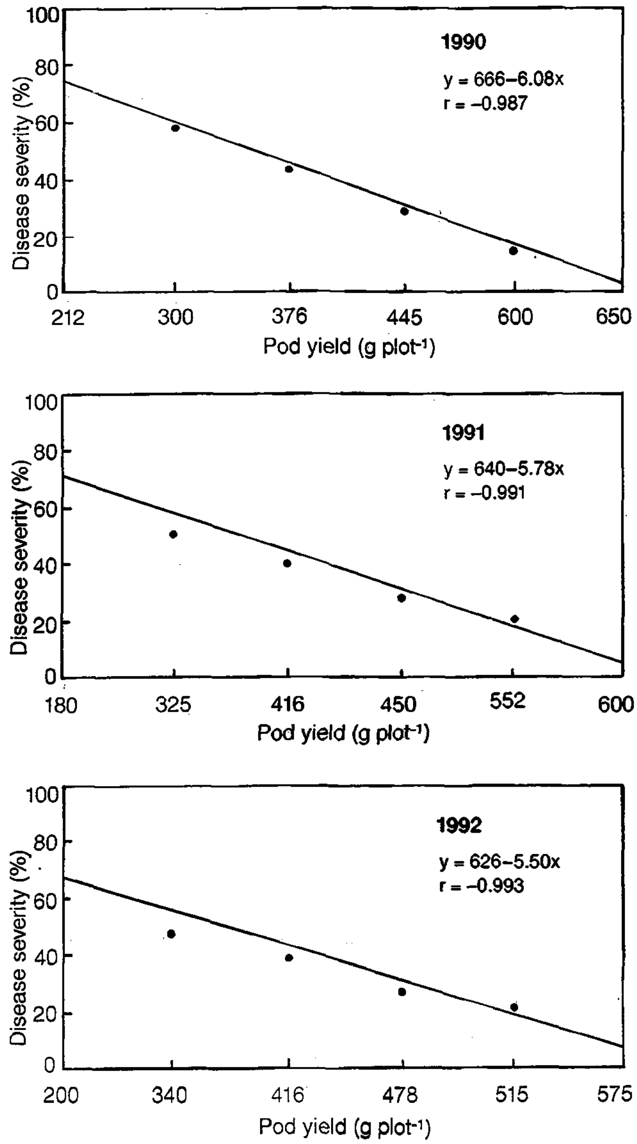

Figure 1. Relationship between leaf spot disease and pod yield in groundnut, Mohanpur, West Bengal, 1990–92 rainy seasons.

Infection or severity index (%) =

$$\frac{\text{Sum of all numerical ratings}}{\text{Total leaflets observed on total plants} \times \text{Maximum rating (6)}} \times 100$$

All plants in a plot were harvested to compute the total yield. The correlation between yield loss and disease infection/severity was calculated using linear regression analysis, and models were developed.

Disease severity and pod yield showed a high negative correlation in all 3 years. The correlation coefficients were –0.987, –0.991, and –0.993 in 1990, 1991, and 1992. A high goodness of fit was noticed for all the three linear regressions (Fig. 1). The equations obtained were: $y = 666 - 6.08x$ in 1990, $y = 640 - 5.78x$ in 1991, and $y = 626 - 5.50x$ in 1992, where y = predicted pod yield and x = disease severity rating.

The data and the prediction equation showed that in 1990, the attainable yield was 666 g plot^{-1} and that this yield declined by 6.08 g plot^{-1} for every 1% increase in disease severity (severity was recorded during the exponential phase of disease development). Similarly, in 1991 the attainable yield (640 g) declined by 5.78 g for every 1% increase in disease severity. In 1992, the attainable yield was 626 g, and declined by 5.50 g plot^{-1} for every 1% increase in disease severity. Similar observations have been recorded for other diseases, including groundnut rust (Das and Raj 1993) and rice blast (Nagarajan 1989).

These results provide evidence for an empirical linear relationship between leaf spot severity and yield loss, and confirm the usefulness of the systemic fungicide carbendazim in the management of leaf spot diseases. The models developed through linear regression, once confirmed through more extensive field trials in different climatic zones, will provide a useful tool for making decisions on initiating and staggering spraying schedules to maximize economic returns.

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Evaluation of Elite Bunch Entries for Productivity and Resistance to Late Leaf Spot in the Transitional Tract of Karnataka

M V C Gowda, V M Hegde, K Subramanyam, and **R S Bhat**
(Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad 580 005, Karnataka, India)

Late leaf spot caused by *Phaeoisariopsis personata* is a major foliar disease of groundnut worldwide. The disease occurs regularly and can cause more than 50% losses in pod and haulm yields in the transitional tract of Karnataka (Puranik et al. 1973). The disease can be controlled effectively by certain fungicides, but these are expensive and often not available. Cultivation of resistant varieties is therefore considered the best strategy. In the present study 12 elite, erect, bunch breeding lines procured from ICRISAT, released resistant varieties, and a susceptible control (JL 24) were assessed for their productivity and reaction to late leaf spot during the 1991, 1992, and 1993 rainy seasons at the Agricultural College farm, Dharwad. Each cultivar was sown in five rows 2.2 m long and 30 cm apart in two replications. The climatic conditions were congenial for late leaf spot development during all three seasons, and hence a meaningful evaluation was possible.

Disease development in each cultivar was assessed 90 days after sowing based on the remaining green leaf area (RGLA), calculated as a percentage using standard area diagrams (Hassan and Beute 1977). Each cultivar was also scored at harvest, using the 1–10 Florida rating scale (Knauft et al. 1988). Pods were washed, dried, and weighed to estimate yields from each plot. Shelling percentage was calculated from 200 g samples of dry pods.

Congenial conditions during 1991 resulted in the early appearance of disease, rapid defoliation, and low pod yields (Table 1). Among the released cultivars, Girnar 1 was as susceptible as the susceptible control JL 24, and less productive. ICG(FDRS) 10 and ICGV 86590 showed better resistance and gave yields comparable to JL 24, but gave low shelling percentages because of their thick shells. Though all the elite breeding lines were marginally superior in terms of disease resistance, only ICGV 88269 was comparable to JL 24 in both pod yield potential and shelling percentage. Some of the productive entries (ICGVs 87194, 87205, and 88261) gave low shelling percentages.

Our results indicate that besides yield, recovery and quality of pods are also greatly affected by the disease. Moderately resistant cultivars that give at least some yield advantage over the currently used varieties should therefore be used until more productive varieties with high resistance and good shelling percentages are developed (Reddy 1992).

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Table 1. Productivity and late leaf spot resistance in elite bunch groundnut genotypes, Agricultural Station, Dharwad, Karnataka, 1991–93 rainy seasons.

	Late leaf spot resistance								Productivity							
	RGLA[1]				Disease score[2]				Pod yield (t ha^{-1})				Shelling percentage			
Genotype	1991	'92	'93	Mean	1991	'92	'93	Mean	1991	'92	'93	Mean	1991	'92	'93	Mean
ICGV 87194	29.4	77.3	37.6	48.1	7	7	6	7	2.08	4.53	3.49	3.37	64.3	67.0	69.1	66.8
ICGV 87199	30.8	77.7	27.7	45.4	7	7	8	7	1.78	4.19	2.69	2.88	68.8	71.4	72.9	71.0
ICGV 87202	24.3	76.7	38.7	41.6	8	8	6	7	1.90	3.79	3.75	3.14	70.0	65.8	68.6	68.1
ICGV 87205	26.9	78.7	30.3	45.3	7	6	7	7	2.33	4.45	4.17	3.65	58.1	61.0	68.6	62.6
ICGV 87236	27.4	74.0	28.7	43.4	7	6	8	7	1.92	3.80	2.97	2.90	64.0	65.4	68.6	66.0
ICGV 87285	18.3	68.8	31.9	39.7	8	8	7	8	1.92	3.37	3.66	2.98	69.8	66.9	69.8	68.8
ICGV 87310	33.2	78.5	38.8	50.2	7	7	6	7	1.58	3.50	3.69	2.92	67.7	67.8	72.6	69.4
ICGV 87820	25.5	72.4	33.9	43.9	8	8	7	8	1.96	3.60	3.35	2.97	68.7	68.4	73.4	70.2
ICGV 87835	31.2	72.3	32.5	45.3	7	7	7	7	2.50	3.69	3.39	3.19	75.3	69.8	76.3	73.8
ICGV 88261	26.5	77.4	31.1	45.0	8	8	8	8	2.45	3.77	4.26	3.49	64.0	64.6	72.6	67.1
ICGV 88269	32.7	77.4	31.4	47.2	8	7	7	7	2.09	4.20	4.03	3.44	68.3	69.8	72.6	70.3
ICGV 89401	24.4	71.8	26.9	41.1	9	9	10	9	2.48	3.61	2.50	2.86	70.0	73.2	71.6	71.6
ICG (FDRS) 10	30.3	70.2	30.1	43.5	8	7	7	7	2.42	3.90	3.66	3.33	68.3	65.3	70.8	68.1
ICGV 86590	28.9	67.7	23.8	40.1	8	8	8	8	1.67	4.01	4.34	3.34	60.8	62.6	65.7	63.0
Girnar 1	24.0	61.5	39.2	41.5	10	10	10	10	1.91	3.29	2.59	2.60	64.3	67.5	67.8	66.5
JL 24	22.5	67.0	33.2	41.1	10	9	10	10	2.44	4.30	3.60	3.45	71.7	70.5	72.9	71.7
Grand mean	27.3	73.1	32.2						2.06	3.87	3.51		67.2	67.3	70.9	
SE	±2.8	±4.1	±4.6						±0.20	±0.28	±0.29		±2.1	±1.4	±3.3	
CD (5%)	7.7	12.3	13.9						0.55	0.85	0.88		5.7	4.3	9.8	
CV (%)	17.6	7.9	20.3						16.7	10.3	11.7		5.3	3.0	6.5	

1. Remaining green leaf area (RGLA) at 90 days after sowing.
2. Disease severity on a 1–10 scale where 1 = no disease, 2 = very few lesions (none on upper canopy), 5 = lesions noticeable even on upper canopy with noticeable defoliation, 7 = lesions numerous on upper canopy with >75% defoliation, 10 = plants dead.

Evaluation of Foliar Disease-Resistant Mutants in Groundnut

A G Patil, R Sheshagiri, and
M V C Gowda (Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad 580 005, Karnataka, India)

Rust (*Puccinia arachidis*) and late leaf spot (*Phaeoisariopsis personata*) are widely distributed foliar diseases of groundnut, and cause substantial losses in pod and haulm yields. Several fungicides are effective in controlling these diseases, but a more effective, less expensive, and environmentally sound means of control would be the use of disease-resistant cultivars. Though a number of genotypes with stable and high levels of resistance to late leaf spot (LLS) and rust are available, most of these genotypes are landraces with undesirable attributes like thick shells, low productivity, long maturity duration, and poor adaptation, making them unsuitable for direct utilization (Subrahmanyam et al. 1983). Many attempts have been made to produce high-yielding disease-resistant cultivars through hybridization, but the lines developed either had only moderate resistance or retained one or more undesirable features (Wynne et al. 1991). Stable interspecific derivatives with high yield and high resistance levels have been developed, but are all late-maturing (Reddy et al. 1992). There is therefore a strong need to identify groundnut germplasm combining high resistance levels and desirable agronomic features with high yield.

On artificial mutagenesis with ethylmethane sulfonate (EMS) at the University of Agricultural Sciences, Dharwad Early Runner yielded resistant, early-maturing, erect bunch mutants 1, 2, 8, 26, 49, 59, and 83 (Nadaf 1993). On subsequent mutagenesis with EMS, mutant 1 yielded secondary mutants (1-1, 1-45, 1-110, and 1-121) with high resistance levels and more desirable attributes (Sheshagiri 1994). In the present study, induced mutants were evaluated for disease resistance, productivity, and pod features. The parent (Dharwad Early Runner), resistant controls (PI 259747, PI 393516, GBFDS 272), and susceptible controls (Dh 39, K 134, JL 24) were also evaluated.

Each genotype was sown in three rows of 1.5 m length with a spacing of 30 × 10 cm, in two replications. Disease development was assessed on the main stem 90 and 100 days after sowing (Subrahmanyam et al. 1984). Percentage defoliation (DFOL) and the leaf area affected (LAA) due to LLS and rust were recorded. These data were used to compute remaining green leaf area (RGLA) percentage. The harvested pods were washed and dried; and pod yield, shelling percentage, percentage of sound mature seeds, and 100-seed mass were determined.

As indicated by the LAA values at both stages, rust and LLS incidence were lower in the mutants than in the susceptible controls (Table 1). However, the mutants 8, 83, 1-45, and 1-110, with lower DFOL values, had higher RGLAs than the resistant controls. Among them, 1-45 and 1-110 showed very high levels of resistance to LLS; the former exhibited a hypersensitive reaction and was also highly resistant to rust. All the mutants matured earlier than the resistant controls and were comparable to the susceptible controls in pod yield, shelling percentage, and percentage of sound mature seeds. The resistant mutants 1-45 and 1-110 matured very early (103 days) and had desirable pod and seed features—smooth pods and tan seeds with high seed mass, indicating their potential usefulness in the development of disease-resistant, productive groundnut genotypes with better pod and seed features.

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Table 1. Rust and late leaf spot resistance, productivity, and pod and seed features of induced mutants of groundnut, University of Agricultural Sciences, Dharwad, Karnataka, 1994 rainy season.

	Resistance parameters[1]								Productivity[2]						
	90 DAS				100 DAS										
	LAA				LAA								Days	Pod	
Genotype	Rust	LLS	DFOL	RGLA	Rust	LLS	DFOL	RGLA	PY	SP	SMS (%)	100-M	to maturity	reticu-lation[3]	Seed color
Mutants															
1	0.08	2.54	58.5	39.7	0.37	6.06	72.0	26.0	11.5	73.1	89	47	102	2	Tan
2	0.00	0.93	44.3	63.7	0.00	3.81	67.1	31.7	17.1	77.7	94	38	109	3	Purple
8	0.51	2.75	19.4	78.2	5.14	7.26	37.7	55.5	10.1	75.1	94	37	108	5	White
26	0.13	3.76	52.8	49.8	0.51	15.46	71.0	24.8	13.4	78.1	92	49	102	1	Tan
49	0.00	1.10	40.5	58.8	0.00	2.51	73.3	26.0	16.7	76.0	86	37	109	3	Purple
59	0.00	1.15	49.3	50.1	0.00	3.48	70.8	28.0	9.3	77.6	90	34	109	3	Tan
83	0.32	2.27	21.5	76.4	2.78	4.79	29.0	65.9	7.5	78.4	91	38	108	4	White
1-1	0.00	1.18	47.9	51.4	0.00	4.08	74.5	24.3	15.6	78.6	94	37	109	3	Purple
1-45	0.18	0.00*	15.4	84.2	0.85	0.00*	14.1	82.8	12.6	71.1	92	50	103	1	Tan
1-110	2.55	0.04	9.5	87.0	6.00	0.45	41.2	51.7	8.2	69.7	93	46	103	1	Tan
1-121	0.00	1.05	25.7	73.5	0.00	3.08	50.2	36.0	15.7	77.2	85	40	109	3	Purple
Parent															
Dharwad Early Runner	0.33	2.85	47.9	50.5	1.29	3.69	73.2	25.6	8.5	71.4	86	27	102	2	Tan
Resistant controls															
PI 259747	0.00	0.38	19.4	80.3	0.21	0.37	60.4	39.4	19.5	74.7	97	51	116	5	Purple
PI 393516	0.21	1.12	26.0	73.0	4.80	0.49	46.5	52.2	14.6	69.7	94	41	116	5	White**
GBFDS 272	0.00	0.00	16.2	83.8	0.00	0.13	27.5	72.2	17.6	73.6	89	62	122	2	Red
Susceptible controls															
Dh 39	0.02	5.96	55.5	41.9	0.20	21.58	66.5	22.8	9.4	78.6	92	37	102	2	Tan
JL 24	0.75	3.45	39.8	57.6	3.73	16.73	64.8	28.0	9.8	78.9	94	50	102	1	Tan
K 134	0.64	3.28	39.2	55.4	1.49	13.91	50.6	41.3	10.9	75.1	95	47	102	2	Tan
Mean	0.34	1.88	34.9	64.2	1.68	6.00	53.4	40.8	12.7	75.3	91	43			
SE	±0.23	±0.44	±5.0	±4.8	±1.30	±2.06	±6.5	±5.6	±1.7	±1.5	±2	±2			
CD	0.70	1.32	14.9	14.2	3.88	6.15	19.5	16.6	5.1	4.6	7	7			

* Hypersensitive reaction. ** with tan and red blotches

1. DAS = days after sowing, LAA = leaf area affected, LLS = late leaf spot, DFOL = percentage defoliation, RGLA = remaining green leaf area.
2. PY = pod yield (g $plant^{-1}$), SP = shelling percentage, SMS = percentage of sound mature seeds, 100-M = 100-seed mass (g).
3. 1 = smooth, 2 = slight, 3 = moderate, 4 = prominent, 5 = very prominent.

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Reaction of Some ICRISAT Groundnut Varieties to Bacterial Wilt Disease in China

Liao Boshou[1], **Duan Naixiong**[1], **Tan Yujun**[1], and **S N Nigam**[2] (1. Oil Crops Research Institute, Chinese Academy of Agricultural Sciences, Wuhan, Hubei 430062, People's Republic of China. 2. ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

In 1992, 101 varieties, representing the fourth series of five ICRISAT international groundnut trials, were grown by the Oil Crops Research Institute (OCRI), Wuhan, for evaluation under central China conditions. These trials were the International Insect Pests Resistance Groundnut Varietal Trial (IIPRGVT), International Drought Resistance Groundnut Varietal Trial (IDRGVT), International Medium- and Long-duration Groundnut Varietal Trial (IMLGVT), International Confectionery Groundnut Varietal Trial (ICGVT), and International Foliar Diseases Resistance Groundnut Varietal Trial (IFDRGVT). In addition to these trials, the same lines were also grown in a natural sick plot of bacterial wilt caused by *Pseudomonas solancearum* in Hong'An, Hubei Province, in 1992 and 1993. The objective of the screening was to score bacterial wilt reactions in these varieties and identify wilt-resistant materials with other desirable traits.

The screening was conducted from Apr to Aug with one replication in 1992 and two replications in 1993. For each breeding line, 60 seeds were sown in a single test row. Taishan Sanlirou (resistant) and E Hua 4 (susceptible) were used as controls, and sown after every four test rows. Wilt incidence was recorded once a month. As the natural disease nursery has been in existence for more than 20 years, disease pressure was uniform and reliable. Wilt incidence was over 95% in the susceptible control, but less than 15% in the resistant control. Disease pressure in 1993 was slightly higher than in 1992, due to higher rainfall.

No variety was highly resistant to bacterial wilt. Almost all the 82 varieties in three international trials (IIPRGVT, IDRGVT, IMLGVT) were highly susceptible, with less than 30% of the plants surviving in the nursery. However, four varieties in ICGVT (ICGVs 88369, 88382, 88389, and 88402) and one variety in IFDRGVT (ICGV 86699) were tolerant of the disease, with plant survival ranging from 50% to 69%. Fourteen varieties, mainly from ICGVT and IFDRGVT, were moderately susceptible, with plant survival ranging from 30% to 49%.

The ICRISAT-developed lines had a longer latent period than the local susceptible spanish type materials; most ICRISAT lines reached the peak stage of wilting rather late. Resistance to bacterial wilt in groundnut has different mechanisms and components, including latent period (Liao et al. 1992). These components might influence the level and stability of resistance. Breeders working on bacterial wilt resistance should therefore pay more attention to utilizing parents with different resistance components.

In this screening, among the 19 tolerant and moderately susceptible varieties (plant survival over 30%), 12 varieties in ICGVT had ICGV 86564 (Ah 114 × NC Ac 1107) or ICG 7350 as their female parent; 4 varieties in IFDRGVT had NC Ac 17090 as their pollen parent. This suggests that these parental genotypes have some tolerance to bacterial wilt, probably with a different mechanism of disease reaction. In Indonesia, a bacterial wilt-resistant line was selected from the cross GH 32 × NC Ac 17090 (Machmud 1993). NC Ac 17090 was tested in Hong'An, China, for 5 seasons, and showed an average plant survival of 38.65% (Duan Naixiong et al., unpublished data) and a relatively long latent period. Therefore, the ICRISAT-developed groundnut lines may offer potential genetic diversity for long latent period and multiple resistance/tolerance.

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Identification of Sources of Resistance to Bacterial Wilt in Groundnut Germplasm Under Southern Vietnamese Conditions

Duc Cam[1], Phan Lieu[1], and S L Dwivedi[2]
(1. Institute of Oil Plants, 171–175 Ham Nghi Street, Ho Chi Minh City, Vietnam.
2. ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

Bacterial wilt, caused by *Pseudomonas solanacearum*, is an important constraint to groundnut production in southern Vietnam. Tay Ninh and Long An provinces are the major groundnut-producing regions in southern Vietnam. Two crops of groundnut after rice is the major cropping pattern. Disease incidence in the range of 20–30% has been reported from this region (Hong et al. 1994). The disease is more common in areas where groundnut is cultivated season after season in the same upland fields.

In the 1993/94 winter-spring season, 73 germplasm lines from Indonesia and a local cultivar Ly were screened for resistance to bacterial wilt. Twenty-two germplasm lines with wilt incidence less than 15% were selected for further screening during the 1994 autumn season, after which 13 germplasm lines were finally selected for a replicated trial during the 1994/95 winter-spring season. All the genotypes were of subspecies *fastigiata* var *vulgaris*, with small to medium sized pods and tan colored seeds. The genotypes were grown in a single-row plot of 5 m length, spaced at 30 cm between rows and 10 cm within rows. The susceptible control Chico was sown after every 5 rows of test materials. Plant debris of wilt-affected plants from neighboring fields was collected and mixed in the soil to increase inoculum levels. Bacterial wilt incidence was monitored at weekly intervals.

Cumulative disease incidence in the selected genotypes is shown in Table 1. Average disease incidence was 52.7% in the susceptible control Chico and 32.1% in the local cultivar Ly. Average incidence in the test entries ranged from 0.2% in ICG 8666 to 7.7% in ICG 8637. Except for ICG 8637 and ICG 8654, seed of the remaining genotypes has been increased for an assessment of agronomic traits during the 1995/96 winter-spring season in southern Vietnam. ICG 8666 was also reported resistant to bacterial wilt in a sick-plot test conducted at Habac in northern Vietnam (Hong et at. 1994).

Table 1. Bacterial wilt disease incidence in 13 groundnut genotypes evaluated over 3 seasons, Cuchi, southern Vietnam.

	Wilt incidence (%)[1]			
	Winter-spring		Autumn	
Genotype	1993/94	1994/95	1994	Average
ICG 8666	0.00	0.64	0.00	0.21
ICG 8625	0.00	0.00	3.33	1.11
ICG 5313	0.00	0.62	3.00	1.21
ICG 8632	0.00	1.63	3.03	1.55
ICG 8627	0.00	4.55	0.73	1.76
ICG 8626	0.00	4.90	2.01	2.30
ICG 8645	2.56	3.77	0.74	2.36
ICG 8675	4.65	0.00	3.42	2.69
ICG 8630	0.00	3.80	7.00	3.60
ICG 8638	8.00	0.71	2.38	3.69
ICG 8662	8.00	3.46	1.10	4.18
ICG 8654	8.51	3.22	8.33	6.68
ICG 8637	8.69	6.63	7.78	7.70
Controls				
Chico	70.43	48.02	39.63	52.69
Local Ly	52.17	25.09	19.68	32.13

1. Nonreplicated trials during the 1993/1994 winter-spring and 1994 autumn seasons.

We are collaborating with Dr Hong of the National Institute of Agricultural Science (INSA), Hanoi, to test these genotypes under northern Vietnamese conditions.

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Aflatoxin-Producing Potential of Various Strains of *Aspergillus flavus* from Groundnut Fields in Different Soil Types

V K Mehan, S V Reddy, S Nahdi, D McDonald, and S Jayanthi (ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

There are numerous reports that *Aspergillus flavus* isolates from groundnut produce aflatoxin in culture media or on a groundnut substrate. However, only a few workers (Joffe 1969, Maggon et al. 1969), have reported aflatoxin production by *A. flavus* isolates obtained from soils, and there is no information on the possible association between soil type and the aflatoxin-producing potential of these isolates. This paper discusses the aflatoxin-producing potential of various isolates of *A. flavus* from groundnut fields in different soil types, and the relationship between aflatoxin production levels and production of sclerotia.

Forty-eight single-spore isolates of *A. flavus* obtained from six fields differing in soil type (red sandy loam, light sandy soil, Vertisol) and management/cultivation practices were tested for sclerotial production and aflatoxin production. Field conditions and soil types are summarized in Table 1. In the irrigated fields groundnut was rotated with pearl millet, while the rainfed fields in light sandy and red sandy loam soils were kept fallow. In Vertisol fields, groundnut was rotated with sorghum. Eight isolates from each field/soil type were tested; these included two isolates belonging to each of the four sclerotial production groups—high, moderate, low, and nil sclerotial production.

Isolates were tested for sporulation and sclerotial production on 0.7% yeast extract medium. Groundnut seeds (cv TMV 2) were used as a substrate for aflatoxin production tests (Mehan et al. 1982). Two replicates were used for each isolate. Sclerotial production of *A. flavus* isolates on groundnut seeds was recorded 5 and 10 days after inoculation. Aflatoxins were determined using the method described by Pons et al. (1966).

All isolates produced aflatoxin B_1 at levels ranging from 1 to 290 $\mu g\ g^{-1}$ (Table 1). Significant differences ($P = 0.05$) were observed between soil types/fields for aflatoxin-producing potential of isolates. Isolates from a Vertisol field produced significantly lower overall mean aflatoxin (42.2 $\mu g\ g^{-1}$) than isolates from red sandy loam and light sandy soil fields; isolates from the latter two types of fields did not differ significantly in their aflatoxin-producing abilities (overall means 70–81.5 $\mu g\ g^{-1}$).

Table 1. Aflatoxin production by various strains of *Aspergillus flavus* varying in sclerotial production, ICRISAT Asia Center.

Strain	Sclerotial production	Aflatoxin B_1 ($\mu g\ g^{-1}$ seed)
Light sandy soil (Field 1, rainfed)		
AF 3	High	150.0
AF 20	High	90.0
AF 2-1	Moderate	80.0
AF 24-1	Moderate	11.3
AF 2	Low	80.0
AF 12	Low	16.5
AF 48	Nil	110.0
AF 210	Nil	16.3
Light sandy soil (Field 2, rainfed)		
AF 191	High	45.0
AF 58	High	65.0
AF 194	Moderate	250.0
AF 69	Moderate	75.0
AF 124	Low	90.0
AF 131	Low	85.0
AF 183	Nil	9.0
AF 197	Nil	4.7
Light sandy soil (Field 3, rainfed)		
AFA/TN	High	100.0
AFA/TP	High	150.0
AFA 41	Moderate	55.0
AFA 8	Moderate	135.0
AFA 33	Low	1.6
AFA 38	Low	70.0
AFA 2	Nil	90.0
AFA 7-1	Nil	50.0
Red sandy loam soil (Field 1, rainfed, unsprayed)		
AF 162	High	65.0
AFA 20	High	115.0
AF 136	Moderate	210.0
AF 149	Moderate	50.0
AF 144	Low	45.0
AF 141-B	Low	70.0
AF 135	Nil	1.2
AF 140	Nil	60.0
Red sandy loam soil (Field 2, irrigated, sprayed with fungicide chlorothalonil and insecticides)		
AFA 26	High	110.0
AFA 29	High	215.0
AFA 27	Moderate	150.0
AFA 30	Moderate	125.0

Continued.....

Table 1. *Continued....*

Strain	Sclerotial production	Aflatoxin B_1 ($\mu g\ g^{-1}$ seed)
AFA 28	Low	150.0
AF 107B	Low	235.0
AFA 24	Nil	290.0
AFA 25	Nil	80.0
Vertisol (irrigated)		
AFA 17	High	2.2
AF 87A	High	70.0
AFA 17-1	Moderate	2.5
AFA 21	Moderate	90.0
AFA 22	Low	80.0
AF 83	Low	90.0
AF 96	Nil	1.7
AF 99	Nil	1.0
SE (fields)		± 12.81
SE (isolates)		± 10.46

There was no association between sclerotial production and aflatoxin production. Some previous reports have suggested that isolates that produced abundant sclerotia were also highly aflatoxigenic (Maggon et al. 1969, Mehan and Chohan 1973). It is possible that among strains which produce both aflatoxin and sclerotia, similar growth conditions would favor their simultaneous production in certain culture media used in several studies. None of the isolates produced sclerotia when grown in vitro on surface-sterilized scarified groundnut seeds.

All isolates tested produced only aflatoxin B_1, confirming our earlier observations that most *A. flavus* isolates from groundnut fields in India produce only aflatoxin B_1.

Our (limited) studies indicate clearly that strains from Vertisols produce lower aflatoxin levels than do strains from light sandy and red sandy loam soil. These results are important in the light of reports indicating low risks of aflatoxin contamination in Vertisols (Mehan et al. 1991). The results of this study emphasize the need to understand and control soil/environmental factors that could influence the aflatoxin-producing potential of *A. flavus* isolates. The cumulative effect of the presence of various toxin-producing strains and their populations, together with the factors influencing the predominance of each strain, is an interesting but complex subject for future investigations.

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Host Races of *Meloidogyne javanica*, with Preliminary Evidence that the 'Groundnut Race' is Widely Distributed in India

S B Sharma, D H Smith, and
D McDonald (ICRISAT Asia Center,
Patancheru 502 324, Andhra Pradesh, India)

Root-knot disease caused by *Meloidogyne* spp is the most important nematode disease of groundnut. The causal agents are *Meloidogyne arenaria, M. javanica, M. hapla,* and *M. incognita. Meloidogyne arenaria* Race 1 is the most widespread and destructive of the groundnut root-knot nematodes; *M. hapla* is also important, particularly in North Carolina, Oklahoma, and Virginia (USA), north-

Table 1. Proposed host races of *Meloidogyne javanica*.

Race	Tomato (cv Rutgers)	Pepper (cv Early California Wonder)	Groundnut (cv Florunner)	Distribution
1	+	–	–	Widespread
2 (pepper race)	+	+	–	Italy, Morocco
3 (groundnut race)	+	–	+	Brazil, Zimbabwe, Egypt, India, USA

+ susceptible host, – resistant host

ern China, and Australia. *Meloidogyne javanica* is not a common pathogen of groundnut. According to differential host tests in North Carolina, *M. javanica* has only one distinct host race. It reproduces on tobacco, watermelon, and tomato but does not commonly reproduce on cotton, pepper, and groundnut; however, a few populations can reproduce on pepper, and a very few on groundnut (Hartman and Sasser 1985).

Taylor and Sasser (1978) suggested that the word 'race' should be used only for populations of *Meloidogyne* that have been shown by numerous experiments to have host preferences significantly different from those established as 'normal' for that species, and have a wide geographical distribution. On the basis of reports of *M. javanica* parasitizing groundnut in Zimbabwe (Martin 1958), USA (Minton et al. 1969), Brazil (Lordello and Gerin 1981), Egypt (Ibrahim and El Saedy 1976), and India (Prasad et al. 1964, Sakhuja and Sethi 1985, Patel et al. 1988), it is apparent that three distinct host races of *M. javanica* occur in nature (Table 1). Di Vito (1979) reported that two populations of *M. javanica* from Sicily and Calabria reproduced on pepper, and these were tentatively designated as a new race (Di Vito and Greco 1982). This race is also present in Morocco (Rammah and Hirschmann 1990). Race 3 is designated as the 'groundnut race'. Populations of *M. javanica* that can parasitize both pepper and groundnut (race 4?) have not been reported.

Meloidogyne javanica has been reported on groundnut in northern (Delhi and Punjab), western (Gujarat), and southern (Andhra Pradesh) India, and is a potentially important groundnut pathogen (Sakhuja and Sethi 1985). Groundnut has been considered as a possible rotational crop in areas with high levels of *M. javanica*. However, a decision to use groundnut as a rotational crop should be delayed until the race of *M. javanica* present in these areas has been identified.

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Preliminary Investigation of a 'Peg Drying' Problem of Groundnut

S B Sharma[1], **V K Mehan**[1], **V M Ramraj**[1], and **D D R Reddy**[2] (1. ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India. 2. Andhra Pradesh Agricultural University, Rajendranagar 500 030, Andhra Pradesh, India)

A new 'peg drying' problem of groundnut has recently been observed in about 6000 ha of the crop grown on sandy soil in the Chirala, Vetapalem, and Bapatla regions of southern coastal Andhra Pradesh, India. The affected plants were slightly stunted, and had mottled leaves and blackened pegs and pods. Some pegs were free from lesions but were flaccid. The roots of the affected plants appeared bushy. In the Vetapalem area, seeds were generally not well-formed and often showed hollow heart symptoms. Yield loss due to this problem was estimated at about 30%.

Soil samples collected from fields with the 'peg drying' problem and from fields with apparently healthy crops were analyzed for pH, nutrient status, fungal pathogens, and nematodes. Density of the ring nematode *Criconemella ornata* ranged between 56 and 472 per 100 cm^3 in the 'peg dried' fields, and between 2 and 22 per 100 cm^3 in fields without the problem. The fungi *Fusarium moniliforme*, *F. solani*, *F. semitectum*, *Rhizoctonia solani*, and *Macrophomina phaseolina* were commonly isolated from the affected pegs.

A pot experiment was set up in the greenhouse at ICRISAT Asia Center to study the problem. Soil collected from the top 20 cm profile of affected fields was placed in 15 cm diameter pots. Main treatments were application of 15 L ha^{-1} dibromochloropropane, Vitavax®, and control (no chemical). Subtreatments were—addition of boric acid (1.43 mg kg^{-1} soil), addition of calcium sulphate (0.5 g kg^{-1} soil), and addition of both boric acid and calcium sulphate to the soil. A week after imposing the treatments, two seeds of the groundnut cv TMV 2 were sown in each pot. There were two pots for each subtreatment and six pots for each main treatment. The pots were irrigated regularly with deionized water, and plant growth was visually assessed before harvesting the plants 102 days after sowing.

Blackening of peg tips was noticed to varying degrees in all the treatments. Plant growth in the nematicide-

Table 1. Soil pH and nutrient status of fields with and without the groundnut 'peg drying' problem, southern coastal Andhra Pradesh.

Soil	pH	Na[2]	Fe	Zn	Ca	Mn	Cu
From apparently healthy fields	7.0 (6.6-7.3)[1]	52 (46-57)	45 (25-65)	0.61 (0.48-0.74)	97 (57-137)	11 (8-13)	0.38 (0.36-0.40)
From fields with 'peg drying' problem	5.4 (5.3-5.5)	21 (16-26)	61 (38-90)	0.28 (0.16-0.36)	40 (15-72)	14 (13-16)	0.27 (0.16-0.36)

1. Figures in parentheses show range.
2. Na, Fe, etc. expressed as mg kg^{-1} soil.

treated soils showed a slight improvement over the control. No improvement in plant growth resulted from the fungicide treatment, and some phytotoxic effect was noticed. Plant growth, root mass, peg number, and pod number and filling were improved by the calcium+boron treatment. All plants in the calcium+boron treatment, and 25–50% plants in soils treated with either calcium or boron, produced pods. Plants in the control treatment generally did not set pods. Low pH, calcium, and zinc concentrations in problem soils (Table 1) and improved response of the plants to calcium+boron indicated the possible involvement of these abiotic factors in the 'peg drying' problem.

Bioefficacy of *Paecilomyces lilacinus* in Controlling *Meloidogyne javanica* (Pathotype 2) on Groundnut

D J Patel, R V Vyas, B A Patel, and **R S Patel** (Department of Nematology, B A College of Agriculture, Gujarat Agricultural University, Anand 388 110, Gujarat, India)

Plant parasitic nematodes, especially the root-knot nematode *Meloidogyne javanica*, are a major constraint to groundnut production and productivity in India and elsewhere. Sharma and McDonald (1990) have reported *M. javanica* infestation on groundnut in light soils of the semi-arid tropics. Several chemicals and bioagents are being used for the management of phyto-nematodes. One bioagent, *Paecilomyces lilacinus*, is an effective microbial tool in controlling root-knot nematodes (Jatala 1986). The present study was undertaken during 1990–92 to test the bioefficacy of *P. lilacinus* against *M. javanica* (Pathotype 2) on groundnut. It was tested in pots in two ways—as seed treatment and as a soil application.

Earthen pots (15 cm diameter) were disinfected with 4% formalin and filled with soil infested with microplot-maintained *M. javanica* (Pathotype 2) (430 second stage juveniles per 100 g soil). In the *P. lilacinus* seed treatment, seeds of groundnut cv GG 2 were coated uniformly with 0.05, 0.1, and 0.2% fungal spore powder containing 10^8 conidia g^{-1}. Soil application of *P. lilacinus* was done @ 1, 2, 3, 4, and 5% (w/w), using 15-day old fungus grown on sterilized neem cake. A treatment of 5% neem cake without fungus was used for comparison. In addition, two controls were maintained, one each for seed treatment and soil application of fungus, thus making a total of 28 treatments in different combinations.

Neem cake and fungus were incorporated in the soil 10 days before seeding. Treatments were replicated thrice using a completely randomized design. Three seeds of groundnut cv GG 2 were sown per pot; thinned to one seed per pot after germination. Observations on fresh shoot and root mass, root-knot index, and nodulation index were recorded 90 days after germination. Data were analyzed statistically to evaluate the different treatments.

Data pooled for 3 years (1990–92) indicated that seed treatment with *P. lilacinus* had no effect on fresh shoot and root mass, or on root-knot index on groundnut plants grown in *M. javanica* infested soils; while *P. lilacinus* soil application gave significant differences for all parameters measured (Table 1). Among the various neem cake based treatments, concentration of 5% (w/w) was the most effective, followed by 4% and 3% fungus application. Concentrations of 1% and 2% fungus application and 5% neem cake (without fungus) gave similar results; these three treatments were all superior to the control in preventing root-knot nematode infestation. Nodulation on groundnut roots by nitrogen-fixing bacteria was not affected by *P. lilacinus*, whether used as seed treatment or as a soil application.

It can therefore be concluded that soil application of *P. lilacinus* @ 3 to 5% (w/w) on a neem cake base is useful for the management of *M. javanica* (Pathotype 2) on groundnut cv GG 2; seed treatment with the fungus may not be effective.

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Table 1. Bioefficacy of *Paecilomyces lilacinus* in controlling *Meloidogyne javanica* on groundnut, 1990–92.

	Fresh weight (g plant^{-1})							
Treatment	Shoot		Root		RKI[1]		Nodulation index[2]	
Seed treatment								
0.05%	3.82 a	(14.59)	1.95 a	(3.80)	1.79 a	(2.20)	1.48 b	(2.19)
0.1%	3.82 a	(14.59)	1.96 a	(3.84)	1.74 a	(2.02)	1.54 ab	(2.37)
0.2%	3.87 a	(14.98)	1.90 a	(3.61)	1.75 a	(2.06)	1.55 a	(2.40)
Control	3.66 a	(13.40)	1.85 a	(3.42)	1.82 a	(2.31)	1.50 ab	(2.25)
SE	±0.09		±0.06		±0.04		±0.02	
Soil application (w/w)								
1%	3.71 c	(13.76)	1.79 ab	(3.20)	1.86 ab	(2.46)	1.47 ab	(2.16)
2%	3.82 bc	(14.59)	1.99 ab	(3.96)	1.84 ab	(2.39)	1.51 ab	(2.28)
3%	3.86 bc	(14.90)	1.99 ab	(3.96)	1.73 bc	(1.99)	1.54 ab	(2.37)
4%	3.95 ab	(15.60)	2.00 ab	(4.00)	1.66 bc	(1.76)	1.53 ab	(2.34)
5%	4.10 a	(16.81)	1.62 a	(2.62)				
5% (neem cake only)	3.81 bc	(14.52)	1.77 b	(3.13)	1.81 ab	(2.28)	1.52 ab	(2.31)
Control	3.30 d	(10.89)	1.85 ab	(3.42)	2.00 a	(3.00)	1.44 b	(2.07)
SE	±0.07		±0.08		±0.07		±0.05	
Interaction (seed treatment × soil application) not significant								
Year effect[3]	s		s		s		ns	
CV (%)	11.0		14.0		10.0		11.8	

1. Root-knot nematode index on a 0–5 scale, where 0 = no knots on root, 5 = maximum knots on root.
2. On a 0–3 scale, where 0 = no nodulation, 3 = heavy nodulation.
3. s = significant, ns = not significant.

Figures in parentheses are transformed values, $\sqrt{x}$ transformation for shoot/root mass and nodulation index, $\sqrt{x+1}$ transformation for RKI.
Figures in a column followed by the same letter(s) are not significantly different at $P = 0.05$ according to DMRT.

Groundnut Virus Identity Problem?

J W Demski[1] and **D V R Reddy**[2]
(1. Department of Plant Pathology, Georgia Experiment Station, Griffin, GA 30223, USA. 2. ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

Groundnut workers in many countries often confront a suspected virus disease problem but are unable to verify the viral nature of the disease or to identify the causal virus(es). At the 1993 meeting of the International Working Group on Groundnut Viruses, it was suggested that laboratories currently investigating groundnut viruses should serve as diagnostic centers. While this approach has its advantages, there are likely to be problems too.

- Sending live virus-infected tissue from one country to another poses plant quarantine problems, unless the material is exported under permit to non-groundnut growing countries (e.g., UK, Netherlands).
- Some laboratories have diagnostic capabilities only for a limited number of viruses.
- Most laboratories with good diagnostic capabilities are research laboratories, and may have restrictions on undertaking 'service' related activities.

These problems can be overcome by cooperation between laboratories. International cooperation can provide data on virus distribution and incidence, identify institutions where proper identification facilities are available, help formulate appropriate control practices, and increase training opportunities for groundnut researchers.

The International Working Group on Groundnut Viruses has recommended that the following procedure be followed when a groundnut virus is suspected. Write to the following address (do *not* send a sample unless you are specifically asked to do so).

Dr D V R Reddy
Principal Scientist (Virology)
ICRISAT Asia Center
Patancheru 502 324, Andhra Pradesh, India
Telephone +91 40 596161
Fax +91 40 241239

The letter should include the name of the groundnut variety (if known), description of symptoms on groundnut, the place of occurrence of the disease, information on its incidence and distribution; your address, telephone, and fax number (if available); and results from any tests conducted on the samples. Dr Reddy will then give advice on how to proceed. If you are asked to send the material for further examination, follow the procedure outlined below; this will help you export the samples without any quarantine risk. Suggestions are also provided on how to transport samples. Dr Reddy can provide groundnut virus identification at ICRISAT Asia Center, or can call on the assistance of the Working Group members listed in the box below.

Data to be recorded

Symptoms

- Distribution of diseased plants in the field—individual plants affected or 'patches' of disease, around edges of field, etc.
- Plant symptoms—stunting, chlorosis, mosaics, necrosis, axillary shoot proliferation, etc.
- Symptoms on—young leaves, older leaves, petioles, stems, roots, pods, seeds (compare with adjacent healthy plants).

Incidence and distribution

- Distribution of suspected virus disease in country/region
- Incidence of diseased plants in affected crops
- Effects on yield (if known).

Other information

If some research has already been carried out, provide data, even tentative indications, on:

- Host range
- Serological reactions
- Vector system.

Dr Deck Peters
Wageningen Agricultural University
POB 8045 6700 EM
Wageningen, The Netherlands
Telephone 31 83 70 8 30 90
Fax 31 83 70 8 48 20
Expertise—all tospoviruses
Permit requirement—unknown

Dr D J Robinson
Scottish Crop Research Institute
Invergowrie, Dundee
Scotland DD2 5DA
Telephone 44 382 562731
Fax 44 382 562426
Cannot offer diagnostic services

Dr Xu Zeyong
Oil Crops Research Institute
Chinese Academy of Agricultural Sciences, 430062 Wuchang
Wuhan, Hubei Province, China
Expertise—serology for PStV, PSV, CMV; indicator hosts for PBNV, PStV, PSV, CMV
Permit requirement—not needed

Dr Roberta Smith
Department of Soil and Crop Sciences
Texas A&M University
College Station, TX 77843-2472, USA
Telephone 01 409 845 3041
Fax 01 409 845 0456
Expertise—ELISA for TSWV
Permit requirement—not needed

Dr Jim Demski
Georgia Experiment Station
1109 Experiment Street
Griffin, GA 30223-1797, USA
Telephone 01 404 412 4011
Fax 01 404 228 7305
Expertise—identification of TSWV, PMV, PStV, PSV
Permit requirement—not needed

Dr Michel Dollet
LPRC-CIRAD
BP 5035 34032, Montpellier, France
Telephone 67 61 58 00
Fax 67 51 59 86
Expertise—identification of most viruses including PCV, TSWV, PStV, PMV, groundnut eyespot, groundnut crinkle
Permit requirement—not needed

Dr Ralf Dietzgen
Queensland Agricultural Biotechnology Centre, Gehrmann Laboratories
University of Queensland
St. Lucia, Q 4072, Australia
Telephone 07 365 4988
Fax 617 365 4981
Expertise—identification of PStV, PMV
Permit requirement—not needed

Abbreviations: CMV = cucumber mosaic virus, PBNV = peanut bud necrosis virus, PCV = peanut clump virus, PMV = peanut mottle virus, PSV = peanut stunt virus, PStV = peanut stripe virus, TSWV = tomato spotted wilt virus.

Collection and treatment of samples

- Collect only young leaflets showing symptoms (retain petioles). Blot excess water using newspaper or any absorbent paper and place in plastic bags. Ideally, use 'Ziplock' plastic bags. If these are not available, use ordinary plastic bags sealed carefully, or securely closed with cellophane tape. Water transpired from leaflets helps to maintain humidity within the bag.
- Collect and bag the samples as close as possible to the day of despatch.
- Leaflets in sealed plastic bags can be stored for up to a week in a refrigerator without undue deterioration.
- If leaflets cannot be collected within a week before departure, rinse the leaflets in water containing 0.01% sodium azide, blot, and then store. This reduces rotting. **Caution—sodium azide is a poison; handle with care.**
- If fresh leaflets are not available, collect about 5 g of infected leaf material, cut it into small pieces, and place the bits directly into a plastic vial containing approximately 10 g calcium chloride ($CaCl_2$). Place a small amount of non-absorbent cotton wool on top of the $CaCl_2$ so that the chemical does not touch the plant material.

Transport of virus-infected material

- Use courier mail if possible. Send a fax or e-mail message to the addressee indicating the date on which the samples were despatched.
- Insulated covers (Jet Packs) or sheets of styrofoam are suitable for packing the material.

Evaluation of an Aphid-Resistant Groundnut Genotype (EC 36892) in China

Xu Zeyong[1]**, J A Wightman**[2]**, D V R Reddy**[2]**, Zhang Zongyi**[1]**, Chen Kunrong**[1]**, Chen Jinxing**[1], and **Hu Jiapeng**[3] (1. Oil Crops Research Institute, Chinese Academy of Agricultural Sciences (CAAS), Wuhan, Hubei 430062, China. 2. ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India. 3. Institute of Crop Germplasm Resources, CAAS, 100081 Beijing, China)

Aphids are major groundnut pests in China, causing direct damage and also acting as vectors for virus disease transmission (Li Yuanlian 1981, Xu Zeyong 1987). Three of the four major groundnut viruses in China are transmitted by aphids in a non-persistent manner; peanut stripe virus (PStV), cucumber mosaic virus (CMV), and peanut stunt virus (PSV). An aphid-resistant groundnut genotype, EC 36892, was introduced from ICRISAT Asia Center in 1990 and evaluated in China for resistance to aphids and PStV. Three local groundnut cultivars, Huohua No. 1 (spanish type), Hua 37, and Yihua No. 1 (both hybrids between virginia and spanish types), were also evaluated in the experiment.

Greenhouse tests. Five plants of each genotype were sown in 10 cm diameter pots in a greenhouse. Each plant was inoculated with two aphids (*Aphis craccivora*), and aphid population was recorded 3 days later. Aphid multiplication rates were much lower on EC 36892 than on two local varieties (Table 1). For example, in three tests in 1991 and 1992, the average number of aphids on EC 36892 was 0.6 aphid plant^{-1} compared with 6.9 aphids plant^{-1} on the local variety Huohua No. 1.

Field trials. Field trials were conducted at the farm of the Oil Crops Research Institute, Chinese Academy of Agricultural Sciences (CAAS), Wuhan, in 1991 and 1992. The trials were sown in a randomized block design with five replications. Each plot was 3.3 × 2.0 m, and contained 10 rows, with a spacing of 33 × 10 cm. Inspection of aphid population and PStV disease incidence was first conducted 5 days after emergence of groundnut, and continued at 10-day intervals. Virus-free seed was used in the 1991 trial. Two rows of a susceptible groundnut variety with high seed transmission of PStV were sown between plots, to provide the primary inoculum. PStV-infected seeds of the test genotypes were used in the 1992 trial.

Table 1. Aphid resistance in three groundnut genotypes in greenhouse tests, Oil Crops Research Institute, Wuhan, China, 1991–92.

Year	Genotype	Number of aphids plant^{-1} Test 1	Test 2
1991	EC 36892	0 (22)	1.5 (16)
	Huohua No. 1	6.7 (9)	10.0 (8)
1992	EC 36892	0.2 (20)	– (–)
	Yihua No. 1	1.2 (25)	– (–)
	Huohua No. 1	3.9 (18)	– (–)

Figures in parentheses show number of plants tested

Table 2. Aphid resistance in four groundnut genotypes in field trials, Oil Crops Research Institute, Wuhan, China, 1991–92.

Year	Genotype	First peak of aphid multiplication: Percentage of plants with aphids	First peak: Number of aphids 100 plants^{-1}	Second peak of aphid multiplication: Percentage of plants with aphids	Second peak: Number of aphids 100 plants^{-1}
1991	EC 36892	4	4	4	27
	Hua 37	7	60	33	561
	Huohua No. 1	24	330	71	1104
1992	EC 36892	2	2	16	217
	Yihua No. 1	3	8	51	838
	Huohua No. 1	34	681	79	2448

Table 3. PStV resistance in four groundnut genotypes in field trials, Oil Crops Research Institute, Wuhan, China, 1991–92.

		First inspection			Second inspection			Third inspection		
		PStV incidence	Significance level		PStV incidence	Significance level		PStV incidence	Significance level	
Year	Genotype	(%)	5%	1%	(%)	5%	1%	(%)	5%	1%
1991	EC 36892	10.5	a	A	24.2	b	B	77.1	b	A
	Hua 37	11.6	a	A	37.3	b	AB	87.6	ab	A
	Huohua No. 1	15.5	a	A	46.2	a	A	92.4	a	A
1992	Yihua No. 1	4.6	b	B	66.4	b	A	88.9	b	A
	EC 36892	8.8	b	B	71.4	b	A	95.4	ab	A
	Huohua No. 1	21.1	a	A	97.2	a	A	99.6	a	A

Significance level columns–genotypes with the same letter are not significantly different at the respective confidence levels.

EC 36892 showed high resistance to aphids in both years of field trials. In 1991, there were 4 aphids per 100 plants of EC 36892, compared to 60 aphids on Hua 37 and 330 aphids on Huohua No. 1, at the first aphid multiplication peak. At the second aphid multiplication peak in 1991, there were 27 aphids per 100 plants of EC 36892, compared to 561 on Hua 37 and 1104 on Huohua No. 1. Similar results were obtained in 1992 (Table 2).

PStV incidence in the genotypes varied during the 2 years of field trials. In 1991, EC 36892 showed the lowest PStV incidence of 24.2%, compared with 46.2% on Huohua No. 1, on 16 June. On 10 Aug, incidence was 77.1% on EC 36892, compared with 92.4% on Huohua No. 1. In 1992, PStV incidence on EC 36892 was 8.8% on 25 May and 71.4% on 6 Jun, compared with 21.1% and 97.2% on Huohua No. 1 on the same dates (Table 3).

In both years, EC 36892 gave yields higher than Huohua No. 1, but lower than those of Hua 37 and Yihua

Table 4. Yields of four groundnut genotypes in field trials at the Oil Crops Research Institute, Wuhan, China, 1991–92.

			Significance level	
Year	Genotype	Yield (t ha^{-1})	5%	1%
1991	Hua 37	3.93	a	A
	EC 36892	3.24	b	B
	Huohua No. 1	2.44	c	C
1992	Yihua No. 1	4.46	a	A
	EC 36892	3.80	a	A
	Huohua No. 1	1.84	b	B

Significance level columns–genotypes with the same letter are not significantly different at the respective (1%, 5%) levels.

No. 1. However, maturity duration was 160 days in EC 36892, longer than in any of the three local varieties (Table 4).

Conclusions. The genotype EC 36892 showed high resistance to aphids both in greenhouse tests and in field trials. However, this resistance (and low PStV incidence in this genotype) cannot be used directly by farmers because of its long duration. However, EC 36892 is a very good genotype for aphid resistance breeding. The results also showed that Huohua No. 1, a spanish type, was much more susceptible to aphids than the two spanish × virginia hybrids, Hua 37 and Yihua No. 1.

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Survey of Groundnut Virus Diseases in Pakistan

P Delfosse[1], **M Bashir**[2], **S N Malik**[2], and **A S Reddy**[1] (1. ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India. 2. National Agricultural Research Centre, Islamabad, Pakistan)

In Jul 1995, a survey of virus diseases was conducted in the major groundnut-producing areas in Pakistan, including Attock, Chakwal, and Rawalpindi districts. In Pakistan, groundnut is sown mainly in Apr and May. Groundnut-fallow-groundnut or groundnut-fallow-wheat are the main rotations used. However, a few farmers sow groundnut after harvesting wheat if there is sufficient soil moisture. Some farmers in the Pothar area sow groundnut in Jul, at the onset of the monsoon. More than 98% of farmers grow the well-adapted spreading variety, No. 334. Soils in the major groundnut-producing areas are sandy or sandy loam. Sowing is done either by broadcasting the seed followed by moldboard plowing, or by using a tractor-driven drill in which seeds are dropped manually. Low plant population, drought stress in the month of Jun, weeds, lack of proper machinery for sowing and harvesting, and damage by boars and other wild animals are the major problems that groundnut farmers face in Pakistan.

It was apparent from the survey that diseases are not a major constraint to groundnut production. However, in one field near Dhudial (on the way to Chakwal from Mandhra), peanut clump virus disease (PCV) was observed, with incidence ranging from 4 to 10%. The diseased plants occurred in patches and were severely stunted, with typical symptoms of mottling on the younger leaflets; the lower leaves were dark green in color. The soil was sandy, and the crop had been sown in April. The variety was the local spreading type. In one field (sown by extension staff as a demonstration plot) 10 km from Fateh Jang en route to Talaganh, we observed 5–15% incidence of peanut bud necrosis virus (PBNV). The field had been sown early, in rows, with a semi-spreading variety mixed with a local spreading type. Virus-infected plants showed typical PBNV symptoms, with chlorotic lines and ring patterns. Some plants showed complete necrosis of the growing terminals. PBNV was observed in every field surveyed in the Pothar area, but always at a very low incidence (less than 1%). In many fields, we also found a few scattered stunted plants, which we suspected were affected by PCV; but mottling symptoms were not clear on young leaflets. PBNV was also observed in groundnut fields adjacent to the road at several places—Tarbela Dam, Hazro Tehsil, Kamra, Attock, Fateh Jang, and Chakwal. At Barani Agricultural Research Institute (BARI), Chakwal, and at the National Agricultural Research Centre (NARC) farm, Islamabad, a few plants suspected to be infected by PBNV and PCV were recorded. Due to the presence of severe iron deficiency, which causes yellowing of the leaflets, it was difficult to detect symptoms of virus diseases.

Samples were collected at all the places surveyed, and tested by ELISA with antisera raised against PBNV and PCV. The ELISA results confirmed the presence of PBNV and PCV in Pakistan. Two serotypes of PCV were identified. At BARI, two suspected plants reacted with an antiserum raised against the Ludhiana isolate of Indian PCV. Another plant (also collected at BARI) reacted with antiserum produced for the Talod isolate of Indian PCV. The plants from Dhudial and NARC also reacted with antiserum produced for the Talod isolate. None of the samples reacted with antisera raised against the Hyderabad or West African isolates.

On the basis of this survey, we conclude that two virus diseases—PBNV and at least two known serotypes of PCV—occur in farmers' fields in Pakistan. The overall crop condition was very good and no fungal diseases were observed, except for crown rot in some fields. Other virus diseases (e.g., peanut stripe, peanut mottle, and cowpea mild mottle viruses) were not observed.

Short- or medium-duration varieties are likely to be introduced in the near future to help farmers obtain two crops per year, wheat in the postrainy season and groundnut in the rainy season. We suggest that new introduced varieties should have resistance to PBNV. Fortunately, the local variety appears to have tolerance to PBNV, judging by comparative field observations with a newly introduced semi-spreading variety that showed very high PBNV incidence. This variety has not been identified. As for PCV, the new wheat-groundnut rotation being discussed for possible extension to farmers, will create conditions that will increase disease incidence; this has already happened in the states of Punjab and Rajasthan in India.

Various groundnut lines were sown at NARC in Jul 1995, in a sandy soil block where wheat is grown once every 2 years. In Sep, the crop was severely affected by PCV (30% incidence). We suggest that a non-preferred host for *Polymyxa* sp (the fungal vector of PCV), such as rapeseed, should be grown prior to groundnut in PCV-infested fields.

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Confirmation of the Effects of Plant Density and Irrigation on Peanut Bud Necrosis Disease Incidence

H Bhatnagar, M V Reddy, J N Rao, and **P Singh** (ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

Peanut bud necrosis disease (PBND), caused by peanut bud necrosis virus (PBNV), is an important disease in the major groundnut-producing countries (Reddy et al. 1992). The virus is transmitted by *Thrips palmi* (Vijayalaxmi et al. 1995). Several options are available for the management of PBND. These include the use of resistant cultivars, insecticides, and cultural practices (adjustment of sowing date and/or plant density, intercropping, elimination of alternative hosts, rogueing of diseased plants, etc.) (Reddy et al. 1991). This paper reports results from a field trial conducted at ICRISAT Asia Center during the 1993 rainy season to study the effect of irrigation and plant population on PBND in a sole groundnut cropping system.

Table 1. Effect of plant density and irrigation on bud necrosis disease on groundnut cv Robut 33-1, ICRISAT Asia Center, 1993 postrainy season.

Plant density ha^{-1}	Disease incidence (%)		
	Nonirrigated	Irrigated	Mean
100 000	12	8	9.8
200 000	7	3	5.3
300 000	3	1	1.9
400 000	2	1	1.2
Mean	5.8	3.3	
	SE	LSD	CV (%)
Population density (P)	±0.72	2.48	
Irrigation (I)	±0.45	1.46	
P × I	±0.96	2.91	34.1

Groundnut cv Kadiri 3 (Robut 33-1) was sown at four plant densities (100 000, 200 000, 300 000, and 400 000 plants ha^{-1}), and grown under perfo irrigation (at 10-15 day intervals) and without irrigation, on an Alfisol. The trial was laid out in a split-plot design with four replications, with plant densities as main plots and irrigation treatments as subplots of 36 m^2. PBND incidence was recorded on each plot 3 months after sowing. The total rainfall during the experimental period was 640.7 mm.

PBND incidence decreased significantly ($P = 0.05$) with increase in plant density up to 300 000 plants ha^{-1} (Table 1), confirming previous reports (Reddy et al. 1991). At 100 000 and 200 000 plants ha^{-1}, PBND incidence was significantly lower ($P = 0.05$) in irrigated plots than in nonirrigated plots. High PBND incidence under drought stress conditions has also been reported by Wheatley et al. (1989), who suggested that the lower incidence in irrigated plots was due to the distribution pattern of the thrips vectors.

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Improved Diagnosis and Control of Peanut Stripe Virus—Progress and Future Directions of an ACIAR-Funded Project Involving Australia, Indonesia, and China

R G Dietzgen[1] and **R G Birch**[2]
(1. Department of Primary Industries, Queensland Agricultural Biotechnology Centre, Gehrmann Laboratories, University of Queensland, St Lucia, Q 4072, Australia.
2. Botany Department, The University of Queensland, Brisbane, Q 4072, Australia)

Peanut stripe virus (PStV) causes severe reductions in groundnut yields in Southeast Asia and China. Prevention of the disease is difficult because the virus is both seed-borne and aphid-transmitted in a non-persistent manner. No sources of resistance to PStV have been found in *Arachis hypogaea* or genetically compatible lines derived from resistant wild *Arachis* species. The project 'Improved Diagnosis and Control of Peanut Stripe Virus' aims to genetically engineer commercial groundnut cultivars to make them resistant to PStV through the expression of novel resistance genes derived from the viral pathogen. The project also aims to develop a molecular diagnostic kit for the identification of a number of viruses that infect groundnut in Asia. The project, which is funded by the Australian Centre for International Agricultural Research (ACIAR), has operated for 3 years. A recent external review recommended continued funding to realize the potential of the set goals.

Before useful genes can be expressed in groundnut, it is necessary to develop an efficient regeneration system for explants amenable to transformation, and methods to deliver the gene to such explants.

Gene transfer and plant regeneration. There have been several recent reports of genetic transformation of groundnut. However, none of these reports provides a system that is practical for the routine transfer of genes into commercial groundnut cultivars. Essential requirements for such a practical gene transfer system are efficiency, fertility, and reproducibility.

In our work, high frequency transient expression of introduced genes was observed in regenerable tissue regions following particle bombardment. Using optimized conditions, 2500 embryonic leaflets (cv McCubbin) were bombarded with p35SlucK and 2500 were co-bombarded with pGN1 and pDO432, cultured on a sub-lethal level of kanamycin (50 mg L^{-1}) and assayed for *luc* activity. Stable expression of the firefly luciferase (*luc*) reporter gene was observed in embryonic leaflet callus for 9 weeks, using a non-toxic bioluminescence assay (Livingstone and Birch in press). No *luc*-expressing shoots were obtained although 10 regenerated plantlets grew vigorously on 50 mg L^{-1} of kanamycin.

Somatic embryogenesis was observed in immature embryos of cvs Gajah and NC 7 cultured on MS medium supplemented with 1 mg L^{-1} picloram; and in mature embryos of McCubbin, NC 7, Gajah, and Florunner cultured on MS medium supplemented with 5 mg L^{-1} picloram. Prolonged expression of the *luc* reporter gene was observed (4 weeks after bombardment) in somatic embryos and embryogenic callus (cv NC 7) which originated from immature embryos. Somatic embryos derived from immature embryos (cvs Gajah and NC 7) were shown to proliferate in liquid culture, and the resulting embryogenic callus was shown to have the potential to regenerate in vitro.

The potential of direct meristem bombardment of mature embryos was also investigated, and bombardment conditions optimized so that the number of cells in the meristematic region transiently expressing the *gus* reporter gene approached that of the published protocol

(Brar et al. 1994). *Agrobacterium tumefaciens* mediated transformation for peanut immature embryos (cv NC 7) and for peanut leaf discs (Gajah, NC 7, McCubbin, Robut 33-1, and Florunner) is also being evaluated.

Preparation of viral CP constructs. The complete nucleotide sequence of the coat protein genes and 3′ untranslated regions of PStV and peanut mottle virus was determined by cloning of recombinant DNA derived from viral genomic RNA (Teycheney and Dietzgen 1994). The PStV coat protein (CP) gene and 3′ untranslated region was modified by site-specific mutagenesis to generate four different constructs which were placed into the plant expression vector pRTL2. The constructs allow the expression of (i) an unmodified CP; (ii) a modified CP in which the amino acid triplet DAG, shown to be essential for aphid transmissibility, has been changed; (iii) a truncated CP lacking the first 45 amino terminal residues; (iv) CP mRNA only, through introduction by frame shift mutation of several in-frame stop codons.

PStV CP constructs were expressed using combined in vitro transcription/translation in a rabbit reticulocyte lysate system. The analysis of transcription and translation products showed that all constructs directed the synthesis of transcripts and proteins of the expected size, and that translation products were detected by virus-specific antisera.

Nicotiana benthamiana plants have been regenerated following leaf disc transformation using *A. tumefaciens* harboring constructs cloned into pBIN19 binary vector. Regenerated plants which are rooting on selective medium containing kanamycin will be potted in soil. Transformed *N. benthamiana* plants will be assessed by polymerase chain reaction (PCR), Northern, and Southern blotting for presence and expression of the viral construct and for virus resistance by challenge inoculation with PStV.

Detection of peanut stripe, peanut mottle, and cucumber mosaic viruses by dot blot hybridization. A dot blot hybridization assay using non-radioactive digoxigenin (DIG)-labelled complementary RNA probes and chemiluminescent detection was developed for sensitive diagnosis of PStV and peanut mottle virus in leaf tissue (Dietzgen et al. 1994). To make this technique more robust and versatile, DNA probes were labelled with DIG during PCR and a probe for cucumber mosaic virus was added to the system.

Preliminary work towards a multiplex RT-PCR method for the detection of PStV and peanut mottle virus and including internal control primers was successful in detecting PStV in groundnut seed. A novel virus release method that does not require grinding of plant tissue is being evaluated for RT-PCR template preparation from groundnut seed (Thomson and Dietzgen 1995).

Future research will be structured towards technology transfer, with a large proportion of the work being done at the Bogor Research Institute for Food Crops and Bogor Agriculture University in Indonesia and the Oil Crops Research Institute, Wuhan, China. The continuing project is targeted towards the selection of a practical system of transformation and regeneration of groundnut to achieve gene transfer with a suitable PStV CP construct. Transgenic resistance to PStV will be assessed with aphid vector-transmitted virus and local Indonesian and Chinese cultivars will be transformed. The molecular detection system(s) will be evaluated and adapted for diagnosis under field conditions. Further training and collaborative research involving postgraduates and staff scientists in Australia, Indonesia, and China is envisaged.

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Effect of Simulated Rainfall on Eggs and Larvae of the Groundnut Leafminer, *Aproaerema modicella*

T G Shanower[1], **A P Gutierrez**[2], and **J A Wightman**[1] (1. ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India. 2. University of California, Berkeley, USA)

The groundnut leafminer (GLM) *Aproaerema modicella* (Lepidoptera: Gelechiidae) is an important pest of groundnut (*Arachis hypogaea*) and soybean (*Glycine max*) across South and Southeast Asia (Shanower et al. 1993). GLM populations fluctuate dramatically between years, seasons, and even between generations at the same location (Amin and Mohammad 1980, Logiswaran and Mohanasundaram 1986, ICRISAT 1986, 1987, 1988). Weather factors are the most commonly cited explanation for the fluctuations, though there is no consensus on which factors are responsible. For example, Lewin et al. (1979) and Logiswaran et al. (1982) reached different conclusions concerning the effect of temperature and rainfall. Lewin et al. (1979) found temperature positively and rainfall negatively correlated with leafminer incidence, while Logiswaran et al. (1982) reported a significant negative correlation between maximum and minimum temperature and GLM infestation levels, and no correlation with rainfall. Another study compared changes in several climatic variables to GLM incidence over 2 years (Khan and Raodeo 1987). None of the four variables measured (rainfall, maximum and minimum temperature, and relative humidity) offered a reasonable explanation for the fluctuations. A fourth study found that while GLM was more abundant on drought-stressed plants, the intensity of irrigation by overhead sprinklers did influence GLM density (Wheatley et al. 1989).

We studied the effect of simulated rainfall on GLM egg and larval mortality at ICRISAT Asia Center in the 1988/89 postrainy season. Potted plants infested with eggs and larvae were exposed to 50 mm of rainfall produced by a mechanical rain simulator. Drop size and velocity in the rain simulator was roughly equivalent to natural rainfall in the area (G Smith, ICRISAT, personal communication).

For eggs, 10 pots (5 with rain, 5 control) with 5 plants each were used. Eight to 10 eggs were marked in each pot and the number before and immediately after the simulated rainfall compared to determine the direct effect on egg survival. Eggs were observed daily to compare hatch rates between the two groups.

The effect of rain on larval survival was tested using 10 pots with 10 plants per pot and infested with third, fourth, and fifth instar GLM larvae. Five pots were put into the rain simulator and five kept as control pots. The number of live larvae before and one week after exposure were recorded in each treatment. After exposure all pots were returned to the greenhouse.

Table 1. Effect of simulated rainfall on *Aproaerema modicella* egg and larval survival, ICRISAT Asia Center, 1988/89 postrainy season.

		Treatment	
		Rainfall	Control
Eggs	Original	48	51
	Number hatching	44	46
	Percentage hatched	92	90
Larvae	Original	360	315
	1 week later	322	299
	Percentage survival	89	95

Exposure to simulated rainfall resulted in only small differences in survival of both eggs and larvae (Table 1). The percentage of eggs hatching was nearly the same in the treated and control groups. Larvae also appeared unaffected by the direct effects of simulated rainfall. More than 89% of the larvae in both treated and control groups survived.

The differences in egg and larval mortality between treatment and control were small and do not appear to be related to the rainfall treatment. These results support the conclusions of Wheatley et al. (1989). Though GLM abundance may be greater under low-rainfall conditions, rainfall is not a direct mortality factor for GLM eggs and larvae. Rainfall may influence GLM populations in more subtle ways. For example, heavy and persistent rainfall may interfere with oviposition, or fungal and other pathogens may be favored by rainfall patterns different from the conditions in this experiment. This aspect of GLM ecology requires further investigation, and is needed to understand the large and erratic population fluctuations.

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Bio-efficacy and Development of a Reduviid Predator, *Rhinocoris marginatus*, on *Spodoptera litura*

K Sahayaraj (Department of Rural Developmental Sciences, Arul Anandar College, Karumathur 626 514, Madurai District, Tamil Nadu, India. Present address: Department of Botany, St Joseph's College, Tiruchirapalli 620 002, Tamil Nadu, India)

The tobacco caterpillar *Spodoptera litura* (Noctuidae: Lepidoptera) is a serious pest of groundnut. The larvae feed on the leaves, flowers, and flower buds, causing heavy yield losses. In nature these caterpillars are attacked by a number of natural enemies; in groundnut crops, members of the family Reduviidae are common predators. The majority of reduviids are predaceous. They usually feed on the body fluids of insects after paralyzing them by stinging with their stylets. *Rhinocoris marginatus* (Reduviidae: Heteroptera) were found feeding on *S. litura* larvae for the first time in groundnut fields in Karumathur, Madurai district, Tamil Nadu. This study was undertaken to study the life history and predatory potential of the nymphal instars and adults of this bug, which were not fully known.

Rhinocoris marginatus were collected from groundnut fields in mid Nov 1992 and reared in the laboratory on *S. litura* larvae. Laboratory-emerged nymphs were allowed to grow individually in plastic containers (5 × 5.5 cm) and were maintained on *S. litura* larvae (3–4 days old). Containers were examined daily to record the molting changes and the number of prey consumed/killed per stadia. Observations on sex ratio and adult longevity were recorded from adults that emerged in the laboratory. The prey insects used in this study were also laboratory-reared individuals originally collected in and around groundnut fields in Karumathur.

First-instar nymphs did not feed on the first day. Thereafter, they mainly attacked 3- and 4-day old prey, though younger caterpillars (less than 3 days old) were also available in the container. If 3–4 day old larvae were not available, the predators fed on younger larvae. The predatory potential increased from early nymphal instars to later nymphal instars. The first moult occurred after 5.30 ± 1.33 days, and the bugs developed through five instars within 38.82 ± 1.64 days, during which period each bug consumed 35.13 ± 3.50 larvae (3–4 day old *S. litura*). Ambrose et al. (1990) observed that the total nymphal period lasted for 84.70 ± 1.01 days in another groundnut pest, *Odontotermes obesus*; this difference

Table 1. **Consumption of *Spodoptera litura* larvae by different nymphal instars of *Rhinocoris marginatus*.**

	Number of larvae preyed upon		Occurence of molt (days)
	3-day old larvae	4-day old larvae	
First instar	5.39 ± 0.57	0.69 ± 0.46	5.30 ± 1.33
Second instar	5.03 ± 0.79	2.13 ± 0.53	7.22 ± 0.72
Third instar	2.78 ± 1.14	3.32 ± 0.76	
Fourth instar	2.09 ± 0.59	4.86 ± 0.62	
Fifth instar	1.82 ± 0.77	6.86 ± 1.48	

could be due to differences in prey species or because *Odontotermes* prey were smaller.

Preference for prey size changed as the *R. marginatus* nymphs developed. First and second instar nymphs preferred 3-day old larvae to 4-day old larvae. Instars 3–5, however, preyed more on 4-day larvae (Table 1). A similar observation was reported by Ambrose and Sahayaraj (1993) in another reduviid, *Allaeocranum quadrisignatum* on *Dysdercus cingulatus*. Large prey obviously provide more food per individual than do small ones, and younger nymphal predators needed less food than older nymphs.

The sex ratio in *R. marginatus* was 1:0.69 male:female. Females lived longer (69.38 ± 4.04 days) than males (47.33 ± 3.02 days), and consumed more prey per day (5–8 larvae as against 4–6 larvae). Similarly, Sahayaraj and Ambrose (1993) observed that in *Coranus nodulosus* the female consumed more prey than the male.

From these results, we conclude that *R. marginatus* can be effectively employed as a biocontrol agent against *S. litura* on groundnut. The information on prey age (prey size) preferences by predators of different sizes can help to ensure the timely release of this predator in biocontrol programs.

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Developmental Stages and Biocontrol Potential of a Reduviid Predator, *Acanthaspis pedestris*, against Termites on Groundnut

K Sahayaraj (Department of Zoology, St Xavier's College, Palayankottai 627 002, Tamil Nadu, India. Address for communication—Department of Zoology, St Joseph's College, Tiruchirapalli 620 002, Tamil Nadu, India)

Termites, *Odontotermes* spp, are widely distributed in central and southern India, and cause damage to several field crops. They are serious pests of groundnut, attacking the tap root, stem, and pods. Pod scarification by termites is associated with increased aflatoxin contamination (Gold et al. 1989). Little quantitative information is available on the use of natural enemies to control *Odontotermes* spp, although the reduviid *Acanthaspis pedestris* has been reported to be a predator (Ambrose 1985, Rajagopal 1984). This study was conducted to study the development of *A. pedestris* and evaluate its potential as a biocontrol agent against *Odontotermes assumthi* in the laboratory.

Adults of *A. pedestris* were collected from semi-arid areas and scrub jungle near groundnut and vegetable fields in Sivanthipatti (25 m asl, 77°47′ E, 8°30′ N) in Nellai Kattabomman district, Tamil Nadu. They were reared on *O. assumthi* in the laboratory in 80 mL plastic containers (6 × 9.5 cm). First instar nymphs that hatched in the laboratory were reared at three levels of prey abundance—1, 2, and 4 prey individuals per container. In each category, 11 *A. pedestris* individuals were maintained in separate containers.

Table 1. Effect of prey abundance on instar duration and adult longevity of *Acanthaspis pedestris* on *Odontotermes assumthi* under laboratory conditions (n = 11).

Prey abundance per container	Instar period (days) 1st instar	2nd instar	3rd instar	4th instar	5th instar	1st instar to adult	Adult longevity (days) Male	Female
1	15.00±0.58 (0.8 ±0.02)[1]	20.62±0.61 (1.12±0.10)	22.07±0.96 (3.78±0.53)	25.45±1.57 (7.64±2.10)	47.16±5.74 (10.18±1.07)	121.00±3.57 (23.58±1.68)	19.66±1.28	22.60±5.93
2	13.66±0.33 (1.02±0.13)	18.86±6.63 (1.87±0.09)	15.28±1.09 (4.56±1.02)	21.41±1.12 (8.11±1.67)	43.40±2.40 (3.61±1.59)	103.18±1.55 (29.07±2.01)	25.8 ±9.78	38.16±2.93
4	15.00±0 (1.13±0.18)	9.46±1.29 (2.34±0.43)	16.16±1.07 (5.07±1.11)	13.92±0.43 (9.57±0.93)	28.09±2.41 (15.06±2.43)	84.41±3.63 (33.67±2.57)	37.57±2.40	52.40±6.46
Mean ± SE among treatments	14.55±0.44 (0.98±0.09)	16.31±3.46 (1.77±0.35)	17.83±2.13 (4.47±0.37)	20.26±3.37 (8.44±0.58)	39.55±5.83 (12.95±1.45)	102.86±10.56 (28.77±2.91)	27.67±5.25	37.72±8.60

1. Figures in parentheses show number of prey killed/predator/day

Fresh, uniform-sized *O. assumthi* were placed in the containers with *A. pedestris*. After every 24 h the number of prey consumed was counted, and fresh prey added to maintain prey abundance in each treatment constant during the lifetime of the predator. Prey consumption measurements continued till the adult stage. Instar lengths, adult longevity, and sex ratio were also recorded for each prey abundance category. The predatory rate (number of prey consumed/predator/day) is a measure of the predator's biocontrol potential.

As shown in Table 1, the total nymphal period was shortest (84.41±3.62 days) when prey was most abundant (4 prey individuals per container), and longest (121.00±3.57 days) at 1 prey per container. This extension of stadial period was probably due to nutrition-related differences at different levels of prey abundance. Similar results have been reported for *Poecilocerus pictus* (Haniffa and Elayappan 1986). At all prey abundances, females lived longer than males (Table 1), as was observed by Ambrose (1987). The sex ratio was male-dominated, except at 4 prey per container.

Table 1 also shows the number of *O. assumthi* killed per day by nymphs of different instars. In all five instars, the number of prey consumed per day increased with an increase in prey abundance. These findings corroborate the view of Sinha et al. (1982) and Ambrose and Kumaraswami (1990), who reported that prey density has a significant influence on the consumption of prey. Nymphal development was fastest in the 4-prey density category, probably due to the large prey intake. As expected, prey consumption increased as the instars advanced (0.8±0.02 prey day^{-1} by 1st instar nymphs, 10.18±1.07 prey day^{-1} by 5th instar nymphs).

These results clearly demonstrate the potential of *Acanthaspis pedestris* as a biocontrol agent against *Odontotermes assumthi* under laboratory conditions. Further studies are needed on stage preference, prey preference, and biocontrol evaluation in groundnut fields.

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Screening Promising Groundnut Varieties Against Termite Damage at Bhubaneswar, Orissa, India

H K Mohapatra[1], **J Padhi**[1], **A P Samalo**[1], and **G J Patra**[2] (1. Department of Entomology. 2. Department of Plant Breeding and Genetics, Orissa University of Agriculture and Technology, Bhubaneswar 751 003, Orissa, India)

Termite damage to groundnut was assessed at harvest from varietal screening trials conducted at the Orissa University of Agriculture and Technology, Bhubaneswar, over two seasons, the 1987 rainy season (Season 1) and 1988/89 postrainy (winter) season (Season 2). In Season 1, 23 varieties were sown on 1 Jul and harvested on 28 Oct 1987; in Season 2, 20 of these 23 varieties were sown on 18 Nov 1988 and harvested on 3 Apr 1989.

The trials were laid out in a randomized block design with three replications. Plots were 1.25 m (5 rows) × 5 m in Season 1 and 1.25 m (5 rows) × 4 m in Season 2, with 10 cm between seeds in a row. Farmyard manure 5 t ha^{-1}, ammonium sulphate 50 kg ha^{-1}, single superphosphate 250 kg ha^{-1}, and potassium chloride 70 kg ha^{-1} were applied basally. Urea 20 kg ha^{-1} was topdressed after the first weeding. The crops were hand-weeded twice. During Season 2, seven irrigations were given. Endosulfan @ 280 g a.i. ha^{-1} was sprayed twice to control foliage pests. At harvest, mature pods from 10 plants per plot were examined for termite damage. Pod damage was calculated as the percentage of damaged pods in the total number of mature pods. Plot yields were recorded and converted to yield per hectare.

Pod damage by termites differed significantly among varieties in both seasons (Table 1). During Season 1, pod damage was 6% or less in all varieties except VG 77 (11.1%) and CGC 9 (9.9%). In Season 2, pod damage ranged from 2.5 to 28.1%, and was higher than in the earlier season in all varieties except one. This difference in termite damage was probably due to differences in moisture levels. Other authors (Johnson and Gumel 1981, Lynch et al. 1993) have also reported that termite infestation on groundnut is more serious during dry seasons. From two seasons' data JL 24, J 11, TMV 2, and CO 1 appear relatively less susceptible to termite attack, while TMV 7, Dh 22, BGP 512, VG 55, and Kisan were highly susceptible (severe damage in Season 2).

Among the less susceptible varieties, JL 24 gave the highest pod yield in both seasons (1.32 t ha^{-1} in Season 1, 2.01 t ha^{-1} in Season 2), and was significantly superior to all other varieties except VG 77 in Season 1 and Dh 22 in Season 2. Therefore, JL 24 may be a better choice of cultivar than AK 12-24, which is popular in the region.

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Table 1. Pod damage by termites and pod yield in 23 groundnut varieties, Bhubaneswar, Orissa, India, rainy and postrainy (winter) seasons.

Variety	Pod damage (%) 1987 rainy[1]		Pod damage (%) 1988/89 winter[2]		Pod yield ($t ha^{-1}$) 1987 rainy	Pod yield ($t ha^{-1}$) 1988/89 winter
CO 1	0.5	(1.0)	3.8	(11.1)	0.66	1.53
ICGS 44-1	0.8	(1.0)	5.9	(12.8)	0.65	1.64
Kisan	0.8	(1.1)	28.1	(30.1)	0.80	1.15
TMV 2	1.0	(1.2)	4.8	(12.2)	0.74	1.62
AK 12-24	1.2	(1.2)	7.9	(16.2)	0.73	1.36
Jyoti	1.5	(1.3)	11.2	(18.9)	0.56	1.65
ICGS 63-23	1.5	(1.4)	6.3	(14.2)	0.55	1.43
RSHY 7	1.6	(1.4)	11.9	(19.6)	0.92	1.27
VG 55	1.9	(1.5)	26.8	(31.1)	0.89	1.54
S 206	1.9	(1.3)	6.0	(13.7)	0.47	1.55
J 11	2.0	(1.5)	3.9	(11.1)	0.72	1.49
KRG 1	2.2	(1.4)	13.3	(21.3)	0.82	1.65
BGP 512	2.5	(1.7)	19.4	(25.5)	0.87	1.67
Polachi 1	2.5	(1.6)	8.8	(17.2)	0.56	1.51
ICGS 67	3.0	(1.8)	7.0	(14.4)	0.75	1.35
JL 24	3.4	(1.8)	3.7	(11.0)	1.32	2.01
Dh 3-30	3.7	(1.9)	12.7	(19.2)	0.71	1.76
Dh 22	4.2	(2.2)	23.3	(27.7)	0.99	1.96
TMV 7	5.5	(2.4)	17.9	(25.0)	0.61	1.58
VG 5	6.0	(2.3)	2.5	(9.0)	0.75	1.51
OG 85-1	4.6	(2.1)			0.95	
CGC 9	9.9	(3.0)			0.80	
VG 77	11.1	(3.3)			1.08	
SE		±(0.4)		±(3.6)	±0.09	±0.08
LSD (P = 0.05)		(1.2)		(10.4)	0.26	0.23

1. Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.
2. Figures in parentheses are arcsine transformed values.

Effectiveness of Soil-Applied Insecticides Against Foliage- and Pod-Feeding Arthropod Pests in Burkina Faso

I O Dicko[1] and **R E Lynch**[2]
(1. University of Ouagadougou, 03-BP 7021, Ouagadougou, Burkina Faso.
2. US Department of Agriculture Research Station, Coastal Plain Experiment Station, Box 748, Tifton, GA 31793, USA)

Groundnut is important in Burkina Faso both as a cash crop and as a protein-rich diet supplement. Unfortunately, production has been declining since 1979, essentially due to poor rainfall, improper cultural practices, foliar diseases, and insect pests. Lynch et al. (1985) identified thrips (Thripidae), jassids (*Empoasca dolichi, E. facialis*), a termite (*Microtermes thoracialis*), and millipedes (Diplopoda) as being among the most damaging arthropod pests in the groundnut-growing areas of Burkina Faso.

Although several chemical insecticides provide effective control of pest populations and damage, few of the currently available insecticides are selective for insect pests. Proper timing of insecticide treatments is therefore critical for achieving adequate control of pests while preserving natural enemies.

This paper reports the results of a series of studies conducted in Burkina Faso to determine the effect of

Table 1. Effect of soil-applied insecticides on thrips control and thrips foliage injury on groundnut genotype TS 32-1, Burkina Faso, 1988–90.

Year	Insecticide combination[1]	Number of thrips/10 buds at different stages (DAS[2])			Leaf damage at different stages (DAS) (%)	
		28	42	56	42	56
1988	Nontreated	7.60 a	4.20 ab	1.40 a	46.7 a	6.7 b
	Aldicarb-AS	1.20 bc	2.10 ab	1.00 ab	33.3 a	13.3 a
	Aldicarb-2X	0.40 c	1.50 ab	0.50 ab	13.3 b	6.7 b
	Chlorpyr-2X	5.90 ab	5.00 a	1.30 a	40.0 a	8.3 ab
	Aldicarb + Chlorpyr	1.60 bc	0.70 b	0.20 b	10.0 b	6.7 b
1989	Nontreated	0.07 b	2.87 ab	2.87 ab	0.8 a	2.7 ab
	Aldicarb-AS	0.00 b	0.40 c	0.40 c	1.0 a	2.2 ab
	Aldicarb-2X	0.07 b	0.53 bc	0.53 bc	0.0 a	1.8 b
	Chlorpyr-2X	0.30 a	3.03 a	3.03 a	1.3 a	2.8 a
	Aldicarb + Chlorpyr	0.03 b	0.80 abc	0.80 abc	0.2 a	0.5 c
1990	Nontreated	0.50 b	2.33 a	12.83 a	2.7 a	5.5 a
	Aldicarb-AS	0.16 b	1.50 a	8.80 a	1.2 b	3.7 b
	Aldicarb-2X	0.50 b	4.33 a	0.99 c	1.2 b	3.8 b
	Chlorpyr-2X	1.83 a	2.33 a	4.60 bc	1.8 ab	4.0 a
	Aldicarb +Chlorpyr	0.40 b	0.66 b	3.60 b	1.0 a	3.0 b

Means within a column followed by the same letter are not significantly different (P =0.05) using Waller-Duncan multiple range test.

1. Aldicarb-AS = Aldicarb applied only at sowing. Aldicarb-2X = aldicarb applied at sowing (5.6 kg a.i. ha^{-1}) and at first pegging (7.5 kg a.i. ha^{-1}). Chlorpyr-2X = chlorpyrifos applied at first pegging (14.6 kg a.i. ha^{-1}) and 40 days later (7.5 kg a.i. ha^{-1}). Aldicarb+Chlorpyr = Aldicarb-2X + Chlorpyr-2X.
2. DAS = days after sowing.

timing and application rates of aldicarb and chlorpyrifos on population densities and/or damage by thrips, jassids, termites, and millipedes on groundnut plants, and the effect of insecticide application on pod yield.

Field experiments were conducted at the University of Ouagadougou's research station at Gampela, Burkina Faso. A local groundnut variety, TS 32-1, was sown on 10 Jul (1988 and 1989) and 13 Jul (1990). The following four insecticide treatments and a nontreated control were replicated six times in a complete randomized block design: (i) aldicarb applied at 5.6 kg a.i. ha^{-1} only at sowing; (ii) aldicarb applied at sowing (5.6 kg a.i. ha^{-1}) and at first pegging (7.5 kg a.i. ha^{-1}); (iii) chlorpyrifos applied at first pegging (14.6 kg a.i. ha^{-1}) and 40 days later (7.5 kg a.i. ha^{-1}); (iv) aldicarb+chlorpyrifos, i.e., a combination of treatments (ii) and (iii).

Thrips. Both single and multiple applications of aldicarb, with or without chlorpyrifos, significantly reduced thrips populations and foliage damage in 1988 and 1989 (Table 1). The effect of these chemicals appeared to last for 4–6 weeks after application; by 70 days after sowing, there were no significant differences in thrips population or leaf damage between treatments. Tappan and Gorbet (1981), Lynch et al. (1984), and Dicko (1989) also reported that a single application of aldicarb at sowing was effective in controlling thrips for several weeks.

Jassids. Jassid densities were so low in 1989 and 1990 (less than 1 individual per 10 sweeps on most sampling dates) that there were no statistical differences between treated and nontreated plots. In 1988, when pest densities were relatively high, aldicarb and chlorpyrifos applied individually and in combination effectively controlled jassid populations for 42 days after sowing; after this stage there was little or no difference between treatments.

Termites and millipedes. The effectiveness of granular insecticides in controlling pod damage by termites and millipedes varied considerably from year to year. For example, multiple applications of aldicarb and chlorpyrifos individually and in combination were effective in 1988 against both termites and millipedes, but showed little to no effect in 1989 and 1990. Studies conducted elsewhere have also reported that aldicarb and chlorpyrifos provide inconsistent control of soil arthropods.

Yields. In 1988 and 1989, pod yields were highest with the aldicarb+chlorpyrifos treatment; 3.07 t ha^{-1}, 40% higher than the untreated control in 1988 and 2.23 t ha^{-1}, 51% higher than the control in 1989. Aldicarb alone increased pod yield by 24% in 1988 and 4–9% in 1989; while chlorpyrifos alone increased yield by 2.7% in 1988 and 17% in 1989.

Conclusions. Soil insecticides vary in effectiveness from place to place, and therefore need to be tested in the area of use before recommendations are made (Sepsawadi et al. 1971). Our data suggest that the use of aldicarb and chlorpyrifos would benefit groundnut cultivation in Burkina Faso. However, the economics of use, in comparison with other pest control methods (e.g., mixed cropping) need to be examined before these insecticides are recommended for extensive use.

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Current Status of Synthetic Pyrethroid Resistance in *Helicoverpa armigera* Populations on Groundnut

P R Sekhar, N V Rao, B R Rao, and **M Venkataiah** (Heliothis Management Scheme, Regional Agricultural Research Station, Lam, Guntur 522 034, Andhra Pradesh, India)

In 1987, pyrethroids failed to give satisfactory control of *Helicoverpa armigera* infesting cotton in the Krishna-Godavari Zone (KG zone) of Andhra Pradesh (McCaffery et al. 1989). Later, resistance levels rose steeply with the increased usage of synthetic pyrethroids (Venugopal Rao et al. 1994). In such situations it is critical to monitor resistance. As a first step, monitoring of pyrethroid resistance was initiated in the groundnut areas of KG zone, where synthetic pyrethroids are extensively used.

Topical bioassays were performed on third-instar larvae of *H. armigera* with eggs collected from groundnut fields in the KG zone during the 1994 season. Standard procedures were used (Armes et al. 1992). Dose-mortality regressions were computed by probit analysis, using MLP 3.08 software (Ross 1987). Resistance factors at LD_{50} were computed as LD_{50} Guntur strain/LD_{50} Reading strain. The Reading strain was considered to be susceptible to pyrethroids and was used as a standard reference for comparison.

The Guntur strain had moderately higher LD_{50} values than the Reading strain, with resistance factors of 4.6 with cypermethrin and 7.5 with fenvalerate (Table 1). Tolerance to deltamethrin could not be calculated for want of the LD_{50} value for the susceptible strain. The slopes of the probit lines were shallow and therefore the population may not have been truly homogeneous with respect to pyrethroid resistance. However, the log dose probit lines did not show any systematic curvilinearity, and heterogeneity was not significant.

The current situation is that pyrethroid resistance in *H. armigera* exists only to a limited extent in the KG zone groundnut belt. One of the reasons for such low tolerance might be that pyrethroids had not been used to any great extent in the majority of fields from which collections were made. It is known that selective survival of resistant larvae and moths accounts for an increase in resistance frequency when pyrethroids are applied to field crops (Forrester and Cahill 1987). As suggested by Armes et al. (1992), the resistance levels were probably driven by high selection pressure created by increased usage of insecticides.

Table 1. Mortality of third-instar larvae of *Helicoverpa armigera* in the Krishna-Godavari zone, Andhra Pradesh, 6 days after topical treatment, 1994 rainy season.

Chemical	Strain	Host plant	LD_{50} (95% F.L.) (mg larva^{-1})		Resistance factor at LD_{50}	LD_{90} (mg larva^{-1})	Slope (± SE)
Cypermethrin	Guntur	Groundnut	0.092	(0.063–0.134)	4.6	0.749	1.41 (0.26)
Cypermethrin	Reading	Artificial	0.02	(0.017–0.024)		0.05	1.31 (0.14)
Fenvalerate	Guntur	Groundnut	0.113	(0.083–0.149)	7.5	0.444	2.15 (0.39)
Fenvalerate	Reading	Artificial	0.015	(0.013–0.017)		0.03	1.80 (0.20)
Deltamethrin	Guntur	Groundnut	0.012	(0.008–0.016)		0.076	1.61 (0.27)

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Recent Developments in the Groundnut Industry in Zimbabwe

G L Hildebrand (Rattray Arnold Research Station, PO Box CH 142, Chisipite, Harare, Zimbabwe)

Until recently, marketing of the groundnut crop in Zimbabwe was controlled. This meant that commercial farmers in the Large Scale Commercial (LSC) farming areas were required by law to sell their produce to the parastatal Grain Marketing Board (GMB) at state-controlled prices. These prices did not keep pace with real market prices, and their levels, relative to other crops, often resulted in swings from one crop to another depending on profitability. This situation led to a steady decline in groundnut production in the country, and the irrigated crop area at present is very small.

In Mar 1992 the government decontrolled groundnut, making it a 'regulated' crop from 1 Apr 1992. Producers are now permitted to dispose of regulated crops to best advantage, but the GMB offers a guaranteed floor price and retains control of imports and exports. Exports are normally permitted only after local requirements are satisfied. The guaranteed GMB floor price in 1993 was Z$ 1170 t^{-1} (1 US$ = 8.4 Z$) for unshelled groundnut, but free market prices were in excess of Z$ 2000. The average price paid to producers in 1994 was Z$ 2900 t^{-1}.

As a result of these changes and the improved prospects of profitable irrigated groundnut production, two private sector companies (ZPGC and Seed Co-op, see below) were formed to promote production and improve marketing. ZPGC (Zimbabwe Peanut Growers Cooperative) is owned by registered farmers who must produce in excess of 20 t annually. Share capital is currently shared between ZPGC members and the Commercial Oilseeds Producers Association (COPA) (which represents all commercial oilseeds growers), but will be transferred away from COPA as ZPGC membership increases. Reapers (Pvt) Ltd handles (buy, shell, store, and market) the crop. Share capital is shared equally between ZPGC and the Seed Co-op Company of Zimbabwe Ltd, the biggest seed company in the country. ZPGC members grow groundnut on contract for Reapers. Machinery was purchased to shell and grade the crop. Reapers is now in its second year of operation. It handles about 5000 t of groundnut each year, and has exported confectionery grades to Europe.

In 1993, Seed Co-op decided to expand its research capabilities to support Reapers, and initiated a groundnut breeding program in 1994. Dr G L Hildebrand joined the staff of Seed Co-op's Rattray Arnold Research Station in Oct 1994 to implement the program. Research effort is directed mainly at improving confectionery quality by developing cultivars with high yield, large seed of uniform size and shape, and suitable chemical composition (e.g., high oleic:linoleic acid ratios to ensure long shelf life).

Rainfed groundnut is a very important component of household food security for a large number of smallholder farmers in Zimbabwe, and some research effort is directed at improving production in this sector. In recent years, rainfall seasons have frequently been subnormal. The rainfall season in many areas seldom exceeds 90–100 days; it is desirable to develop short-duration cultivars for these areas to avoid drought stress that frequently occurs at the end of the season. Some evaluation of ICRISAT breeding lines was undertaken by Seed Co-op in 1993/94, and this was extended in 1994/95 to include a total of about 200 confectionery, and 180 spanish, short-duration, and drought-tolerant breeding lines.

Four confectionery lines that showed promise in a preliminary trial in 1993/94 were included in three on-farm trials in 1994/95. Two of these entries, ICGV-SM 11 90709 and ICGV-SM 90710, have shown particular promise, with yields slightly higher and seed size considerably larger than the currently grown commercial cultivar Flamingo. These entries will be tested on-farm again in 1995/96.

A number of ICRISAT short-duration breeding lines grown with less than 300 mm of rain, and harvested 94 days after sowing, gave yields of more than 700 kg ha^{-1}; the control spanish cultivars gave less than 200 kg ha^{-1}. A number of these lines will be evaluated at different sowing and harvest dates at two locations in 1995/96. These include ICGVs 92206, 92263, 93252, 93436, and 93437.

Groundnut Production on the Coast of Oaxaca, Mexico

C F Bermúdez (Peanut Research Program, Instituto Nacional de Investigaciones Forestales y Agropecuarias, Apdo, Postal No 5, 71830 Rio Grande, Oaxaca, Mexico)

Ninety percent of the groundnut production in Oaxaca state in Mexico is from the Coast region in the south of the state (15–17°N, 95–98°W). The average area under groundnut during the last 20 years has been around 10 000 ha, with significant annual variation because of unpredictable profit levels (in comparison to other crops) and adverse weather conditions in some years (the crop is totally rainfed). The groundnut area was highest—about 18 000 ha—in 1980/1981 (Bermúdez 1994). However, the potential groundnut area in the Coast of Oaxaca region is far larger, and has been estimated at 114 453 ha (INIFAP 1992).

During the groundnut-growing season (Jun-Nov), the mean temperature ranges between 24° and 27°C, and rainfall is 650–700 mm. The groundnut area on the Coast of Oaxaca has well-drained, light-textured, fertile soils suitable for groundnut production (Bermúdez 1994). Seed yields ranged between 600–800 kg ha^{-1} during the period 1973 to 1987. In 1985, the Campo Experimental Costa de Oaxaca of the Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP) began research on several areas—introduction and evaluation of

Table 1. Groundnut technologies developed by INIFAP during 1988–94 for the Coast of Oaxaca, Mexico.

Technology	Period of research	Increment in yield
Introduction and evaluation of virginia and spanish varieties	1985–87	30%
Fertilizer application	1985–86	No response
Preplanting soil incorporated with pre-emergence herbicides	1987–88	10%
Control of broadleafed weeds with post-emergence herbicides	1988–89	20%
Grass control with post-emergence herbicides	1988–89	20%
Control of foliar and soil diseases with fungicides	1990–91	10%

virginia and spanish varieties, soil fertility, pre-emergence herbicides, control of broadleafed weeds with post-emergence herbicides, and control of foliar and soil diseases with fungicides. The productivity increases that resulted from these studies are listed in Table 1. Average yields during the last 7 years (1988–94) were 1.2–1.4 t ha^{-1}.

Fertilizer is applied neither to groundnut nor to the preceding crop, because soil nutrient levels are medium to high. Seeds are treated with recommended fungicides.

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Possibility of Groundnut Cultivation in a Subtropical Area of Ethiopia

I Žugec, I Jurić, and **M Knežević** (Faculty of Agriculture, J J Strossmayer University of Osijek, PO Box 117, 54000 Osijek, Croatia)

The possibility of groundnut cultivation was investigated in two areas in Ethiopia—a wooded savanna, cleared in 1985, and the newly formed Horro Alleltu state farm (6000 ha), 40 km northwest of Nekemte, Wollega province. Conditions in this area are suitable for groundnut cultivation (IAR 1978, ADRD 1985). The soil is of the ferralsol rhodic type, medium-deep, with a favorable structure. According to Šalinović et al. (1989) the soil is characterized by high humus content (4–5%), moderate content of potassium (0.28–0.56 meq), low phosphorus content (2.5–17.2 ppm), and low pH (4.8–5.2 in KCl and 5.6–6.0 in H_2O). The climate is marked by dry (Oct to May) and wet (Jun to Sep) periods, with a total annual precipitation of 1095 mm and mean monthly air temperature of 22–23°C.

Varietal evaluation trials have been conducted from 1987 onwards. In 1987 and 1988, five varieties— NC 4X, NC Ac 343, Shulamit, Mani Pintar, and the new variety ICG 7794—were grown at different densities (37 000 to 166 000 plants ha^{-1}). Hilling up was done several times, and soil tillage included normal practices (e.g., plowing in autumn and discing before sowing). Fertilizer was applied @ 54 kg ha^{-1} N and 138 kg ha^{-1} P_2O_5 (300 kg ha^{-1} diammonium phosphate).

Three such trials were conducted (Jurić and Žugec 1989, 1991). In the first trial, ICG 7794 gave a significantly higher seed yield (2.58 t ha^{-1}) than the control cultivars NC 4X (1.94 t ha^{-1}) and NC Ac 343 (1.91 t ha^{-1}). In the second trial with Shulamit (2.03 t ha^{-1}), the yield of ICG 7794 (2.24 t ha^{-1}) was close to being significantly higher than that of the controls. In the third trial local varieties Mani Pintar, Shulamit, and NC 4X gave equal yields, higher than that of NC Ac 343.

The varieties Shulamit, NC 4X, NC Ac 343, and Mani Pintar were evaluated further in a new series of trials in 1989 and 1990. These trials were laid out in a split-split plot design with four replications, and were designed to study the effects of sowing date (trials were sown on 5, 15, and 25 Jun and 5 Jul) and of hilling up during the vegetative growth stage.

The results are shown in Table 1. The highest average seed yield in 1989 (2.61 t ha^{-1}) was obtained by sowing on 25 Jun. This yield was not significantly different from yields from earlier (Jun) sowings, but there were large and significant differences between Jun sowings and the last sowing (5 Jul), which yielded 1.78 t ha^{-1}. The lower yields from early Jun sowings were due to rains in late autumn (Nov and Dec), which caused pods to rot. Hilling up gave no significant advantage, although specific varietal reactions were observed.

In 1990, because of a lack of moisture during pod- and seed-filling, the best average yield (1.89 t ha^{-1}) was obtained from the earliest sowing (5 Jun); this yield was significantly higher than at other sowing dates. Specific varietal reactions to hilling up were recorded, but the differences were not significant.

Pooled data for the 2 years showed that the best average yields (2.14 t ha^{-1}) were from the plots sown earliest (5 Jun). Yield decreased progressively up to the last sowing on 5 Jul (1.57 t ha^{-1}). Differences between the Jun sowings were not significant, but the 5 Jul sowing gave significantly lower yield than did all earlier sowings. The best yielders were Mani Pintar, Shulamit, and NC 4X; NC Ac 343 gave significantly the lowest yield ($P = 0.01$). There was no apparent benefit from hilling up, and on average, specific varietal reactions disappeared. Groundnut should probably be sown in late Jun to maximize yields, but due to inter-year variations, additional data are required before firm conclusions can be drawn. However, two factors

Table 1. Effect of sowing date and hilling up during the vegetative growth stage on yield in four groundnut varieties, Horro Alleltu, Ethiopia, 1989/90.

Year	Sowing date (A)	Hilling up[1] (C)	Seed yield (t ha^{-1}) from different varieties (B): NC 4X	Mani Pintar	NC Ac 343	Shula-mit	Mean (A)	Mean (C)
1989	5 Jun		1.78	3.08	1.78	2.93	2.39	
	15 Jun		2.16	3.06	1.64	3.30	2.54	
	25 Jun		2.09	3.16	1.75	3.44	2.61	
	5 Jul		1.41	2.04	1.39	2.29	1.78	
	Mean (B)		1.86	2.84	1.64	2.99	2.33	
		h	1.97	2.84	1.68	3.01		2.38
		n	1.74	2.83	1.60	2.96		2.28
1990	5 Jun		2.75	2.60	0.86	1.34	1.89	
	15 Jun		2.18	1.83	0.87	1.30	1.55	
	25 Jun		1.55	1.57	0.93	0.98	1.26	
	5 Jul		1.62	1.76	0.95	1.12	1.36	
	Mean (B)		2.03	1.94	0.90	1.19	1.52	
		h	1.94	1.93	0.89	1.14		1.48
		n	2.11	1.95	0.92	1.23		1.55
1989/90	5 Jun		2.27	2.84	1.32	2.14	2.14	
	15 Jun		2.17	2.45	1.26	2.30	2.05	
	25 Jun		1.82	2.37	1.34	2.21	1.94	
	5 Jul		1.52	1.90	1.17	1.71	1.57	
	Mean (B)		1.95	2.39	1.27	2.09	1.93	
		h	1.96	2.39	1.29	2.08		1.93
		n	1.93	2.39	1.26	2.10		1.92

	1989 A	1989 B	1989 C	1990 A	1990 B	1990 C	1989/90 A	1989/90 B	1989/90 C
SE	±0.085	±0.063	±0.038	±0.045	±0.025	±0.015	±0.093	±0.093	±0.026
CV (%)	20.8	15.4	13.1	31.6	17.5	14.7	38.9	38.9	15.3
LSD (0.05)	0.24	0.17	ns	0.27	0.13	ns	0.26	0.26	0.07
LSD (0.01)	0.31	0.23	ns	0.38	0.18	ns	0.34	0.34	0.09

1. h = hilling up, n = no hilling up, ns = not significant

are important—sowing in Jul may lead to low yields, while early Jun sowings may be affected by pod rotting (due to rains in Nov). Hilling up during the vegetative growth period provided no clear advantage to the crop.

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Collaboration Between the Institut National de la Recherche Agricole du Bénin and ICRISAT Sahelian Center

Moustafa Adomou (Station de recherche sur les culture vivrières d'INA (SRCV-INA), BP 03 N'dali, Republic of Benin)

The Republic of Benin in western Africa lies between latitudes 6°30′ and 12°30′N. The climate varies from humid subtropical in the south to dry Sudano-Sahelian in the north. Northern Benin, which covers about 75% of the country's land area, is characterized by three main agroecological zones; Sudanian savanna, Sudano-Sahelian savanna, and Sahelian savanna. The annual rainfall varies between 600 and 1100 mm. The end of the rainy season is characterized by dry winds blowing from the Sahara desert. The dry season lasts between 4 and 7 months. The soils are typically tropical ferrogenous and shallow, with concretions near the soil surface, except for the fluvial soils in river valleys. Cotton is the principal cash crop. The food crops include legumes and oilseeds (groundnut, cowpea, sesame, bambara groundnut), cereals (maize, sorghum, millet, fonio), and roots and tubers (yams, cassava).

Several of ICRISAT's mandate crops (sorghum, millet, and groundnut) are important in northern Benin. The Institut national de la recherche agricole du Bénin (INRAB) therefore started a collaborative program with ICRISAT Sahelian Center (ISC) in the early 1980s, at the initiative of INRAB scientists at the Station de recherche sur les cultures vivrières (SRCV) d'INA at N'dali. This article briefly describes the main areas of collaboration between SRCV-INA and the ISC groundnut program since 1989, the major outputs of this collaboration, and future perspectives.

Groundnut pathology. The first groundnut pathology trial was initiated in 1989 and conducted until 1991. The main focus was to determine yield losses due to late leaf spot (*Phaeoisariopis personata*). The trial included six varieties, of which ICG (FDRS) 4 and ICG (FDRS) 10 are moderately resistant to foliar diseases, with 55-437 as a susceptible control. One to four fungicide treatments were applied. Yield losses were 20–30% in the resistant varieties, and up to 60% in the susceptible varieties. The resistant varieties gave pod yields of 3–3.5 t ha^{-1} even without spraying, while the unsprayed susceptible control yielded only 1 t ha^{-1}.

We initiated another study in 1992 to determine the economic level of fungicide treatment. This study was conducted for 2 years. The results showed that a single spray between 55 and 70 days after sowing gave satisfactory protection and improved yields.

Breeding. The first series of trials, comprising short-duration and medium- to long-duration material, was conducted in 1989 and 1990. Promising lines from these trials were further evaluated for 3 years (1991–93) at five locations in northern Benin. The main objective was to determine the stability of these lines and select the most promising ones for on-farm trials.

Among the short-duration types, ICGV-SM 83011 and ICGV 86072 were the most stable and gave pod yields of 2 t ha^{-1} on the average. Among the medium- to long-duration types, ICGV-SM 85754 and ICGV 86028 were the most stable and gave an average of 2 t ha^{-1}. These varieties will be seed-multiplied in 1995 for large scale on-farm testing in 1996.

New advanced breeding lines (short-duration, medium-duration, drought- and foliar disease-resistant) introduced from ISC in 1991 were evaluated during 1992 and 1993. Promising lines were tested at several locations. In 1994, 56 medium-duration rosette-resistant lines were evaluated in an advanced trial. Selected lines from this trial will be tested at locations with high rosette incidence to confirm the resistance.

Significant achievements. The ISC groundnut improvement program has helped to train INRAB technicians at Niamey and at ICRISAT Asia Center, India. Senior scientists also benefitted from short visits to ISC to analyze results and discuss collaborative activities. This interaction and training has enhanced the capabilities of INRAB scientists and technicians in experimental design, data analysis, and interpretation. The introduced breeding lines have increased the genetic diversity of groundnut in the national program. Six manuscripts are being prepared for publication in association with ISC scientists.

Looking ahead. INRAB will continue its efforts to popularize promising new varieties and the use of integrated disease management strategies to increase and stabilize production. There is a need for a Memorandum of Understanding between INRAB and ICRISAT to institutionalize this useful collaboration. Future collaboration could cover other ICRISAT mandate crops (sorghum and pearl millet) in addition to groundnut.

Effect of Transparent Polythene Mulch during the Reproductive Stages of Groundnut

S D Golombek, H S Talwar, and
C Johansen (ICRISAT Asia Center,
Patancheru 502 324, Andhra Pradesh, India)

Under low-temperature conditions in Korea, polythene mulch applied at the beginning of crop growth accelerated emergence, seedling growth, and flowering, and increased pod number and 100-seed mass of groundnut by increasing soil temperatures (Choi et al. 1979). This technique has also been popular in China since 1967. In a preliminary postrainy-season study at ICRISAT Asia Center (IAC), polythene mulching from sowing onwards reduced the time to emergence and flowering, and increased pod yield by 73% (Nigam, S N, Rao, R C N, and Talwar, H S, unpublished data).

To study the effects of soil temperature during reproductive growth and development, we investigated the effects of transparent polythene mulch treatments applied during the early and later reproductive stages. The experiments were conducted on an Alfisol at IAC during the 1994 rainy season. There were three treatments—a control treatment (without mulch), polythene mulching applied from the start of pegging (50 days after sowing, DAS) until harvest (113 DAS) (treatment M1), and mulching from pod filling (71 DAS) until harvest (treatment M2).

Treatments were laid out in a split plot design, with mulch treatments in main plots and genotypes in subplots, with three replications. Plot size was 1.5 × 2.4 m. The mulch was applied by placing polythene sheets between rows, and stapling the sheets together between plants in each row. Three spanish type groundnut cultivars were used; TMV 2, AH 6179, and Comet. They were

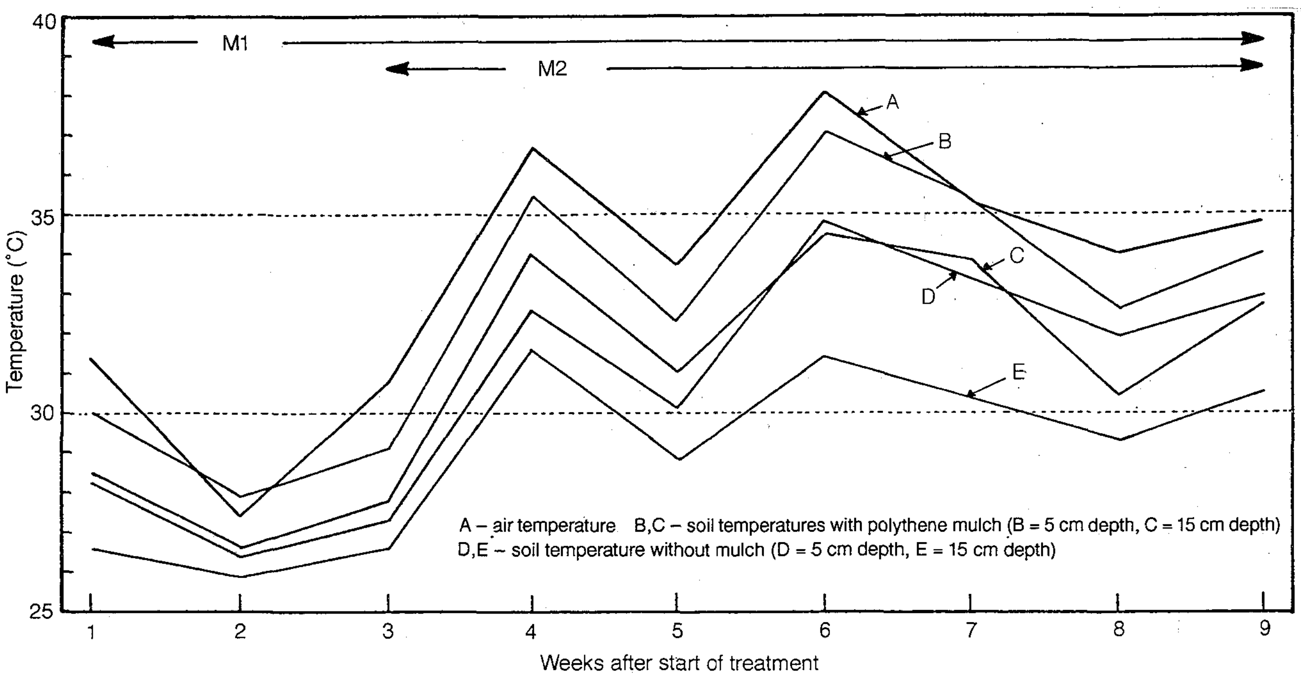

Figure 1. Soil and air temperatures (weekly means) recorded at 1300 hrs, starting from 51 days after sowing (DAS) until harvest (113 DAS). M1, M2 are mulching treatments (see text).

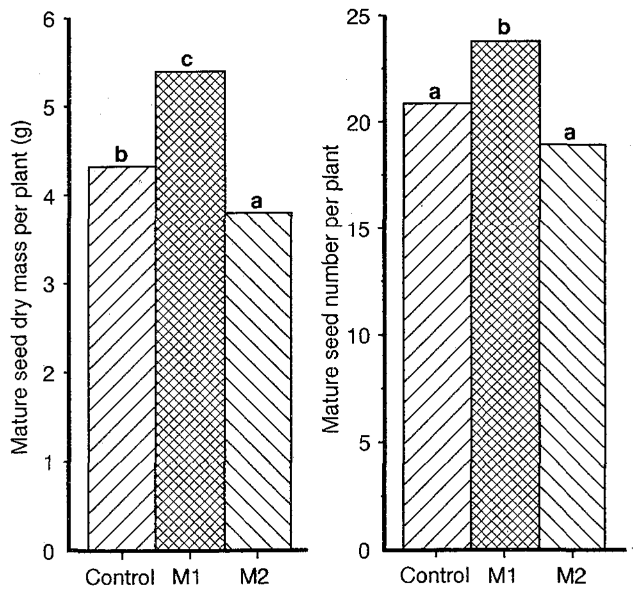

Figure 2. Effect of two polythene mulch treatments M1, M2 (see text for details) on dry mass and number of mature seeds per plant. Bars labelled with the same letter indicate that means are not significantly different at P<0.05 according to the Multiple Range Test.

sown on 30 Jul 1994, 10 cm apart in rows spaced at 60 cm. This wider-than-normal spacing facilitated light penetration through the canopy, thus ensuring that mulching would increase soil temperatures even at the later growth stages. A portable rain-out shelter was used to protect the experimental plots from rain. Soil moisture was periodically determined gravimetrically at 0–15 and 15–30 cm soil depths. Based on these moisture content determinations, the plots were irrigated to field capacity once or twice a week.

Soil temperatures were recorded daily at 1300 hrs at 5 cm and 15 cm depths in each plot. Mulching increased the soil temperature at 1300 hrs by 0.7 to 3°C (Fig. 1). Soil temperatures under polythene mulch were similar in treatments M1 and M2.

There were no genotypic differences in vegetative or reproductive growth; therefore the means for each treatment are presented. Mulching had no influence on the dry mass of vegetative parts (leaves, stems, and tap root), on leaf area and stem length, or on specific leaf area. However, reproductive growth and development was influenced by mulching.

When polythene mulch was applied at the early reproductive stages (M1), mature seed dry mass per plant increased by 24% (Fig. 2). This effect was mainly due to an increased number of mature seeds, not due to increased seed filling (100-seed mass). One reason for this increase in seed yield was the significantly lower partitioning of assimilates to pods which are still immature or juvenile at harvest (unpublished data).

Application of polythene mulch in the later reproductive stages (M2) marginally decreased the seed yield. This might be due to a change in temperature sensitivity at the later growth stages and/or the generally higher soil temperatures during these stages (Fig. 1).

Polythene mulching during the early reproductive stages can improve seed yield by increasing seed number, at least within the temperature ranges of this experiment. Thus the beneficial effects of polythene mulching appear to extend beyond the early vegetative growth stages, for which the technique is primarily used in East Asia.

Acknowledgments. We gratefully acknowledge the discussions with R C N Rao and the assistance of M Narsi Reddy in conducting the experiment.

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Bioenergetic Considerations in Increasing Groundnut Yield

J B Mishra and **S K Yadav** (National Research Centre for Groundnut, Post Bag No 5, Junagadh 362 001, Gujarat, India)

The biomass productivity of a crop plant depends on its efficiency in intercepting and utilizing solar radiation for photosynthesis. Selection and breeding have enhanced the yield potential of several crops by improving partitioning in favor of the harvested portion of the plant. The radiation-use efficiency of groundnut has been compared with wheat (a C_3 crop) and *Cynodon dactylon* (a C_4 plant), and groundnut has been found to be more efficient both in trapping solar energy and in energy partitioning (Dwivedi et al. 1985).

In developing countries like India, groundnut is primarily grown as an oilseed crop. Consequently, breeding programs are formulated to develop varieties with a higher oil content or higher productivity. The bioenergetic costs of increasing oil percentage have been discussed

Table 1. Calculations showing the quantities of glucose required to produce 100 g of groundnut shell, seed, pod, and haulm.

Part of plant	Chemical constituent (g 100 g^{-1} dry weight)		Production value (g g^{-1} glucose)		Glucose requirement (g 100 g^{-1} dry weight)
Haulm	Carbohydrate	71.0	0.83		85.54
	Protein	15.0	0.40		37.50
	Oil	2.0	0.299		6.69
	Minerals	12.0	–		–
				Total	**129.73**
Shell	Carbohydrate	84.0	0.83		101.20
	Protein	8.5	0.40		21.25
	Oil	1.5	0.299		5.02
	Minerals	6.0	–		–
				Total	**127.47**
Seed	Carbohydrate	24.0	0.83		28.92
	Protein	25.0	0.40		62.50
	Oil	48.0	0.299		160.54
	Minerals	3.0	–		–
				Total	**251.96**
Pod[1]					**214.61**

1. Pod has been assumed to consist of 30% shell and 70% seed (w/w). Glucose requirements were computed accordingly, i.e., 30% of 127.47 + 70% of 251.96 = 38.34 + 176.37 = 214.61.

in earlier studies (Mitra and Bhatia 1979, Bhatia and Mitra 1988), and it has been shown that it would be more efficient to increase the oil content in seed at the cost of protein than at the cost of carbohydrates.

Crop productivity can be enhanced by increasing biomass productivity or harvest index or both. There is little information available about the bioenergetic implications of these approaches for groundnut; this study seeks to provide such information.

The calculations were based on the conclusions of Penning de Vries et al. (1974) that 1 g glucose (photosynthate) is required to produce 0.83 g carbohydrate or 0.40 g protein, or 0.299 g groundnut oil (Mitra and Bhatia 1979). The production value (PV) was defined as the ratio of the weight of the end product to the weight of glucose required for both carbon skeleton and energy production. The biomass of the groundnut crop comprises haulms and pods. The pod has two major fractions, shell and seeds. Standard values for the chemical composition of shell, seed, and haulm were used. To simplify the calculations, constituents other than oil and protein were subsumed under carbohydrate. The calculations of quantity of glucose required to produce 100 g of shell, seed, and haulm are shown in Table 1.

Table 2. Bioenergetic efficiency of increasing crop productivity by varying harvest index (HI) and biological yield.

Option[1]	Biological yield (t ha^{-1})	Pod yield (t ha^{-1})	HI	Glucose required (t ha^{-1})	Increase over baseline (%)
Baseline	2.25	0.90	0.4	3.68	
A	2.25	1.35	0.6	4.07	10.4
B	3.38	1.35	0.4	5.52	50.0
C	2.70	1.35	0.5	4.65	26.2
D	4.50	1.35	0.3	6.98	89.6

1. Four options, A to D. See text for details.

Four options described by Donald and Hamblin (1976) for cereals, were considered for groundnut to improve pod yield by 50% over the base of 900 kg ha^{-1}:

(A) increasing harvest index (HI) by 50% without affecting biological yield, (B) increasing biological yield by 50% without affecting HI, (C) increasing biological yield by 20% and HI by 25%, (D) increasing biological yield by 100% while reducing HI by 25%.

The theoretical demand for photosynthate (in glucose equivalents) for these four options are shown in Table 2. The calculations indicate that option A would demand the least (10.4%) increment in photosynthate, followed by options C (26.2%), B (50.0%), and D (89.6%). It is thus clear that in bioenergy terms, the most efficient approach to increasing pod yield would be by improving HI; whereas increasing biological yield while simultaneously lowering HI would be the most inefficient.

It may therefore be concluded that the most energy-efficient strategy for increasing groundnut productivity would be to improve HI alone; combined improvement in HI and biological yield would be the second choice.

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Performance of Spanish Groundnut TG 26 under Varying Plant Density

A Krishna, V Satyanarayana Rao, and **K Gopal** (Regional Agricultural Research Station, Jagtial 505 327, Andhra Pradesh, India)

The production of rainy-season groundnut in Andhra Pradesh is declining due to low yields and the uncertainty of rains. Cultivation is shifting to the postrainy and summer seasons, during which irrigation facilities are available. The rainy-season varieties predominant in southern India—JL 24, TMV 2, KRG 1, and S 206—do not have fresh seed dormancy, and late-season rains cause seeds to sprout before harvest. Under these circumstances, the new genotype TG 26 seems to be promising. This genotype has recently been identified for cultivation in the states of Gujarat, Maharashtra, and Andhra Pradesh. It matures in 100 days, gives high pod, seed, and oil yields, and has about 20 days fresh seed dormancy.

As TG 26 is a semi-dwarf type, it was felt that it may respond to an increase in plant density. A field investigation was therefore carried out at the Regional Agricultural Research Station, Jagtial, using a randomized block design with four spacings/plant populations; 22.5 × 7.5 cm (estimated plant population 580 000 ha^{-1}), 22.5 × 10 cm and 30 × 7.5 cm (estimated population 440 000 ha^{-1}), and 30 × 10 cm (330 000 ha^{-1}). These treatments were replicated five times. The experimental site had red sandy loam soil, highly deficient in available P_2O_5, moderate in K_2O availability, and low in organic matter. A uniform dose of 30 kg N, 60 kg P_2O_5, and 40 kg K_2O ha^{-1} was applied.

Data on final plant stand, pod and haulm yields, number of pods $plant^{-1}$, and shelling percentage are presented in Table 1. Final plant stand was different at different spacings. The spacing of 30 × 7.5 cm gave the highest pod yield (2.78 t ha^{-1}), haulm yield (2.82 t ha^{-1}), and number of mature pods (30 pods $plant^{-1}$), although other spacings gave results that were not significantly inferior (Table 1). The next best spacing was 22.5 × 7.5 cm, which gave results on par with those at 30 × 7.5 cm for all the parameters measured.

Similar yield increases at 30 × 7.5 cm were also reported by Kumar and Venkatachary (1971). A study at Bhavanisagar, Tamil Nadu (Jagannathan et al. 1974), indicated that a spacing of 22.5 × 10 cm with a density of 44 plants m^{-2} gave the highest pod yield in spanish bunch groundnut.

Table 1. Performance of groundnut variety TG 26 at different spacings, Regional Agricultural Research Station, Jagtial, Andhra Pradesh.

Spacing (cm)	Final plant stand ('000 ha^{-1})	Pod yield (t ha^{-1})	Haulm yield (t ha^{-1})	Number of mature pods $plant^{-1}$	Shelling percentage
22.5 × 7.5	520	2.53	2.61	20	68
22.5 × 10	420	2.69	2.72	28	70
30 × 7.5	430	2.78	2.82	30	71
30 × 10	320	2.20	2.52	22	68
SE	±7.2	±0.087	±0.094	±1.1	±0.8
LSD at 5%	23.0	0.28	0.30	3.2	2.4

Thus, on the basis of this study and earlier reports, it is indicated that to maximize yields, TG 26 should be sown at the recommended spacing of 30 × 7.5 cm or at 22.5 × 10 cm, giving a plant population of 440 000 ha^{-1}.

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Plant Population Dynamics of Groundnut/ Mustard Intercropping

B P Patil (National Agricultural Research Project, Agricultural Research Station, Palghar 401 404, Maharashtra, India)

Groundnut (*Arachis hypogaea*) and mustard (*Brassica juncea*) are major oilseed crops in the Konkan region in Maharashtra, India, where they are well adapted for irrigated cultivation in rice fallows. Both crops are sown in Nov-Dec in the Konkan. Due to differences in their phenology, groundnut and mustard can be intercropped; the combination can give higher yields than monocultures (Mead and Willey 1980). This study was conducted to evaluate the effect of population dynamics on yields in a mustard/groundnut intercrop.

The experiment was conducted in a randomized block design during the 1989/90 postrainy season at the Central Experiment Station, Wakawali, Ratnagiri district, Maharashtra. The treatments comprised five intercrop combinations at different populations:

(i) 100% mustard (148 148 plants ha^{-1}) in paired rows, with 30 cm between rows and 60 cm between pairs + 50% groundnut (111 111 plants ha^{-1}) at 30 × 15 cm; (ii) 50% mustard (74 074 plants ha^{-1}) at 90 × 15 cm + 50% groundnut (111 111 plants ha^{-1}) at 30 × 15 cm; (iii) 50% mustard (74 074 plants ha^{-1}) at 90 × 15 cm + 100% groundnut (222 222 plants ha^{-1}) at 30 × 15 cm; (iv) sole mustard at 45 × 15 cm (148 148 plants ha^{-1}); (v) sole groundnut at 30 × 15 cm (222 222 plants ha^{-1}).

The treatments were replicated three times. The soil of the experimental site was lateritic, with 0.8% organic carbon, 256 kg ha^{-1} available nitrogen, 6 kg ha^{-1} phosphorus, 240 kg ha^{-1} potassium, and pH 6.5. Plot size was 6.6 × 5.4 m. The experiment was sown on 31 Dec 1989. The usual plant protection, fertilizer, and irrigation schedules were followed. Mustard was harvested on 25 Mar and groundnut on 5 May 1990. Mustard seed yield and groundnut pod yield were analyzed statistically, and the land equivalent ratio (LER) calculated based on intercrop and sole-crop yields of the component crops.

Intercropping mustard at 100% population with groundnut at 50% population did not reduce mustard seed

Table 1. Yields of mustard and of groundnut as influenced by population dynamics, Central Experiment Station, Wakawali (Ratnagiri), Maharashtra, India, 1989/90 postrainy season.

Treatment	Mustard seed yield (kg ha^{-1})	Groundnut pod yield (kg ha^{-1})	LER[1]
100% mustard + 50% groundnut	501	622	1.53
50% mustard + 50% groundnut	473	408	1.28
50% mustard + 100% groundnut	382	850	1.49
Sole mustard or sole groundnut	508	1152	
SE	±18	±58	
LSD at 5%	61	198	

1. Land equivalent ratio

yield significantly below sole-crop yield. Neither did the combination of 50% mustard + 50% groundnut reduce mustard yield significantly below sole-crop yield (Table 1). However, intercropping mustard at 50% population with groundnut at 100% population reduced mustard yield significantly. Mustard seed yield was not markedly affected by reducing population by up to 50%, indicating the crop's ability to compensate for reduced population.

In contrast, groundnut pod yield was sensitive both to reduction in population and to intercropping with mustard (Table 1). When groundnut at 100% population was intercropped with mustard at 50% population, groundnut yield was reduced by as much as 26% below sole-crop yield. This indicated that intercropping groundnut at increased population with mustard did not help overcome the yield loss. Nevertheless, yield advantage in the intercrop (as measured by LER) was greater when 100% population of one component was combined with 50% population of the other.

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Effect of Different Irrigation Schedules and Methods of Sowing and Irrigation on Yield, Economics, and Water Saving in Summer Groundnut

K R Patel, T D Patel, and **J B Patel**
(Department of Agronomy, B A College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand 388 110, Gujarat, India)

Gujarat ranks first among the Indian states in groundnut area and production. However, average productivity is relatively low as groundnut is mostly grown rainfed during the rainy (kharif) season. Because of the crop's high water-use efficiency under assured irrigation, summer-season groundnut cultivation is becoming increasingly popular. Productivity of the irrigated summer crop is 2–3 times as high as that of the rainfed crop.

In irrigation scheduling, a climatological approach based on IW/CPE ratio (irrigation water IW to cumulative pan evaporation CPE) was found most appropriate. This approach takes into account all the weather parameters that determine water use by the crop, and is likely to increase production by at least 15–20% (Dastane 1972). The method of irrigation is also important; for example in the border method, water loss (through percolation beyond the reach of the root zone) is 27–42% (Agrawal and Khanna 1983). Land management practices can alter the physical properties of the soil and thereby affect crop productivity. Summer groundnut is generally sown on flat beds using a seed drill, but sowing in furrows would be more advantageous, as it would increase moisture recharge in the soil by collecting water for re-absorption, and simultaneously increase water-use efficiency by draining away excess water (Shanmugam 1983).

A field experiment was conducted at the Agronomy Farm, Gujarat Agricultural University, Anand, during summer 1992. The soil was loamy sand in texture, low in total N (0.034%), medium in available phosphorus (43.5 kg ha^{-1}), and high in available potassium (280 kg ha^{-1}). Moisture retention was 16.5% at field capacity and 4.65% at permanent wilting point (gravimetric basis). Bulk density of the soil was 1.33 g cm^{-3}. Twelve treatment combinations were used—two irrigation schedules I_1 and I_2 as main plots and six sowing/irrigation methods (Fig. 1) as subplots. I_1 = IW/CPE ratio 0.6, 75 mm water per irrigation, I_2 = IW/CPE ratio 0.8, 50 mm water per irrigation. A split plot design was used, and the experiment replicated four times.

Details of the various treatments are shown in Table 1. Groundnut GG 2 was sown on 5 Feb and harvested on 7 Jun 1992. The crop was fertilized with 25 kg N and 50 kg P_2O_5 ha^{-1}. Irrigation was applied when CPE was 125 mm for I_1 and 62.5 mm for I_2. Thus, treatment I_1 involved 7 irrigations and treatment I_2 involved 13 irrigations, including one common irrigation applied just after sowing to facilitate germination.

Effect of IW/CPE ratio. Treatment I_2 (irrigation at IW/CPE ratio of 0.8 with 50 mm water) resulted in significantly higher yield (26% superiority) than treatment I_1 (Table 1). This was partly because the quantity of water applied was higher in I_2 (13 irrigations × 50 mm) than in I_1 (7 irrigations × 75 mm), and because the higher irrigation frequency provided congenial conditions throughout the crop growth period, resulting in an increase in mature pods $plant^{-1}$ and 100-seed mass. These findings are similar to those reported by Thorat et al. (1988). Cost:benefit ratio (1:2.26) and water-use efficiency (5.25 kg ha^{-1} per mm of water) were higher under treatment I_2. The crop matured significantly earlier under I_1 than under I_2. The delayed maturity in I_2 was mainly due to two factors—

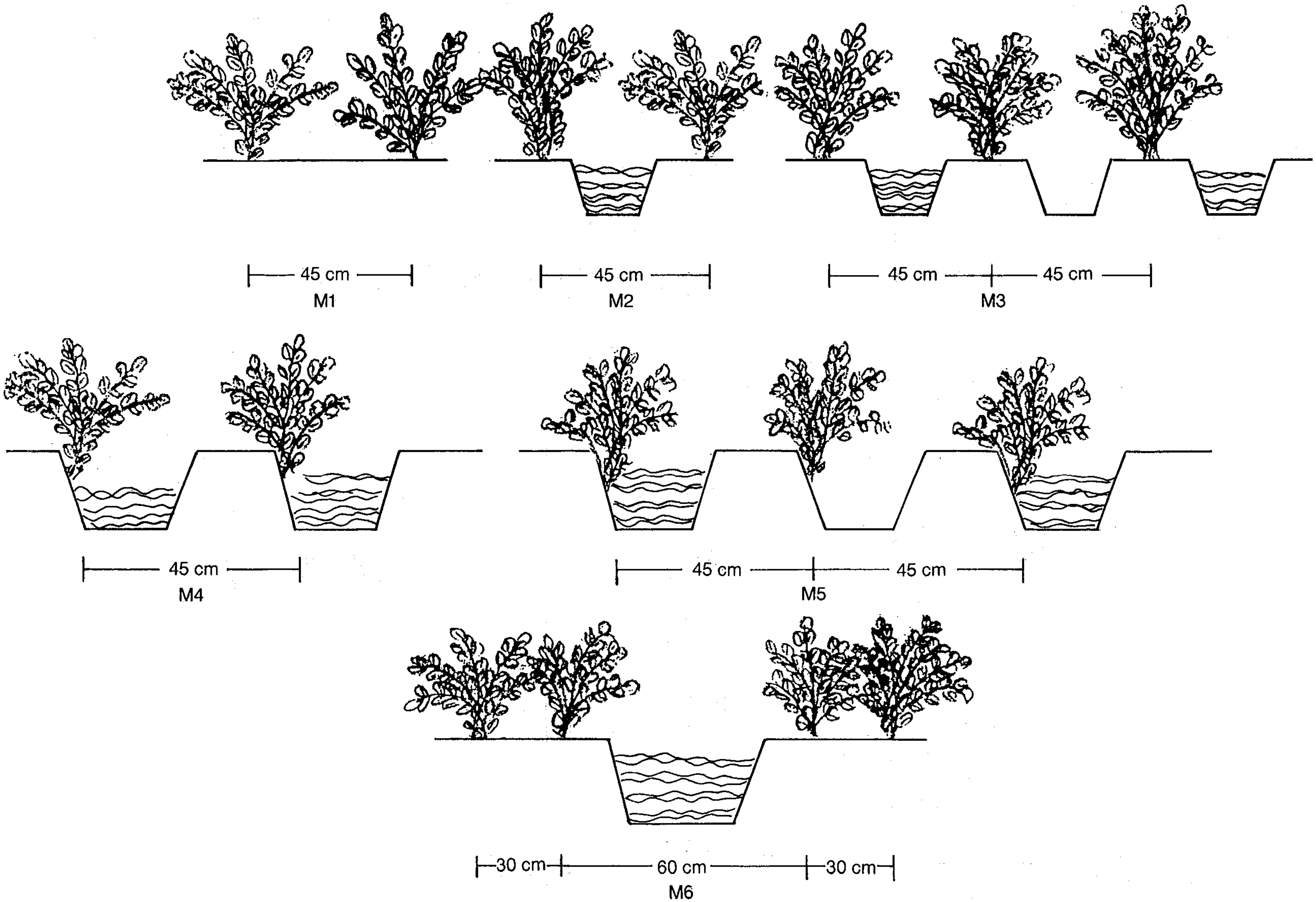

Figure 1. Sowing and irrigation methods (treatments M_1 to M_6) used in the groundnut trials, Anand, Gujarat, 1992 summer.

Table 1. Yield, economics, and water saving in groundnut as influenced by different irrigation schedules and methods of sowing and irrigation.

Treatment	Pod yield (t ha^{-1})	Average quantity of water applied (mm)	Water-use efficiency (kg ha^{-1} per mm water)	Cost: benefit ratio	Days to maturity
Irrigation (IW/CPE ratio)					
I_1 = 0.6 (75 mm water)	1.41	344	4.91	1:1.89	106
I_2 = 0.8 (50 mm water)	1.90	438	5.25	1:2.26	113
LSD (P = 0.05)	0.186				3
Sowing/Irrigation methods					
M_1 = Flat bed/Border	1.74	575	3.52	1:1.61	112
M_2 = Flat bed/Furrow	1.60	483	4.17	1:2.03	110
M_3 = Flat bed/Alternate furrow	1.56	269	7.01	1:2.24	109
M_4 = Furrow/Furrow	1.90	483	4.84	1:2.35	110
M_5 = Furrow/Alternate furrow	1.66	269	7.71	1:2.50	109
M_6 = Skip sowing/Furrow irrigation between two pairs	1.44	269	6.32	1:2.08	107
LSD (P = 0.05)	0.092				ns
Interaction	ns				ns

Skip sowing: 30 cm distance between rows, 60 cm between pairs

extended vegetative growth and pegging stages (as a result of frequent irrigation), and the indeterminate growth habit of the crop.

Effect of sowing and irrigation methods. As shown in Table 1, pod yield (1.90 t ha^{-1}) and cost:benefit ratio (1:2.35) were highest under treatment M_4 (furrow sowing, furrow irrigation). This treatment was superior to the M_1 treatment (flat bed sowing, border irrigation) by 9% in pod yield and 16% in terms of water saving. Other treatments also resulted in water saving, but gave lower yields than treatment M_1. Water-use efficiency was highest (7.71 kg ha^{-1} per mm water) under treatment M_5 (furrow sowing, irrigation in alternate furrows). The high pod yield under treatment M_4 was evidently due to increased water availability, resulting in more mature pods and higher 100-seed mass; and because this treatment provides a larger contact area for peg penetration and also better root aeration (because the medium is comparatively porous). These findings confirm the results of Rasve et al. (1983). There were no significant differences between treatments in days to maturity.

These results suggest that to maximize pod yield and profitability in summer groundnut (GG 2) in the middle Gujarat agroclimatic zone, irrigation should be applied at an IW/CPE ratio of 0.8, with 50 mm water (13 irrigations); and that furrow sowing and furrow irrigation should be used.

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Response of Groundnut Varieties to Fertilizer Nitrogen in Medium Black Soils of the Konkan Region of Maharashtra, India

L S Chavan and **B P Patil** (National Agricultural Research Project, Agricultural Research Station, Palghar 401 404, Maharashtra, India)

The practice of double cropping with rice in the command areas of irrigation projects leads to tillage problems because fields are wet almost throughout the year, and to plant protection problems due to the perpetuation of the yellow stem borer of rice. In addition, double cropping with rice requires large amounts of water (over 2000 mm), and labor for transplanting. As part of the effort to diversify cropping patterns, irrigated postrainy-season groundnut is being increasingly promoted as a cash crop in the command areas of irrigation projects in the Konkan region of Maharashtra (Thorat and Patil 1986). Recent studies have shown that, with broadbed-and-furrow technology, pod yields of over 4 t ha^{-1} can be obtained on medium black soils of the Konkan region (Patil 1989). However, on medium black soils of the North Konkan Coastal Zone, the recommended dose of 25 kg N + 50 kg P_2O_5 ha^{-1} leads to excessive vegetative growth. This study was conducted on some promising groundnut genotypes to explore the possibility of reducing the recommended dose of fertilizer nitrogen in the postrainy season, without affecting pod yields.

A field experiment was conducted on medium black soil at the Agricultural Research Station, Palghar, during the 1989/90 and 1990/91 postrainy seasons, after the rice harvest. A split plot design was used with three replications. The land was prepared by plowing with a tractor-drawn soil turning plow and tyne cultivator. The soil of the experimental plot was clayey, with pH 8.1, 0.61% organic carbon, 200 kg ha^{-1} available nitrogen, 42 kg ha^{-1} available P_2O_5, and 346 kg ha^{-1} available K_2O (Jackson 1973). Four groundnut varieties (SB XI, JL 24, ICGS 1, and UF 70103) constituted the main plots, while three nitrogen levels (0, 12.5, and 25 kg N ha^{-1}) were the sub-

Table 1. Effect of nitrogen levels on pod yield and harvest index of four groundnut varieties, Palghar, Maharashtra, India, 1989/90 and 1990/91 postrainy seasons.

	Pod yield (t ha^{-1}) and harvest index at different nitrogen levels (kg ha^{-1})							
	1989/90				1990/91			
Variety	0 N	12.5 N	25 N	Mean	0 N	12.5 N	25 N	Mean
SB XI	2.70	2.76	2.78	2.75	2.14	2.36	2.42	2.31
	(37.9)	(36.5)	(33.3)	(35.9)	(33.4)	(33.3)	(31.3)	(32.7)
JL 24	2.91	3.98	4.43	3.77	2.29	2.60	2.81	2.57
	(32.6)	(38.0)	(39.5)	(36.7)	(34.5)	(35.7)	(36.4)	(35.5)
ICGS 1	4.25	4.53	4.71	4.49	2.93	2.95	2.98	2.95
	(50.4)	(48.0)	(44.6)	(47.6)	(43.5)	(39.2)	(34.9)	(39.2)
UF 70103	3.53	3.55	4.20	3.76	2.64	2.86	3.05	2.85
	(38.2)	(36.5)	(37.4)	(37.4)	(34.3)	(33.4)	(31.2)	(33.0)
Mean	3.34	3.70	4.03		2.50	2.69	2.81	
	(39.8)	(39.7)	(38.7)		(36.4)	(35.4)	(33.5)	

	Varieties		N levels		Varieties × N	
	1989/90	1990/91	1989/90	1990/91	1989/90	1990/90
SE	±0.147	±0.025	±0.099	±0.029	±0.199	±0.059
LSD (P = 0.05)	0.508	0.086	0.299	0.088	0.599	0.176
CV (%)	11.92	2.81	9.36	3.81	9.36	3.81

Figures in parentheses indicate harvest index (%)

plots. Gross plot size was 4.5 × 3 m, and net plot size 3.9 × 2.7 m. A uniform basal dose of 50 kg P_2O_5 in the form of single superphosphate and nitrogen (depending on the treatment) in the form of urea were applied. Gypsum was not applied to the crop. Seeds were treated with Thiram® @ 4 g kg^{-1} seed and sown on flat beds in the second week of Dec at 30 × 15 cm spacing. The usual weed and pest control measures were followed. In all, 10 irrigations were applied at intervals of 10–12 days, using 60 mm water per irrigation. The crop was harvested during the third and fourth weeks of April. Dry pod yields were recorded and analyzed statistically. Similarly, haulm yields were recorded and the harvest index (HI) calculated for each variety.

The variety UF 70103 showed a consistent and significant response to increased levels of fertilizer nitrogen in both years. Variety JL 24 showed a graded and significant yield increase up to 25 kg N ha^{-1} in 1990/91, whereas it responded only up to 12.5 kg N ha^{-1} in 1989/90, indicating its tendency towards high nitrogen demand. The variety SB XI was not consistent in its response pattern. Nevertheless, its response up to 12.5 kg N ha^{-1} in 1990/91 and nonresponse to N levels in 1989/90 indicated its low requirement for fertilizer nitrogen (Table 1). Interestingly, ICGS 1 did not respond to fertilizer nitrogen in either year, while it gave the highest pod yields. This suggests that it is more effective in fixing nitrogen than the other varieties tested.

Harvest indices of SB XI, ICGS 1, and UF 70103 declined with an increase in nitrogen levels in both years. However, the reduction in HI was more pronounced in SB XI, providing evidence for its tendency towards increased vegetative growth at high nitrogen levels. JL 24 showed an increase in HI with an increase in the dose of nitrogen, indicating that the variety is relatively efficient at transferring photosynthates to pods (rather than tending to accumulate photosynthates in the vines) even at high nitrogen levels. Among the different genotypes tested, ICGS 1 had the highest HI, followed by JL 24.

The results suggest that on medium black soils of the North Konkan Coastal Zone, varieties UF 70103 and JL 24 should be fertilized with the recommended dose of 25 kg N + 50 kg P_2O_5 ha^{-1}, whereas for SB XI the dose of nitrogen could be reduced (12.5 kg N + 50 kg P_2O_5 ha^{-1}) to control vegetative growth without affecting yield. Variety ICGS 1 probably requires no nitrogen fertilizer for irrigated postrainy-season cultivation in rice fallows on this soil—with only 50 kg P_2O_5 ha^{-1}, it gave the highest pod yields in the experiment.

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Response of Erect Bunch Groundnut Genotypes to Nitrogen Fertilizer

D H Sukanya[1], **M V C Gowda**[2], and **S G Hegde**[1] (1. Department of Genetics and Plant Breeding, University of Agricultural Sciences, Bangalore 560 065, Karnataka, India. 2. Corresponding author: Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad 580 005, Karnataka, India)

Erect bunch varieties of groundnut (*Arachis hypogaea* var *fastigiata*) are popular because of their short duration and the ease with which they can be harvested. Often, the response of these varieties to applied nitrogen reveals nitrogen limitations that could inhibit growth and productivity (Cox et al. 1982). However, the application of external nitrogen at higher levels inhibits biological nitrogen fixation (Streeter 1988). Though virginia types belonging to *A. hypogaea* var *hypogaea* fix more nitrogen (Nambiar et al. 1982), improvement of erect bunch types through inter-subspecific crossing has been unsuccessful because segregating populations often show depressed performance and undesirable recombinations (Wynne 1974). Therefore, exploitation of intra-subspecific variation has been suggested as a way to enhance groundnut productivity (Arunachalam et al. 1982).

An evaluation of 95 erect bunch germplasm lines of groundnut showed wide variation for growth and development under different levels of applied nitrogen ranging from 0 to 225 kg ha^{-1}. Nine genotypes representing a diversity of performance at different nitrogen levels, the popular variety JL 24, and a high nitrogen fixer (NC Ac 2821) were evaluated at two levels of applied nitrogen, zero and 225 kg ha^{-1}. A randomized block design was used, with two replications. The experiment was con-

Table 1. Nodulation, acetylene reductase activity at 75 days after sowing, and pod yield, total dry matter, nitrogen yield plant^{-1}, and N harvest index of groundnut genotypes at maturity as influenced by combined N.

	NN			NM (mg)			ARA (μM h^{-1} g^{-1})			PY (g)			TDW (g)			TNC (g)			NHI		
Genotype	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Mani Blanco	57.0	41.5	–27	39.5	86.5	119	34.9	5.7	–84	30.9	30.9	0	76.5	79.7	4	1.8	1.9	9	0.44	0.40	–7
S 206	48.5	62.0	28	44.0	60.5	38	45.6	20.4	–55	28.7	30.1	5	79.3	71.0	–10	1.4	1.5	0	0.41	0.52	27
Spanish 191-1	42.5	95.0	123	139.0	54.0	–62	43.7	20.8	–52	32.0	37.5	17	74.3	90.6	22	1.7	2.1	21	0.46	0.43	–7
Short 1	50.0	81.0	62	86.0	108.5	26	94.1	129.9	38	32.6	38.2	17	74.4	94.8	27	1.9	2.4	24	0.38	0.44	11
US 1	75.0	35.0	53	130.0	67.0	–49	48.0	10.5	–78	30.8	37.3	21	75.6	90.8	20	1.7	1.9	10	0.44	0.49	11
RS 113	34.0	37.0	9	66.5	45.0	–32	24.9	65.4	163	36.4	28.9	–21	89.4	76.2	–15	2.0	1.8	–11	0.41	0.42	2
U 1-2-3	29.5	65.0	36	30.5	57.5	88	44.3	22.0	–50	37.9	29.0	–24	94.9	75.1	–21	2.3	1.8	–21	0.40	0.41	3
EC 21032	103.0	80.0	–22	88.5	88.5	0	61.9	36.9	–40	40.1	39.5	3	100.3	94.8	–5	2.3	2.1	–8	0.38	0.41	8
No. 276	36.0	26.5	–26	72.0	52.0	–28	25.2	63.2	151	40.2	35.1	–13	95.3	86.5	–9	2.0	1.9	–8	0.43	0.44	2
JL 24	55.0	32.5	–41	57.5	63.0	10	31.9	47.7	50	39.6	42.8	8	93.9	97.4	4	2.3	2.6	17	0.48	0.38	–21
NC Ac 2821	44.5	33.5	–11	90.0	79.0	–12	66.7	101.5	52	39.7	43.2	9	95.9	92.5	–4	2.4	2.7	13	0.36	0.38	6
Mean	52.3	47.1	–10	76.7	69.2	–10	47.4	47.6	0	35.4	35.7	1	86.3	86.3	0	2.0	2.1	4	0.42	0.43	2
SE(m)	±19.3	±3.2		±16.3	±23.7		±6.2	±37.7		±2.2	±1.4		±5.0	±2.8		±0.1	±0.1		±0.02	±0.01	
LSD	ns	10.0		51.3	ns		5.9	ns		6.8	4.4		15.9	8.8		0.3	0.2		0.06	0.03	
CV (%)	8.3	4.6		7.7	5.5		6.9	4.9		12.3	9.5		15.2	18.5		13.6	17.0		6.73	0.10	

NN = nodule number, NM = nodule mass, ARA = actylene reduction assay, PY = pod yield, TDW = total biomass, TNC = total nitrogen content, NHI = nitrogen harvest index.
a = Mean performance under low N, b = Mean performance with applied N, c = Percentage change upon application of N.
ns = nonsignificant.

ducted in sandy loam soil with pH 5.4 and EC 0.20 ds m^{-1}. The soil was low in available nitrogen (162 kg ha^{-1}), high in P_2O_5 (56 kg ha^{-1}), and moderate in potash (172 kg ha^{-1}). Available nitrogen was estimated by the alkali permanganate method (Subbaiah and Asija 1956). Bray's method and the flame photometric method (Jackson 1973) were used for estimating available P_2O_5 and potash, respectively.

The evaluation was done during the rainy season (Jun-Sep) under irrigated conditions. Each entry was grown in 5 rows of 2 m length with a spacing of 60 × 20 cm. Three competitive plants were sampled in each plot, and observations recorded on nodule number (NN), nodule mass (NM), and acetylene reduction assay (ARA) at the pod-filling stage (75 days after sowing). Total biomass (TDW), total nitrogen content (TNC), pod yield (PY), and nitrogen harvest index (NHI) were recorded at harvest. Only effective nodules (pink colored) were counted for NN. Nitrogen content was estimated by the Kjeldahl method, and NHI was computed by dividing seed N content by TNC. ARA was measured by gas-liquid chromatography using a Poropak N column and expressed as µM of C_2H_4 formed h^{-1} g^{-1} of fresh root.

When no nitrogen was applied, the genotypes RS 113, No. 276, EC 21032, JL 24, NC Ac 2821, and U 1-2-3 produced more dry matter, gave higher pod yields, and accumulated more nitrogen than the other genotypes (Table 1). EC 21032 was superior in nitrogen fixation characters (NN, NM, and ARA), while JL 24 was superior in NHI, which indicates N mobilization. Among the poorer-yielding genotypes, Short 1 performed best in terms of NN, NM, and ARA.

Mani Blanco, Spanish 191-1, Short 1, US 1, JL 24, and NC Ac 2821 responded positively to applied N, with increased accumulation of nitrogen and higher biomass production and/or pod yield. The positive response to combined N in biological nitrogen fixation characters was apparent in S 206, U 1-2-3 (NN, NM), RS 113 (NN, ARA), JL 24 (NM, ARA), and Short 1 (NN, NM, ARA), indicating the possibility of nitrate tolerance in these genotypes. Short 1 also showed an increase in NHI, indicating that, in addition to being nitrate-tolerant, it was also superior in N mobilization, utilization, and accumulation. Thus, after a detailed confirmatory analysis Short 1 could be used as a potential parent in developing nitrate-tolerant genotypes that could use N from biological nitrogen fixation and from soil more efficiently.

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Response of Groundnut to Boron With and Without Molybdenum and Lime in Lateritic Soils (Aeric Haplaquept) in Orissa, India

S K Sahu[1], **J K Dhal**[2], **B B Das**[1], and **P K Das**[1] (1. Department of Agricultural Chemistry, Soil Science and Biochemistry. 2. Division of Breeder Seed Production, Orissa University of Agriculture and Technology, Bhubaneswar 751 003, Orissa, India)

Groundnut is a major oilseed crop in Orissa state in India, where it accounts for 34% of the total area under oilseeds. It is grown on about 345 000 ha, of which nearly 50% is red and lateritic soils. These soils are light in texture and acidic in reaction, with low cation exchange capacity (CEC) and high phosphate fixing capacity. They

Table 1. Response of groundnut cv ICGS 11 to application of lime, boron, and molybdenum—pod yield, shelling percentage, oil content, and oil yield, Bhubaneswar, Orissa, rainy (mean of 1991, 1992) and postrainy (mean of 1991/92, 1992/93) seasons.

	Pod yield (t ha^{-1})		Shelling percentage		Oil content (%)		Oil yield (t ha^{-1})	
Treatment	Rainy	Postrainy	Rainy	Postrainy	Rainy	Postrainy	Rainy	Postrainy
Control	1.20	1.19	65.25	66.75	37.50	37.65	0.29	0.30
Lime	1.26	1.41	68.80	69.20	40.35	38.90	0.33	0.37
B 1.5 kg ha^{-1}	1.34	1.57	67.85	69.50	42.60	38.75	0.39	0.39
B 2.0 kg ha^{-1}	1.43	1.52	70.45	70.05	41.05	39.25	0.40	0.41
B 2.5 kg ha^{-1}	1.39	1.69	68.70	69.25	43.90	40.15	0.41	0.46
B 1.5 kg ha^{-1} + Mo	1.62	1.76	70.95	70.75	44.35	40.90	0.49	0.44
B 2.0 kg ha^{-1} + Mo	1.53	1.78	69.65	70.50	42.85	40.05	0.46	0.49
B 2.5 kg ha^{-1} + Mo	1.47	1.58	70.10	70.00	40.50	40.05	0.38	0.51
Lime + B 1.5 kg ha^{-1} + Mo	1.59	1.77	70.20	70.65	43.10	40.20	0.48	0.46
Lime + B 2.0 kg ha^{-1} + Mo	1.66	1.87	71.35	69.35	43.75	39.90	0.46	0.49
Lime + B 2.5 kg ha^{-1} + Mo	1.54	1.89	69.90	69.40	43.00	39.50	0.50	0.48

are rich in iron, aluminum, manganese, and zinc, and deficient in available calcium, boron (B), and molybdenum (Mo) (Panda and Nanda 1985, Sahu 1993). Yields on these soils are unsatisfactory (Sahu and Dash 1994). Calcium deficiency causes the formation of shrivelled seeds or empty pods. Failure of peg development and hollow heart disease are the symptoms of boron deficiency. Molybdenum deficiency inhibits or prevents the activity of rhizobium bacteria, and consequently increases nitrogen requirements.

Four field experiments—1991 and 1992 rainy seasons, 1991/92 and 1992/93 postrainy seasons—were conducted at the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar, to determine the response of groundnut to lime, B, and Mo in a typical lateritic soil. There were 11 treatments: lime; three levels of B (1.5, 2.0, and 2.5 kg ha^{-1}); Mo seed treatment at each of these B levels; lime application plus Mo seed treatment at each of these B levels; and a control without lime, B, or Mo.

The treatments were replicated thrice in a randomized block design. Sources of lime, B, and Mo were paper mill sludge, borax, and sodium molybdate respectively. Lime @ 2 t ha^{-1} (i.e., 50% of lime requirement) was broadcast 15 days before sowing. All treatments received 20 kg ha^{-1} N, 17.4 kg ha^{-1} P, and 23.5 kg ha^{-1} K. Urea, single superphosphate (SSP), and muriate of potash (MOP) were the sources of NPK. Borax was placed along with urea, SSP, and MOP, in lines and the seeds then sown. Seeds were treated with sodium molybdate @ 10 g 25 kg^{-1} and at the same time inoculated with rhizobium bacterial culture. Groundnut variety ICGS 11 was used in all the experiments.

The soils at the experimental site were sandy loam (Aeric haplaquept) with pH 5.5, CEC 5.8 meq g^{-1} soil, organic carbon 0.31%, available N 80 ppm, P 8.3 ppm, K 135 ppm, B (hot-water soluble) 0.16 ppm, and Mo (extractable in ammonium oxalate pH 3.3) 0.03 ppm. Lime requirement of the soil was 4.0 t ha^{-1}.

All amendments, individually and in combination, increased pod yield, shelling percentage, oil content, and oil yield to levels higher than in the control (Table 1). Application of B alone was more effective than application of lime alone. The B+Mo treatment was still more effective; it increased pod yields by 10.8% in the rainy season and 8.2% in the postrainy season, and increased oil yields by 11.9% in the rainy season and 14.8% in the postrainy season, over the control. The lime+B+Mo treatment did not give appreciably better results than the B+Mo treatment.

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Influence of Organic Amendments on Groundnut Pod and Oil Yields in *Theri* Soils (Typic Ustipsamments)

D Subbaraj and **P P Ramaswami**
(Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India)

The sandy soils (Typic ustipsamments) occurring in *Theri* lands in Tamil Nadu are very deep, red sandy to loamy sand, with a single-grain structure. Moisture retentivity is poor, and cation exchange capacity and organic carbon content are very low. Consequently nutrient availability is poor in such soils.

A pot experiment was conducted to study the effects of different locally available amendments on groundnut pod and oil yields in these soils. Fourteen amendments were tried (Table 1), at the general level of application for sandy soils. The groundnut crop was harvested at maturity and pod yields recorded. Seed oil content was estimated using the ether-extraction procedure.

Significant differences were observed in pod yield due to the application of different amendments. Pod yields ranged from 7.66 to 19.00 g pot^{-1}, obtained with the arecanut waste treatment. Several other treatments (Thankaikulam silt, seaweed residue, *Cassia nigricans* manure, farmyard manure, and biogas slurry) gave pod yields on par with those from the arecanut treatment. These amendments improved both the physical and chemical conditions of the soil and resulted in higher pod yields. Some of the amendments used in this study have been reported to be effective in other studies. Koo (1988) reported that seaweed-based nutrient spray improved fruit yield from citrus trees. Improved pod yields in groundnut have been reported with green leaf manure (Singh et al. 1975) and biogas slurry (Singh 1989). Oil yields ranged from 1.3 to 4.9 g pot^{-1}; the arecanut waste treatment was the most effective in this respect.

Large-scale field studies need to be conducted in areas where these organic amendments are inexpensive and easily available, to confirm their practical utility and cost-effectiveness.

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Table 1. Influence of soil amendments on pod and oil yields in a pot experiment on groundnut, Tamil Nadu Agricultural University.

Treatment	Application rate (t ha^{-1})	Nutrient content of amendments (%)			Pod yield (g pot^{-1})	Total oil yield (g pot^{-1})
		N	P	K		
Composted coir pith	12.5	1.20	0.03	1.87	15.00	4.1
Pressmud	12.5	0.35	0.73	1.20	15.33	4.0
Farmyard manure	12.5	0.47	0.20	0.29	16.00	4.2
Thankaikulam silt	25.0	0.03	0.04	0.28	18.66	4.8
Killikulam silt	25.0	0.08	0.01	0.17	13.66	3.2
Cassia nigricans	5.0	2.90	0.17	1.70	16.33	3.9
Biogas slurry	12.5	1.20	0.70	0.80	16.00	4.4
Banana sheath	5.0	0.11	0.26	0.43	12.66	3.0
Tannery waste	5.0	0.44	–	0.48	11.66	2.5
Jalsakthi	12.5	–	–	–	11.33	2.7
Ipomoea cornea	5.0	1.60	0.06	0.76	12.66	2.8
Seaweed residue	12.5	1.05	0.26	0.43	17.00	4.3
Arecanut waste	5.0	1.46	0.09	0.20	19.00	4.9
Vermiculite clay	12.5	0.03	–	0.02	13.00	2.8
Control					7.66	1.3
LSD (P = 0.05)					3.45	0.86

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Farming Situation Based Extension Approach for Groundnut

Ravi Kumar Theodore and
K A Ponnusamy (Department of Agricultural Extension and Rural Sociology, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India)

Since the National Agricultural Research Project (NARP) was instituted in 1979, each state in India has been divided into a number of agroclimatic zones (ACZs). The ACZs provide the scope for developing location-specific technologies. However, even within each ACZ, crops are grown under a number of farming situations, which may differ in terms of micro-level variability in rainfall, soil type, sowing date, previous crop, source of irrigation, etc. Thus several farming situations may exist within a single ACZ, with different combinations of these factors. Wilson and Kareem (1991) have identified six farming situations in which postrainy-season groundnut is grown in Nalgonda district of Andhra Pradesh, based on previous crop (paddy and non-paddy) and source of irrigation (Table 1). However, there is currently only one generalized technology package available for postrainy-season groundnut. This raises a series of questions.

- Can a single package of technologies or practices be relevant for all farming situations within an ACZ?
- Do we need to have as many technology packages as there are farming situations?
- Can we afford to have as many research programs as the number of farming situations?
- If not, do we leave the responsibility of refining the technologies to extension staff, researchers, and farmers?

Technology packages for specific farming situations. Under the existing financial and human resource constraints, on-station research cannot be expected to serve all the farming situations within each ACZ. The alternative is to resynthesize the available technology options to meet situation-specific requirements. This in turn depends on feedback from farmers and extension staff about the suitability of individual technology components under specific farming situations, indigenous knowledge, and specific production problems encountered in the concerned farming situation (Theodore et al. in press). Based on this information the original package of practices can be fine-tuned after joint evaluation by extension staff, researchers, and farmers from each farming situation. Such fine-tuned technology options for six different farming situations for postrainy-season groundnut in Nalgonda district are presented in Table 2. The revised technology options should be continuously updated on the basis of future field experience. This process will help to evolve location-specific groundnut technologies with farmer participation.

Table 1. Postrainy-season groundnut area under different farming situations (classified by previous crop and method of irrigation) in Nalgonda district, Andhra Pradesh.

Previous crop/Method of irrigation	Area (ha)
Paddy/Well irrigation	15 000
Paddy/Canal irrigation	5 000
Non-paddy/Well irrigation	10 000
Non-paddy/Canal irrigation	12 500
Non-paddy/Tank irrigation	5 000
Non-paddy/Residual moisture	2 500
Total	50 000

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Table 2. Specific technology packages for different farming situations of postrainy-season groundnut, Nalgonda district, Andhra Pradesh, 1991/92.

Technology component	Technology options for different farming situations[1]					
	1	2	3	4	5	6
Land preparation	Raised beds	Flat beds	Raised beds	Flat beds	Flat beds	Deep plowing
Variety	JL 24	TMV 2	JL 24	JL 24	TMV 2	TMV 2
Sowing time	Dec	Dec	Oct	Oct	Oct	Sep
Seed rate (pods, kg ha^{-1})	230	170	230	230	170	150
Row spacing (cm)	20	25	20	25	25	30
Seed treatment (Dithane M-45, g kg^{-1})	3	3	3	3	3	3
Weed control	Butachlor (2 L ha^{-1})	Butachlor (2 L ha^{-1})	Butachlor (2 L ha^{-1})	Butachlor (2 L ha^{-1})	Butachlor (2 L ha^{-1})	Manual weeding
Fertilizer (kg ha^{-1})						
– P_2O_5	60	50	60	50	50	40
– K_2O	40	40	40	40	40	–
– N	20	20	20	20	20	–
– $ZnSO_4$	5	5	5	5	5	–
Gypsum (kg ha^{-1})	250	250	250	250	250	125
Pest/disease control						
– Leaf webber, aphids (Follidol dust, kg ha^{-1})	20	20	20	20	20	20
– *Helicoverpa, Spodoptera* (Monocrotofos, L ha^{-1})	0.75	0.75	0.75	0.75	0.75	–
– Leaf spot (Dithane M-45 + Bavistin, kg ha^{-1})	–	–	2 + 0.5	2 + 0.5	2 + 0.5	–

1. Farming situations 1 to 6 are described in Table 1

Yield, Water-Use Efficiency, and Moisture Extraction Pattern of Summer Groundnut Under Different Irrigation Schedules, Row Spacings, and Seed Rates

J B Patel[1] **and I S Patel**[2] (1. Department of Agronomy, B A College of Agriculture, Gujarat Agricultural University, Anand 388 110, Gujarat, India. 2. Regional Research Station, Gujarat Agricultural University, Sardar Krushinagar 385 506, Gujarat, India)

A field experiment was conducted during the 1992 summer season at Sardar Krushinagar (northern Gujarat), to study the yield, water-use efficiency, and moisture extraction pattern of groundnut cultivar GG 2 as influenced by irrigation, row spacing, and seed rate. Irrigation schedules were based on IW/CPE ratio, i.e., the ratio of irrigation water (IW) to cumulative pan evaporation (CPE).

Three irrigation schedules (IW/CPE ratios of 0.8, 1.0, and 1.2) with 50 mm water were the main plots; and three levels each of row spacing (15, 22.5, and 30 cm) and seed rate (100, 125, and 150 kg ha^{-1}, equivalent to populations of 228 000, 285 774, and 351 733 plants ha^{-1}) were the subplots. A split plot design was used with four replications. The soil was loamy sand in texture, well drained and with low moisture retention capacity (field capacity 9%, permanent wilting point 2.7%, bulk density 1.58 g cm^{-3}). The crop was sown on 16 Feb and harvested on 6 Jun 1992. All treatments received 25 kg N and 50 kg P_2O_5 ha^{-1}. Irrigation was applied at IW/CPE ratios of 0.8, 1.0, and 1.2, corresponding to CPE values of 62.5, 50.0, and 41.7 mm. A total of 12, 14, and 16 irrigations were given, including two irrigations that were common to all treatments—one immediately after sowing (50 mm) and another 7 days after sowing (40 mm) to facilitate germination. Soil moisture observations were recorded from sowing to harvest as suggested by Dastane (1972).

Effect of irrigation. Irrigation at IW/CPE ratios of 1.0 and 1.2 gave significantly higher pod yields than irrigation at 0.8 IW/CPE (Table 1). The highest haulm yield was obtained at 1.2 IW/CPE ratio, but haulm yields between two successive ratios were not significantly different. The consumptive use (Cu) of water increased with an increase in IW/CPE ratio, probably due to increased water availability in the root zone at high ratios. The soil and irrigation water-use efficiencies decreased with an increase in IW/CPE ratio. The low water-use efficiency at 1.2 IW/CPE was partly due to increased vegetative growth. Similar results were reported by Katre et al. (1989). At 1.0 and 1.2 IW/CPE ratios the percentage of soil moisture extracted from the surface layers (0–30 and 30–60 cm soil depth) was higher than at 0.8 IW/CPE. However, the percentage of moisture extracted from deeper layers (60–90 cm) was higher at 0.8 IW/CPE, probably because frequent irrigations increased soil moisture availability in the surface layers. At 0.8 IW/CPE ratio, the dry condition of the surface soil (0–30 cm) may have resulted in roots going to deeper layers to meet water requirements. These results are in accordance with the findings of Ramchandrappa and Kulkarni (1992).

Effect of row spacing. Pod yields at row spacings of 15 and 22.5 cm were significantly higher than at 30 cm row spacing (Table 1). Haulm yield was not affected significantly by spacing. These results corroborate the findings of Nijhawan (1963). The Cu of water increased with an increase in row spacing, and was highest at 30 cm spacing. Soil and irrigation water-use efficiencies were highest at 22.5 cm. This indicates that a row spacing of 22.5 cm is optimal for the interception of solar energy and for efficient use of water for pod production.

Table 1. Yield, water-use efficiency, and moisture extraction pattern of groundnut under different irrigation schedules, row spacings, and seed rates.

Treatment	Pod yield (t ha^{-1})	Haulm yield (t ha^{-1})	Cu of water[1] (mm)	Water-use efficiency (kg ha^{-1} per mm)		Moisture extraction pattern (%) at different soil depths		
				Soil	Irrigation	0–30 cm	30–60 cm	60–90 cm
Irrigation (IW/CPE ratio)								
I_1 = 0.8	2.08	4.08	476.86 (590)	4.37	3.53	42.79	36.99	20.22
I_2 = 1.0	2.28	4.27	538.21 (690)	4.24	3.31	45.55	37.11	17.34
I_3 = 1.2	2.32	4.48	600.04 (790)	3.87	2.94	45.68	37.25	17.07
LSD (P = 0.05)	0.142	0.229						
Row spacings (cm)								
S_1 = 15.0	2.29	4.36	515.10	4.44	3.31	44.43	36.86	18.71
S_2 = 22.5	2.37	4.25	531.72	4.45	3.43	44.71	37.12	18.17
S_3 = 30.0	2.03	4.11	568.59	3.58	2.95	44.88	37.36	17.76
LSD (P = 0.05)	0.097	ns						
Seed rates (kg ha^{-1})								
R_1 = 100	2.10	4.16	578.81	3.63	3.04	45.16	35.88	18.96
R_2 = 125	2.27	4.24	540.36	4.20	3.29	44.58	37.20	18.22
R_3 = 150	2.31	4.42	495.94	4.66	3.35	44.29	38.26	17.25
LSD (P = 0.05)	0.097	0.130						

1. Cu = consumptive use. Figures in parentheses indicate the total amount of water applied.

Effect of seed rate. Pod yield increased with an increase in seed rate, although the increase between seed rates of 125 and 150 kg ha^{-1} was not significant (Table 1). Haulm yield was highest at a seed rate of 150 kg ha^{-1}. The increase in pod and haulm yields at high seed rates was mainly because of high plant populations. These results are similar to those of Gutstein (1975). The Cu of water decreased with an increase in seed rate, and was highest at 100 kg ha^{-1}. At low seed rates (100 kg ha^{-1}), high evaporation rates may have resulted in high Cu of water. Soil and irrigation water-use efficiencies decreased with an increase in seed rate. More soil moisture was extracted from the 60–90 cm layer at a seed rate of 150 kg ha^{-1}.

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Effect of Irrigation, Interrow Spacing, and Seed Rate on Quality and Economics of Summer Groundnut

J B Patel[1] and **I S Patel**[2] (1. Department of Agronomy, B A College of Agriculture, Anand 388 110, Gujarat, India. 2. Regional Research Station, Gujarat Agricultural University, Sardar Krushinagar 385 506, Gujarat, India)

A field experiment was conducted at Sardar Krushinagar (northern Gujarat) during the 1992 summer season to study the effect of irrigation, interrow spacing, and seed rate on the quality and economics of GG 2 bunch groundnut. Irrigation schedules were based on the ratio of irrigation water (IW) to cumulative pan evaporation (CPE). The soil of the experimental site was loamy sand in texture, with available nitrogen 149 kg ha^{-1}, P_2O_5 47 kg ha^{-1}, K_2O 289 kg ha^{-1}, and pH 7.9. Three irrigation schedules (IW/CPE ratios of 0.8, 1.0, and 1.2) were the main plots, and three levels each of interrow spacing (15, 22.5, and 30 cm) and seed rate (100, 125, and 150 kg ha^{-1}) were the subplots. Details of materials and methods are given in 'Yield, water-use efficiency, and moisture extraction pattern of summer groundnut...' earlier in this Newsletter.

Data on pod and haulm yields are presented and discussed in the previous article in this Newsletter. Data on shelling percentage, seed oil content, oil yield, and economics are presented in Table 1.

Effect of IW/CPE ratio. Shelling percentages at IW/CPE ratios of 1.0 and 1.2 were significantly higher than at 0.8 IW/CPE ratio. Seed oil content did not differ among treatments. However, oil yield increased with an increase in IW/CPE ratio, because of higher yields and shelling percentages. The net incremental cost benefit ratio was highest (1:4.70) at IW/CPE ratio of 1.0. For example, irrigating the crop at IW/CPE 1.2 increased profits by Rs 69 ha^{-1} (1 US$ = Rs 32) over the 1.0 ratio, but this was more than offset by the additional cost of Rs 360 ha^{-1}.

Effect of spacing. Interrow spacing had no significant effect on shelling percentage or seed oil content. However, oil yield was significantly higher at closer spacings (15 and 22.5 cm) than at 30 cm interrow spacing. Net realization was highest at a spacing of 22.5 cm.

Table 1. Quality and economics of groundnut variety GG 2 as influenced by irrigation schedule, interrow spacing, and seed rate, Sardar Krushinagar, Gujarat, summer 1992.

Treatment	Shelling percentage	Oil content (%)	Oil yield (kg ha^{-1})	Net realization (Rs ha^{-1})	Net ICBR[1]
Irrigation (IW/CPE ratio)					
$I_1 = 0.8$	68.05	48.82	692	13 724	
$I_2 = 1.0$	70.03	48.89	781	15 416	1:4.70
$I_3 = 1.2$	70.47	48.87	799	15 485	1:2.45
LSD (P = 0.05)	1.97	ns	53		
Interrow spacing (cm)					
$S_1 = 15.0$	69.50	48.85	776	15 473	
$S_2 = 22.5$	69.44	48.89	803	16 241	
$S_3 = 30.0$	69.61	48.83	691	12 911	
LSD (P = 0.05)	ns	ns	34		
Seed rate (kg ha^{-1})					
$R_1 = 100$	69.43	48.85	712	14 084	
$R_2 = 125$	69.61	48.88	773	15 300	1:2.38
$R_3 = 150$	69.51	48.84	785	15 240	1:1.13
LSD (P = 0.05)	ns	ns	34		

1. Incremental cost:benefit ratio

Effect of seed rate. Shelling percentage and seed oil content were not influenced by seed rate. Oil yield increased with an increase in seed rate (because pod yields were higher at high seed rates), but the increase between seed rates of 125 and 150 kg ha^{-1} was not significant. Net realization and net incremental cost benefit ratio (1:2.38) were highest at the seed rate of 125 kg ha^{-1}.

Conclusions. The data thus indicate that for bunch groundnut GG 2 grown in the northern Gujarat agroclimatic zone, yield, quality, and profits can be maximized by scheduling irrigation at an IW/CPE ratio of 1.0 with 50 mm depth of water, and by using an interrow spacing of 22.5 cm and a seed rate of 125 kg ha^{-1}. Crop management did not affect the percentage oil content in seeds. Total oil production was directly proportional to seed yield.

Effect of 'Green Gold Plus' Application on Groundnut Yield

K N Singh[1] and S K Pal[2] (1. Product Development Department, Khatau Junker Limited, Khatau House, Moghul Lane, Mahim 400 016, Bombay, India.
2. ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India)

Plant growth regulators are known to influence physiological processes in crop plants, and their positive impact has been reported in chickpea, soybean, sorghum, wheat, and many other field crops. This study was conducted during the 1992/93 postrainy season at ICRISAT Asia Center to determine the effect of 'Green Gold Plus' (GGP), an amino acid-based plant growth regulator, on growth and yield of groundnut. The composition of GGP (g L^{-1}) is as follows: free amino acid (total) 119, natural amino acid (total) 153, organic matter 189, total nitrogen 27, copper 2.5, manganese 10.0, magnesium 5.0, iron 2.6, zinc 28.0, boron 0.25.

The experiment was laid out in a randomized block design with three replications. Plot size was 3 × 1.5 m,

Table 1. Effect of Green Gold Plus, an amino acid based plant growth regulator, on groundnut yield in Alfisols, ICRISAT Asia Center, 1992/93 postrainy season.

Treatment	Yield (t ha^{-1}) Pod	Haulm	Seed
Green Gold Plus	3.06	3.83	1.91
Control	2.43	3.10	1.47
CV (%)	3.7	4.7	6.0
SE	±0.059	±0.095	±0.006
Increase over control (%)	26	24	35

sown on a 1.5 m wide broadbed-and-furrow (BBF) system. Each BBF contained four rows; rows were spaced at 30 cm and plants within a row at 10 cm. Foliar sprays of GGP were applied twice during the season, at 60 days and 75 days after crop emergence (DAE), using the recommended dose of 2.5 mL GGP L^{-1} water. In control plots, only water was sprayed up to drenching point. Standard agronomic practices were followed to raise a healthy crop.

The application of GGP contributed to an increase in the chlorophyll content of leaves; GGP-treated plants looked healthy and lush green one week after spraying, and growth was more uniform than in control plots. Differences in haulm, pod, and seed yields were quite distinct and consistent over replications (Table 1). Pod yield was 3.06 t ha^{-1} in sprayed plots and 2.43 t ha^{-1} in control treatments, reflecting a 26% increase as a result of two applications of GGP.

The manufacturer claims that GGP is non-toxic and safe for the operator. It is compatible with insecticides and fungicides recommended for the control of groundnut pests. Small samples for field research can be obtained from Khatau Junker Ltd, Bombay.

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Effects of Crop Residue Burning and Calcium Supply on the Growth of Groundnut Cultivars in a Sandy Clay Soil in Congo

Y M Djondo and **G R Mandimba**
(Laboratoire de Biotechnologie, Institut de Développement Rural, Km 17, Université, BP 13346, Brazzaville, Congo)

Groundnut production in the Congo is based on 'Swidden cultivation' (Atal 1974), which involves the burning of all crop residues. This experiment was conducted at the Institut de développement rural in Kombé-Brazzaville (4°20'S, 15°20'E, altitude 295 m). The objectives were to investigate the effects of burning and calcium supply on growth, nodulation, and yield of three groundnut cultivars in symbiosis with native cowpea *Bradyrhizobia.*

The experiment was conducted on a ferralitic sandy-clay soil containing 64% sand and 26% clay, in a field that had received no fertilizer for 2 years. The upper soil layer was deficient in organic matter (1.4% w/w) and acidic (pH 4.7). Rainfall during the 12-week growing period was 404 mm. Three groundnut cultivars—Talon-Dame (TD, a spanish variety), 73-30 (spanish), and Mixed Red of Loudima (MRL, valencia) were tested. Seed was obtained from Dr Mavoungou Nzaou's collection of the Centre de recherches agronomiques de Loudima in southern Congo.

A split-plot design with four replications was used. There were four treatments—burned and non-burned, calcium-treated and no calcium—of which the non-burned, no-calcium treatment was used as a control. Each plot was 6.4 m^2 in size. On burned plots, all crop residues were burned as outlined by El Moursi (1987) and NeSmith et al. (1987). In the calcium treatments, the recommended level (2 t ha^{-1}) of agricultural limestone containing 52.6% CaO was added to the top 15 cm soil layer before sowing. It was expected that this addition would increase soil pH from 4.7 to 5.6. Seeds were sown manually, 3–5 cm deep, on 19 Oct 1986. Spacing was 30 × 20 cm, equivalent to 160 000 plants ha^{-1}.

Five plants from each replicated treatment were randomly selected at full bloom, placed in plastic bags, taken to the laboratory, and separated into tops, roots, and nodules. Nodule number and mass per plant, biomass of plant top per plant, and percentage nitrogen content in nodules and plant tops were measured. For plant tops and nodules, biomass was determined by the method outlined by Faizah Abdul (1980) and van Beusichem (1981), while nitrogen content was determined by the Kjeldahl method.

Table 1. Nodulation parameters, nitrogen content, plant top mass, yield and yield components, and protein and crude fat content in three groundnut genotypes (averaged across treatments), Brazzaville, Congo, 1986.

Cultivar	At flowering					At harvest				
	Nodule number plant-1	Nodule mass (mg plant-1)	Nitrogen content in nodule (%)	Nitrogen content in plant top (%)	Plant top mass (g plant-1)	Pod yield (t ha-1)	Seed yield (t ha-1)	Shelling (%)	Seed protein (%)	Seed crude fat (%)
Mixed Red of Loudima (valencia)	195ab	189.9a	1.81a	2.19a	18.5a	2.66a	1.97a	73.5a	29.9a	45.1a
Talon-Dame (spanish)	252a	188.9a	1.82a	2.18a	17.0a	2.16b	1.58b	73.1a	27.8a	45.0a
73-30 (spanish)	138b	95.0b	1.81a	2.17a	13.3b	2.04b	1.47c	71.5a	28.0a	46.1b

Numbers in a column followed by the same letter are not significantly different at P = 0.05

Table 2. Nodulation parameters, nitrogen content, plant top mass, yield and yield components, and protein and crude fat content in four treatments (averaged across three groundnut genotypes), Brazzaville, Congo, 1986.

Treatment[1]	At flowering					At harvest				
	Nodule number plant-1	Nodule mass (mg plant-1)	Nitrogen content in nodule (%)	Nitrogen content in plant top (%)	Plant top mass (g plant-1)	Pod yield (t ha-1)	Seed yield (t ha-1)	Shelling (%)	Seed protein (%)	Seed crude fat (%)
BoCo	142a	127.7a	1.81a	2.11a	11.9a	1.87a	1.31a	69.1a	28.4a	47.7a
BoCi	187a	131.4a	1.81a	2.17b	14.0a	1.81a	1.34a	74.0b	28.1a	46.9b
BiCo	207b	172.2b	1.82a	2.22c	18.4b	2.72b	2.01b	73.9b	29.2a	45.5c
BiCi	244b	216.3b	1.82a	2.24d	20.7b	2.75b	2.03b	73.8b	28.5a	44.3d

1. Bo = burned, Bi = non-burned, Ci = treated with calcium, Co = no calcium.
Numbers in a column followed by the same letter are not significantly different at P = 0.05.

The crop matured 90 days after sowing. Plants were harvested, and pod and seed yields measured from the middle three rows of each plot (seeds were dried and adjusted to 14.4% moisture content for seed yield estimations). Nitrogen content was determined by the Kjeldahl method, and crude fat by the Soxhlet process. Experimental data were analyzed using ANOVA and mean differences determined by orthogonal comparisons.

Ten days after sowing, seedling emergence was high (82.4–83.4%) in all cultivars and treatments, due to adequate rainfall. At full bloom, nodulation was abundant, but with differences among different varieties and treatments (Tables 1 and 2). Irrespective of calcium application, burning appeared to increase nodule number and nodule mass per plant (Table 2).

Burning also increased biomass production and nitrogen content in plant tops, but had no effect on nitrogen concentration in nodules (Table 2). The results show that burning did not prevent the establishment of a wide population of native cowpea *Bradyrhizobia* which are normally abundant in tropical soils, and would presumably initiate nodulation at an early stage of plant growth.

Positive correlations were found between nodule mass and nodule number (r = 0.83), plant biomass production and nodule mass (r = 0.92), and plant top nitrogen and nodule mass (r = 0.71). These observations confirm that nitrogen in plant parts is a good indication of the nitrogen fixation potential of groundnut under field conditions.

Interactions between cultivars and treatments were nonsignificant (1% level) for most of the parameters measured, except for nitrogen content in plant top and crude fat content in seed. Interactions between burning and liming were also nonsignificant, except for nitrogen content in plant top, shelling percentage, and crude fat content in seed.

Table 2 shows that varietal differences (averaged across different treatments for each cultivar) in pod and seed yields can be explained in terms of burning effects. Burning significantly ($P<0.01$) increased yields, by approximately 52%. According to Stromgaard (1991), this increase is related to an increase in mineral concentrations as a result of burning. Liming had no effect on crops (Table 2). This could be explained by an increase in pH as a result of burning (Stromgaard 1991).

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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 semi-arid tropics. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

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Editor

S N Nigam

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

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