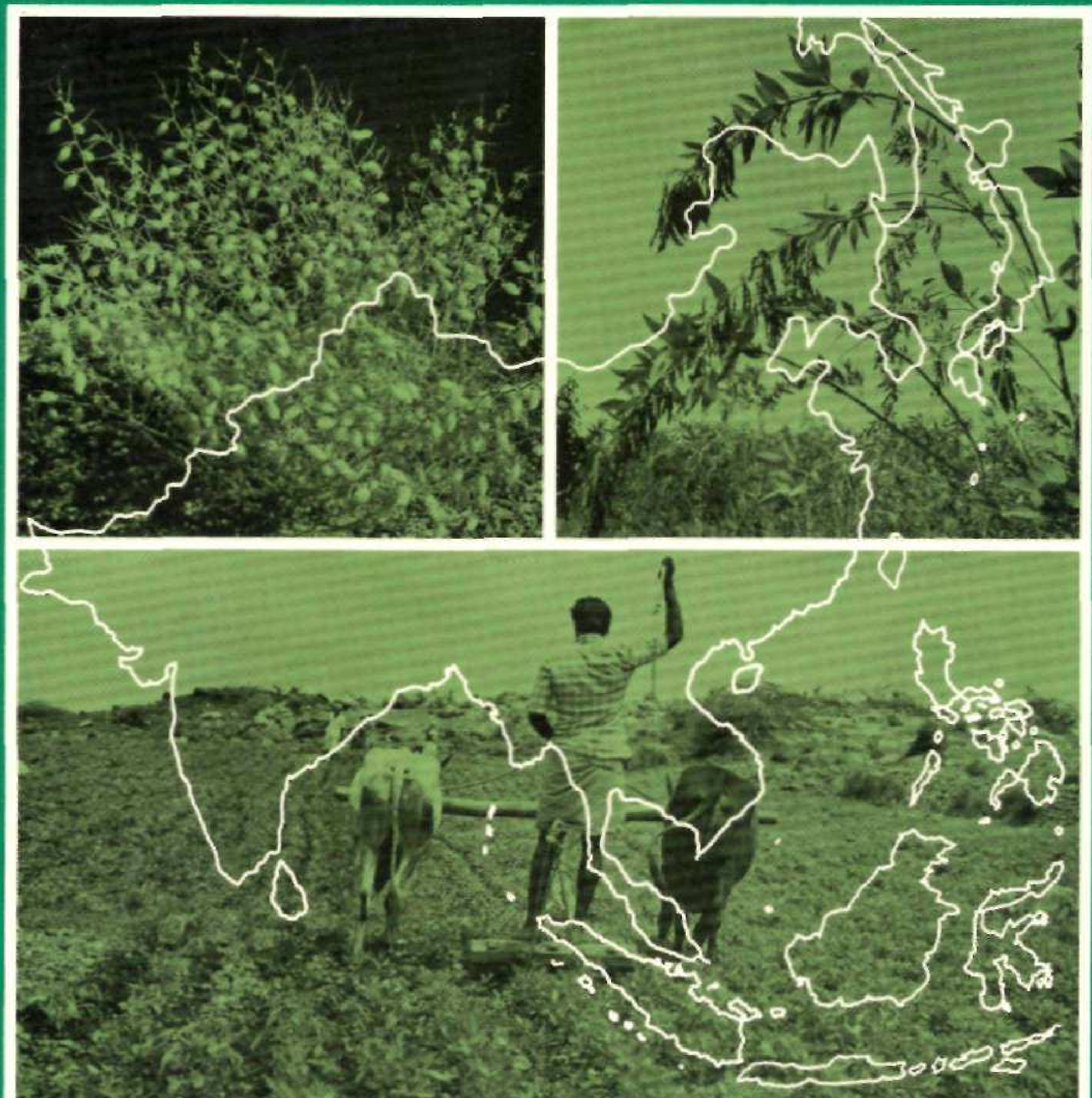
# Coordination of Grain Legumes Research in Asia



International Crops Research Institute for the Semi-Arid Tropics

The Review and Planning Meeting for Asian Regional Research on Grain Legumes, 16-18 December 1985, summarized in this publication, was sponsored by the:
Australian Development Assistance Bureau (ADAB);
Australian Centre for International Agricultural Research (ACIAR);
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); and
International Rice Research Institute (IRRI).

The International Crops Research Institute for the Semi-Arid Tropics is a nonprofit scientific educational institute receiving support from donors through the Consultative Group on International Agricultural Research. Donors to ICRISAT include governments and agencies of Australia, Belgium, Canada, Federal Republic of Germany, Finland, France, India, Italy, Japan, Netherlands, Norway, People's Republic of China, Sweden, Switzerland, United Kingdom, United States of America, and the following international and private organizations: Arab Bank for Economic Development in Africa, Asian Development Bank, Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), Global 2000 Inc., International Development Research Centre, International Fertilizer Development Center, International Fund for Agricultural Development, The European Economic Community, The Ford Foundation, The Leverhulme Trust, The Opec Fund for International Development, The Population Council, The World Bank, United Nations Development Programme, and the University of Hohenheim. Information and conclusions in this publication do not necessarily reflect the position of the aforementioned governments, agencies, and international and private organizations.



**Correct citation:** ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1987. Coordination of grain legumes research in Asia. Summary proceedings of the Review and Planning Meeting for Asian Regional Research on Grain Legumes (Groundnut, Chickpea, and Pigeonpea), 16-18 December 1985, ICRISAT Center, India. Patancheru, A.P. 502 324, India: ICRISAT.

# Coordination of Grain Legumes Research in Asia

## Summary Proceedings of the Review and Planning Meeting for Asian Regional Research on Grain Legumes (Groundnut, Chickpea, and Pigeonpea)

16-18 December 1985
ICRISAT Center, India

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

1987

**Meeting Objectives:**

To assess the progress made since the 1983 Consultative Group Meeting.
To develop plans for future cooperation, including testing of genotypes of groundnut, pigeonpea, and chickpea.
To identify cooperative links between ACIAR, ICRISAT, IRRI, and other organizations concerned with legume research in the region, and propose projects for adoption and funding.

**Organizing Committee:**

Y.L. Nene, Chairman
D.G. Faris, Member
R.W. Gibbons, Member
D. McDonald, Member
W. Reed, Member
H.A. van Rheenan, Member
J.B. Wills, Member
P.R. Murthy, Secretary

**Editorial Subcommittee:**

J.B. Wills, Convenor
D.G. Faris, Member
R.W. Gibbons, Member
Y.L, Nene, Member
W. Reed, Member

**The Proceedings: Explanatory Note**

During the meeting, many participants made helpful suggestions for collaborative activities within the region. These were noted and are also recorded in the full texts of contributed papers lodged with the Coordinator of the Asian Grain Legumes Network at ICRISAT Center. Agreed priorities for action in collaborative work in the future have been outlined in the Recommendations. The latin binomials for the three principal grain legumes in these proceedings are as follows. Groundnut: *Archis hypogaea* L. Chickpea: *Cicer arietinum* L. Pigeonpea: *Cajanus cajan* (L.) Millsp.

# Contents



## *Summaries of Papers Presented*

# Acronyms

| | |
|---|---|
| ACIAR | Australian Centre for International Agricultural Research |
| ADAB | Australian Development Assistance Bureau |
| ADB | Asian Development Bank |
| AICORPO | All India Coordinated Research Project on Oilseeds |
| AICPIP | All India Coordinated Pulses Improvement Project |
| ARPP | Agricultural Research and Production Project |
| AVRDC | Asian Vegetable Research and Development Center |
| BARD | Barani Agricultural Research and Development Project (Pakistan) |
| BARI | Bangladesh Agricultural Research Institute |
| BAU | Bangladesh Agricultural University |
| BINA | Bangladesh Institute of Nuclear Agriculture |
| BIOTROP | Southeast Asia Regional Center for Tropical Biology (Indonesia) |
| BNF | biological nitrogen fixation |
| CGIAR | Consultative Group on International Agricultural Research |
| CGPRT | Coarse Grains, Pulses, Roots and Tubers |
| CIDA | Canadian International Development Agency |
| CIMMYT | Centro Internacional de Mejoramiento de Maiz y Trigo |
| CRIFC | Central Research Institute for Food Crops (Indonesia) |
| CMMV | cowpea mild mottle virus |
| DOA | Department of Agriculture (Thailand) |
| ESCAP | Economic and Social Commission for Asia and the Pacific |
| FAO | Food and Agriculture Organization of the United Nations |
| IAEA | International Atomic Energy Agency |
| IBPGR | International Board for Plant Genetic Resources |
| ICARDA | International Center for Agricultural Research in the Dry Areas |
| ICGS | ICRISAT Groundnut Selection |
| ICP | Integrated Cereals Project (Nepal) |
| ICRISAT | International Crops Research Institute for the Semi-Arid Tropics |
| IDRC | International Development Research Centre (Canada) |
| IGEMCT | International Groundnut Extra-early-maturing Cultivar Trial |
| IITA | International Institute for Tropical Agriculture (Nigeria) |
| IPB | Institute of Plant Breeding (The Philippines) |
| IPM | integrated pest management |
| IRRI | International Rice Research Institute |
| KKU | Khon Kaen University (Thailand) |
| KU | Kasetsart University (Thailand) |
| NARC | National Agricultural Research Centre (Pakistan) |
| NCSU | North Carolina State University (USA) |
| NifTAL | Nitrogen-fixation by Tropical Agricultural Legumes |
| ODA | Overseas Development Administration (UK) |
| OFRD | On-farm Research Division (Bangladesh) |
| PMV | peanut mottle virus |

| | |
|---|---|
| Peanut CRSP | Peanut Collaborative Research Support Project (USA) |
| PStV | peanut stripe virus |
| QDPI | Queensland Department of Primary Industry |
| TCDC | Technical Cooperation among Developing Countries |
| TDRI | Tropical Development and Research Institute (UK) |
| TSWV | tomato spotted wilt virus |
| UNDP | United Nations Development Programme |
| UPLB | University of the Philippines at Los Banos |
| USAID | U.S. Agency for International Development |
| VAM | vesicular-arbuscular mycorrhizae |
| YSV | yellow spot virus |

# Recommendations

## Preamble

These recommendations arise from plenary discussion of presented papers that described national and regional progress in the research and development of groundnut, chickpea, and pigeonpea, outlined research needs, and proposed new emphases in the coordination of research within South and Southeast Asia. They are based on the two stated objectives of the meeting, namely

1. to assess progress in research since the 1983 Consultative Group Meeting for Asian Grain Legumes; and
2. to develop plans for future cooperation.

An additional objective, included at the request of ADAB, was

3. to identify cooperative links between ACIAR, ICRISAT, IRRI, and other organizations concerned with legume research in the region, and propose projects for adoption and funding.

The recommendations take the form of a general plan of action and a list of specific activities to be undertaken under the guidance of the Coordinator of the Asian Grain Legumes Network, appointed by ICRISAT on 1 January 1986.

## General Plan

Since 1972, ICRISAT has carried out intensive plant breeding and related research into the improvement of the legume crops chickpea and pigeonpea, and of groundnut since 1976. It has built up a large collection of germplasm and breeding material, and its staff have developed research expertise in these crops derived from studies in many countries in the semi-arid tropics. ICRISAT will make this material and expertise available to the Network in the best possible way, within the constraints of its resources. The expertise relating to these crops that ICRISAT has to offer includes breeding and cytogenetics, pathology, virology, entomology, physiology, microbiology, farming systems, economics, food quality, agrometeorology, and training.

ICRISAT will provide administrative support for the Coordinator at ICRISAT, and travel funds so that the Coordinator and ICRISAT scientists may visit countries in the region to monitor research progress, act as consultants, make surveys, and collect germplasm. ICRISAT will also sponsor a limited number of workshops or other specialist meetings, and support training at ICRISAT of appropriate national staff in the region.

Steps will be taken to develop close working relationships with a research working group in each country, in order to develop a plan of work for ICRISAT's involvement in national research on each of the three crops. Such plans will include the identification of the role ICRISAT can usefully play, including the arranging of visits by scientists from ICRISAT, assistance in planning trials, and the supply of appropriate germplasm and breeding material.

The degree of ICRISAT's participation in national research on each crop will naturally vary greatly among countries, depending on national priorities and research policies, and on collaboration with donors and international agencies. The type of research and the nature of ICRISAT's involvement appropriate to the three crops in each country will also be influenced by how well each crop is established, either as a traditional crop with known marketing outlets, or as a "new" nontraditional crop that requires concurrent marketing, consumption, and crop improvement research.

A central feature of the plan will be to ensure direct personal contact between ICRISAT scientists and the concerned scientists in each country. These will include monitoring tours for observing material growing in the field and assessing production and research problems on the spot.

## Specific Recommendations

1. Identify and utilize possible operational links between such organizations as ICRISAT, ACIAR, IRRI, Peanut CRSP, and FAO, in order to integrate research efforts and reduce duplication as much as possible.
2. Continue to conduct surveys of growing crops to determine the importance of disease incidence and insect pest attack, to obtain data on the basis of which recommendations can be made concerning the breeding of resistant cultivars and/or the implementation of control measures.
3. Make tours to collect and preserve germplasm before landraces become lost as a result of the introduction of new cultivars. Make arrangements to conserve the collected material at ICRISAT Center and in its country of origin.
4. Plan multilocation trials under collaborative guidance from ICRISAT and ACIAR to generate information about genotype and environment ($g \times e$) interactions. The resulting data will be made available within the region, and are expected to be of particular value to plant breeders.
5. Undertake socioeconomic research on nontraditional crops within selected countries, to determine their present and future marketing potential and identify possible ways of utilizing them, e.g., as new food products after appropriate processing, as a vegetable, or as animal feed. Such research might involve the Resource Management Program and the Biochemistry Unit in ICRISAT, ACIAR, TDRI, Peanut CRSP, and national agricultural research organizations.
6. Explore the possibility of developing joint special projects between national programs and ICRISAT, to constitute the research needed to support the improvement of the three legume crops. Such projects might involve research in laboratories located outside the region.
7. Identify the training needs of research personnel in the countries of the region and select appropriate people for training in special courses at ICRISAT. Such training might include instruction in the use of equipment or in screening procedures, or it might take the form of participation in an in-service fellowship course, or taking advanced degrees in cooperating universities.
8. Supplement the agrometeorological data on countries in the region that are already

available within ICRISAT, to identify agroecological zones in Asia based on ICRISAT criteria, and thus to facilitate the transfer of plant material and improved technology. This work will include testing the groundnut simulation model "Peanutgrow," running special training courses in the use of agrometeorological models, and supporting the multilocational trials and g x e analyses mentioned in recommendation 4.

# Keynote Address

# Research Needs for Groundnut, Chickpea, and Pigeonpea in South and Southeast Asia

**L.D. Swindale**

Director General, ICRISAT,

Patancheru, Andhra Pradesh 502 324, India

## Introduction

I extend a cordial welcome to all participants in this review and planning meeting for Asian Regional Research on Grain Legumes.

Thanks are due to ACIAR for suggesting this meeting to review progress in grain legume research that has taken place almost exactly 2 years since the Consultative Group Meeting for Asian Regional Research on Grain Legumes was held at ICRISAT to discuss the future direction of grain legume research in Asia, in conjunction with IRRI's Rice Farming Systems Program. Thanks are especially due to ADAB for asking ACIAR to organize this meeting and for providing the necessary funds.

ACIAR originally invited ICRISAT and IRRI to cosponsor this present meeting to examine the progress of research on groundnuts and pigeonpeas in Thailand, Indonesia, and India but, since then, they have generously expanded the meeting to include chickpea, which is not a crop in which they are directly interested, and to include countries where they presently have no contacts. As part of this review, ACIAR staff were anxious to have an in-depth discussion on methods of identifying and interpreting genotype x environmental interactions in grain legume trials. This has also been provided for in the program.

With these suggestions in mind, we have brought together scientists from Bangladesh, India, Indonesia, Nepal, Pakistan, the Philippines, and Thailand (invitations having also been sent to the People's Republic of China, Burma, and Sri Lanka). This program will allow you as part of this group to discuss the production and research being conducted on groundnut, chickpea, and pigeonpea in your country. We also have several workers from the ACIAR in Australia, from IRRI, and from other regional agencies such as IDRC, ODA, FAO, and ESCAP/CGPRT to take part in this meeting.

In this meeting, staff from ICRISAT, ACIAR, and IRRI will review research that has been done on groundnut, chickpea, and pigeonpea in the region in light of the recommendations made at the meeting 2 years ago, and will describe the present situation. The scientists from each country will then describe the work being done on these three crops in their country. You will then be invited to develop a future plan of work to coordinate the activities of the regional agencies and organizations, such as ACIAR, ICRISAT, IRRI, and Peanut CRSP, and integrate them with the research activities on groundnut, chickpea, and pigeonpea being conducted in your country and in other countries of the region.

In my address in Bangkok on the occasion of the 40 th Anniversary of FAO, I said that I believed that of all the FAO regions in the developing world, Asia and the Pacific region has gone the farthest in achieving Lester B. Pearson's vision of the FAO as "the first [international agency] which sets out with so bold an aim as that of helping nations to achieve freedom from want. Never before have the nations got together for such a purpose". It is my hope that this present meeting will carry forward the great tradition set by FAO in this region—for the action of the FAO in Asia and the Pacific region justifies the high hopes of the enlightened people who created the FAO of the United Nations in the dark days after World War II.

I also said that, although the overall success story in food-grain production in this region is plain for all to see, there is no room for complacency, for there still are areas of real concern. Indeed, greater efforts are needed, far in excess of what has been done so far—if poverty and malnutrition are to be banished from Asia. Population increases are still too large in the region, and standards of income are rising, creating increasing demands for higher-quality food.

In Asia and the Pacific region, production of cereals and grain legumes over the past 10 years has grown at the compound rate of about 3.9%, compared with 1.8% for the rest of the world, so that this region now produces 41% of these crops. More than 87% of the increases in this production comes from increases in productivity, as is appropriate for a region where little suitable unused arable land is now available.

Population increase in the region of 1.9% is still too great, however, for in Asia a 1.5% annual population increase adds over 30 million people per annum to the world's population. As population growth is generally greater in rural areas, it puts even more pressure upon the land and steadily reduces the size of agricultural holdings that are already less than 0.27 ha per person.

Cereals are the major source of food in Asia. Although pulses and groundnut production is only about 5% of the total cereal production, they too are very important because they provide an important supplementary source of protein to vast numbers of the region's population.

The fact that the growth in production of food grains and groundnuts has exceeded the regional population growth of 1.9% per annum is particularly noteworthy (Table 1). On the other hand the growth rate of pulses production at only 0.9% over the past 10 years has not kept pace with population growth. The fact that the growth rate of pulses production in the region for the years 1981-84 was 3.4% per annum gives some hope that this poor performance for pulses may be improving.

The potential for increased production of pulses clearly does exist. The problems lie in inadequate government attention to this category of crop, partly because pulses are grown largely under rainfed conditions.

The growth rate in groundnut production at around 4% per year looks promising, even though most of this crop is also grown under rainfed conditions. This indicates that, if enough interest and attention can be given to a crop, then its production and yield can be improved, even under rainfed conditions.

Table 1. Production, productivity and their average per annum growth rates for cereals, pulses, and groundnuts in 21 developing countries of Asia compared with the rest of the world (FAO, RAPA Monograph 1984/5).

| | Production | | | Yield | | |
|---|---|---|---|---|---|---|
| | | % Annual growth rate | | kg $ha^{-1}$ | % Annual growth rate | |
| | Tonnes | 1974-84 | 1981-84 | (1984) | 1974-84 | 1981-84 |
| Cereals | | | | | | |
| Asia[1] | 713550 | 4.0 | 6.5 | 2564 | 3.7 | 5.4 |
| Rest of the world | 1042492 | 1.8 | -0.7 | 2421 | 1.8 | 0.9 |
| Pulses | | | | | | |
| Asia | 21698 | 0.9 | 3.4 | 672 | 1.1 | 2.8 |
| Rest of the world | 25456 | 0.9 | 4.1 | 730 | -0.2 | 1.4 |
| Groundnut | | | | | | |
| Asia | 13703 | 4.0 | 3.9 | 1215 | 2.9 | 3.9 |
| Rest of the world | 6806 | -2.7 | -5.3 | 971 | -0.8 | -2.9 |

1. Countries: Bangladesh, Bhutan, Burma, People's Republic of China, Kampuchea, Korea, India, Indonesia, Laos, Malaysia, Maldives, Mongolia, Nepal, Pakistan, Papua New Guinea, the Philippines, Sri Lanka, Thailand, Tonga, Vanuatu, and Vietnam.

## Production Systems

A recent publication by IRRI has proposed eight main agroecological zones in Asia. For the purposes of grain legumes and groundnut, we are interested in three of these: irrigated wetlands with one rice crop, rainfed wetlands, and rainfed drylands (Table 2).

Table 2. Estimates of crop yields (kg $ha^{-1}$) in three agroecological zones of South and Southeastern Asia.

| Crop | Irrigated wetlands: one rice crop | Rainfed wetlands[1] | Rainfed drylands[2] |
|---|---|---|---|
| Rice | 3000 | 1800 | 1000 |
| Maize | | 1500 | 1300 |
| Wheat | 2000 | 1500 | 1000 |
| Sorghum | | - | 700 |
| Sweet potato | | - | 2000 |
| Pulses | | 700 | 600 |
| Groundnut | 1200 | 800 | 700 |

1. Data from IRRI, 1981. 2. Data from CIMMYT, 1980.

In the **irrigated wetlands,** rice is the principal crop as is to be expected. Although more than one crop of rice may be taken, it also can be followed by other crops such as cereals, pulses, and groundnut. Yield of groundnut in this system average over 1 t $ha^{-1}$.

In the **rainfed wetlands,** rice is again the predominant crop. But, more frequently than in irrigated lands, rice will be followed by other cereals, pulses, or groundnut. Where the second crop is not irrigated, 0.5-1.0 t $ha^{-1}$ of pulses or groundnut may be obtained.

In contrast, in the **rainfed drylands** many crop combinations are used. Some are based on rice as the first crop, and others on maize, sorghum, or wheat. Rice may be followed by maize, or wheat by pulses or by groundnut. The dryland cereals may be followed by rice, sweet potatoes, or groundnut. Where pulses are taken after the cereals, yields of 0.25-1.0 t $ha^{-1}$ are obtained and, where groundnut is taken, yields of 0.5-1.0 t $ha^{-1}$ are common. The best benefit-cost ratios are generally obtained with those cropping systems that include groundnut, as is the case in the rainfed wetlands.

Improvements in efficiency and productivity are required in all the agroecological zones to keep food production ahead of the inexorable march of population, with sufficient excess to provide for an improved standard of living, particularly for the poorest people.

Increasing the area and efficiency in the use of irrigated, well-fertilized land is needed to increase food production. But even optimistic projections suggest that, by the year 2000, only about 70% of food needs for the region can be met by these means. And it is worth noting that FAO statistics show that, in the 10-year period 1972-82, the percentage of arable and permanent cropland irrigated in the developing countries of the region increased by only 4%. The projections would increase this percentage by more than 1% per year for the next 18 years. And costs of irrigating land and the likelihood of serious damage to the environment will both increase substantially.

## Rainfed Agriculture

Greater efforts are clearly needed to improve rainfed agriculture. The potential to do so exists, land development costs per hectare will be only about 10% of the costs of irrigation, and the main beneficiaries will be the poorest people of the region.

Rainfed farming regions and crops have traditionally received a low priority in resource allocations for development and research. A turning point, however, came in the early 1970s. Alarmed by widening regional inequities and impressed by technological breakthroughs achieved in crops of the well-endowed areas that were supported by sustained agricultural research, policymakers at both national and international levels decided to allocate more resources to these regions. The establishment of ICRISAT was just one of the responses of that time.

In India, the area of pulses and oilseeds cultivated under rainfed conditions is greater than 80% of the total area under these crops. Wide fluctuations in production occur in these areas year after year, and adversely affect the total production, thereby eroding the benefits accruing from increased production from irrigated areas. The need to ameliorate the problems of the drylands led to a larger and more concentrated research effort. Included in these efforts have been methods of increasing the production of pulses and groundnut.

In India, cropping intensities are generally around 100%, but, on at least half the land, the monsoon rains are sufficient to allow two crops to be taken. Even where irrigation is available, however, cropping intensities do not exceed 120%, and nearly 18 million ha—or 24% of the net sown area of semi-arid India—is fallowed during the rainy season.

Multiple cropping—growing two or more crops simultaneously—is a common feature in the Asian region. It is most common among small farmers and where farmers have little access to irrigation. It is less risky than growing sole crops. Common combinations are cash crops with food crops, drought-resistant with drought-susceptible crops, and cereals with grain legumes.

### *IRRI*

The International Rice Research Institute formulated its Asian cropping systems network in 1974. An on-farm network approach has been utilized from the beginning. Dr Carangal will be describing this network later in this meeting.

### *ACIAR*

The Australian Centre for International Agricultural Research was established in June 1982, to fund collaborative research between Australian scientists and those in developing countries. One of the first programs they established was concerned with grain legumes. At the time of our last meeting this program included the projects Plant Viral Identification, Development of Legumes for Farming Systems in Northeast Thailand, and the ACIAR/University of Queensland Pigeonpea Project. Since then, several more projects have been added. We will learn about some of these in the course of this meeting.

During the past 2 years, the Pigeonpea Improvement Program at ICRISAT has continued to maintain its close contacts with the University of Queensland Pigeonpea Project, sending one of its breeders to Australia for 6 months and taking part in the monitoring tours and planning meetings for pigeonpea in Thailand and Indonesia.

### *ICRISAT*

Although ICRISAT has not been able over the past 2 years to put the concentrated effort into extending grain legume research in the region that was expected at the time of the last meeting, there have been some significant contributions.

**Groundnut.** For example, besides the usual filling of requests for germplasm and breeding material, the Groundnut Improvement Program has made important contributions towards understanding the disease situation on groundnut in the region. These contributions included a viral-disease survey in conjunction with Peanut CRSP in Thailand, the Philippines, Indonesia, and Papua New Guinea, and a disease and pest survey on groundnut in Thailand and the Philippines; the entering on the computer of virus data and information about the serum banks; and the attendance of one of our scientists at the Bacterial Wilt Meeting in the Philippines, sponsored by ACIAR. This program has also conducted a specialist training course at ICRISAT in cooperation with Peanut CRSP, and has cooperated with ACIAR in the region. Pakistan has recently shown great interest in some of the early-maturity groundnut lines supplied by ICRISAT because they appear to be highly adapted in their low-rainfall areas. They have asked ICRISAT to carry out a special seed multiplication of these lines so that they can be tested by farmers, next season.

**Chickpea.** In chickpea the major contribution since the last meeting has been the start in Pakistan of the program on breeding for aschochyta-blight resistance financed by the Asian Development Bank (ADB). ICRISAT has stationed Dr M.S. Rahman in Islamabad to be responsible for this project. He has already planted his second crop. During this time same period our entomologists have toured most of the important chickpea areas of South Asia and identified *Heliothis armigera* as the most important pest on chickpea. During the last 2 years, chickpea scientists have also monitored chickpea trials in Bangladesh, Burma, Indonesia, Malaysia, Nepal, Pakistan and Thailand and held useful discussions with chickpea scientists in those countries.

**Pigeonpea.** The last 2 years have seen a continuation of the shift in emphasis toward breeding early-maturing, large-seeded, disease- and insect-resistant, photoperiod-insensitive pigeonpea lines. This has been associated with developing ways of growing these types to give higher, and more stable yields. This work has generated widespread interest among Indian farmers and in other countries of the region that has resulted in a growing demand for seed of early-maturing determinate pigeonpeas. In many trials throughout Asia, early-maturing lines from ICRISAT have yielded over 3 t ha$^{1}$. During the past 2 years, pigeonpea breeders have made 10 monitoring tours during which they visited Burma, Bangladesh, the People's Republic of China, Indonesia, Nepal, Pakistan, and Thailand. Most of the tours to Indonesia and Thailand have been in conjunction with ACIAR scientists.

Recently ICRISAT has started trials in conjunction with IRRI and the Indian national program to test all three crops as part of the rice-based cropping system.

## Regional Coordinator

As a result of the strong recommendation at the last meeting, ICRISAT has recently identified a coordinator for the Asian Grain Legumes Network. He will be commencing his duties in early January 1986. As he will be taking part in this present meeting, he should be in a good position to help implement the recommendations and plans developed during the next 3 days.

### Country Representatives

I am looking forward to learning during this meeting about the research advances made in each country on groundnut, chickpea, and pigeonpea. I will listen with care to your presentations to learn how ICRISAT may best help advance the research in these three crops in your countries. Your participation in the discussions is vital in order to be able to develop the best action plan possible.

### Regional Representatives

Likewise, the participation of representatives from the donor organizations is vital for the formulation of a sound plan for research on these three crops in Asia. I want to thank again the representatives of the various regional agencies for coming to participate in this meeting.

### Conclusion

I hope that this meeting turns out to be even more effective than our last one for understanding each other's problems and the possibilities for overcoming them, and in developing a strong and effective program of regional research on grain legumes.

# Review of Progress
# and
# Research Resources

# Review of the Recommendations of the 1983 Meeting and Assessment of Future Potential

**J.S. Kanwar**

*International Crops Research Institute for the Semi-Arid Tropics*

Dr Swindale in his keynote address has already emphasized the significance of this workshop and its goals and objectives. Let me join him in adding my warm welcome. I believe that, for planning for the future, it is essential to review the action taken on the recommendations of the first group that met 2 years ago.

The most important recommendation of the first meeting was the resolution to work together, to recognize the pivotal role of the Coordinator for the Asian Grain Legumes Network, and to appoint an experienced scientist to this post. You will be pleased to know that, after a good deal of search, we have come to the conclusion that we can't find a better person than Don Faris to take up this responsibility. We are happy to mention that he has accepted the challenge, but he needs your help to achieve the goals of his job.

The last Consultative Meeting drew attention to high-priority problems in research. The main emphasis was on constraints to production and related research aspects. ICRISAT scientists have followed these recommendations. They have an impressive account of their achievements. I leave it to them to apprise you of the developments and future plans in this area of research. I need hardly emphasize that the technology to alleviate constraints to production can best be evaluated only with your active cooperation and participation under natural environments.

I hope in this workshop the participants will identify themselves with task teams for problem-solving research. Progress is difficult without such commitments. The last meeting also emphasized the need for the intensification of on-going research. It may be an opportune time to take stock of things and chalk out a strategy for the future. It is my feeling that, unless a scientist and the environment for a specific research program are identified, it is difficult to make good progress.

You may recall that the last meeting stressed the need for effective working arrangements for adaptation trials. My colleagues will be able to inform you about the progress made so far.

We have initiated some research on groundnut postharvest technology research in collaboration with TDRI in the UK. But it is a small effort and we look to others for expanding this program. Studies on pigeonpea processing have also been started. We feel some of you have a comparative advantage in conducting such studies. We would like you to come forward with your plans.

The last meeting also emphasized the need for expansion of ICRISAT's disease and pest nurseries of grain legumes in the region. It was recommended that efforts should be made to facilitate screening of ICRISAT germplasm for locally important diseases, e.g., bacterial wilt of groundnut in Indonesia and Malaysia. I am aware of the visits by Dr. D.V.R. Reddy, Dr D. McDonald, and Mr R.W. Gibbons to the groundnut-growing areas in Southeast Asia. They have critically examined the situation of the diseases and viruses in groundnut in the region. They have many interesting things to report. Likewise, the Pulses Program of ICRISAT should be able to apprise you of their efforts in this direction.

The last meeting recommended that ICRISAT should assign priority to producing a comprehensive catalog of available germplasm and breeders' lines. This will assist national programs in making requests for the supply of relevant material to enrich their programs. I regret the catalog is not yet ready in a presentable form, but I can assure you that the scientists are on the job and it will be available soon.

International networks are the main plank of the cooperation strategy and teamwork for achieving the common goal of improving production through the use of improved technology. Within the limitations of resources we have made serious efforts to do as much as we can, but clearly it is not enough.

The importance of crop diversification and development of a suitable cropping system to improve the utilization of natural resources and monetary inputs by small farmers of South and Southeast Asia can hardly be overemphasized. We believe grain legumes have a great potential for improving the economy of agriculture in the region. Their importance in improving the economy, increasing the intensity of cropping, and enhancing the production of vegetable proteins and oils that are in short supply in the region, also cannot be overstressed. Though a beginning has been made in this direction, more intensive efforts are needed. The scope is vast, but its realization will depend on cooperative teamwork.

The importance of socioeconomic research, particularly projections of the demand for and supply of grain legumes, and research on the advantage of these crops in comparison with traditional cereal or noncereal crops, was emphasized during the first workshop. It is high time that such organizations as CGPRT, FAO, and others that are better equipped to do these studies, come forward to grapple with these problems. Regional studies are needed to make critical analyses of the situation and to indicate policy implications.

International linkages have been a subject of intensive discussion in the past, and will continue to be in the future as well. I hope, in this workshop, the agencies concerned develop specific projects and form task forces for implementing these decisions. Unless a well-integrated and coordinated plan is developed, and efforts are made to make use of the comparative strength of each cooperator, the maximum payoff from international cooperation cannot be achieved.

We should not forget that legume research scientists in national programs already have full research commitments. Their productivity in research can be increased if ICRISAT, ACIAR, Peanut CRSP, CGPTR, IDRC, and other organizations operating in the region, evolve a well-coordinated action plan taking advantage of the strength of each organization. Training needs of the national programs are specific and very demanding. Their staff need specialized training, not general training. It should be need-based, and take into consideration the requirements of high-priority research programs as well as the strengths and weaknesses of existing staff, so as to make them effective partners in regional research. Unless the cooperators are equipped to use the same methodology and collect minimum data sets, the evaluation of results becomes difficult. Fortunately, in this region, the national programs are strong, but they may need some critical inputs and short-term training in the use of improved techniques and instruments. I understand that facilities for virus research are being developed by ACIAR in Thailand. ICRISAT scientists will be happy to cooperate with you in this effort.

Biotechnology has recently become a watchword for scientists. Many problems of pulses and groundnut could be addressed by the use of biotechnology to break the barriers in crop improvement and disease-resistance transfer. We hope this workshop will examine these developments critically and evolve joint-action plans.

Traveling seminars—in which a scientist or team of scientists present their views at different places and elicit responses—are effective means of exchanging information and developing a better understanding of the problems and potentials of research. I hope this meeting also considers this approach in developing an international network and a mechanism for technology transfer.

# IRRI's Grain Legume Research Program

**V.R. Carangal**

*Rice Farming Systems Program,*
*International Rice Research Institute*

## Introduction

In IRRI, a systems approach to research on rice-based farming has been adopted, and the cropping-systems research program was established in 1974. It involves several departments: Agronomy, Multiple Cropping, Economics, Entomology, Technology Transfer and Training, and Rice Farming Systems Program. Other IRRI senior scientists participate on a part-time basis. The upland crops initially involved in this cropping-systems research were maize, sorghum, soybean, mung bean, cowpea, groundnut, sweet potato, and cassava. Pigeonpea and chickpea were added in 1983. IRRI's research on chickpea is limited to varietal evaluation.

A conceptual framework for a network approach to cropping systems research and development was formulated after three meetings of the Asian Rice Farming Systems Working Group, the members of which are leaders of cropping/farming systems research from national programs. The Asian Cropping Systems Network was established, and the methodology adapted was further refined by the various national programs involved. The methodology was then expanded to include not only cropping but also animal production, fisheries, and forestry. Some national programs were enlarged to include farming systems research and, in 1983, the Network changed its name to the Asian Rice Farming Systems Network.

It has an interdisciplinary and intercommodity research approach, involving biological and social scientists, with farmer participation. A research team comprising an agronomist, an economist, and a crop protection specialist is assigned to each research site, which normally comprises one or several villages. The methodology provides feedback to commodity and discipline researchers in experiment stations and makes their research more relevant.

## Asian Rice Farming Systems Network

Farming/cropping systems research is highly environment-specific. Research has to be conducted in different major environments to make technology relevant for major production complexes. This is done through collaborative research between scientists from national programs and the IRRI Rice Farming Systems Program, and this mechanism is the Asian Rice Farming Systems Network. The IRRI program coordinates the Network's activities.

To help the Network accomplish its objectives, an Asian Rice Farming Systems Working Group was set up to provide guidance and direction to its collaborative activities. It meets yearly in different countries in the region.

The Network now involves 15 Asian countries—Bangladesh, Bhutan, Burma, Indonesia, India, Nepal, Malaysia, Pakistan, the People's Republic of China, the Philippines, Thailand, Taiwan, Sri Lanka, South Korea, and Vietnam. Madagascar is a candidate participant. In 1985 there are 238 research sites in 13 countries.

The work on the sites is concentrated on the design and testing of cropping patterns and a few instances of component technology research, such as varietial testing, fertilizer rates, etc. The main focus in each site is to increase production and cropping intensity. In some sites where the intensity is already high, research is focused on increasing the productivity of the crops in the cropping pattern. The work on crop-livestock research sites includes the design and testing of cropping patterns and animal systems.

## Cropping Pattern Testing

The first collaborative research started in 1975 on cropping-pattern testing at five sites in three countries. In 1984, there were 44 cropping-systems sites in 13 countries. Most of the experiments are conducted in farmers' fields with farmer participation. IRRI monitors the environment, crop performance, and economic performance of different cropping patterns. The sites are carefully selected to represent the major rice-growing environments in Asia. In most cases, the focus in each site was to increase production, net income, and cropping intensity. In some sites we increased the production of each crop in the pattern and income of the total system.

Interestingly, groundnut is one of the promising crops in cropping patterns in Kota Bharu, Malaysia; Katapotha and Mahaweli H, Sri Lanka; Yezin, Burma; Hathazari, Bangladesh; Antique and Bukidnon, Philippines; and Batumarta and

Barambai, Indonesia. In the Philippines, groundnut is tested in several cropping-systems research sites. Rice-chickpea is one of the most promising systems in Saichaina, Nepal, where farmers used to grow one rice crop before. Now chickpea is involved in their pilot production program.

## Varietal Testing of Upland Crops

One of the major problems identified by cropping-system scientists is the need to improve varieties of upland crops that fit into a cropping system. Since IRRI has no mandate to improve varieties of other crops, we work with national programs to improve varieties of upland crops that fit rice-based cropping systems. Work at IRRI involves maize, sorghum, soybean, groundnut, mung bean, and cowpea. The Institute of Plant Breeding (IPB) has set up a project that includes screening of lines and varieties from ICRISAT, IITA, and AVRDC and other national breeding programs, and the hybridization of promising varieties and selections. The breeding programs concentrate on soybean, groundnut, and mung bean.

The most promising entries are submitted to IRRI for seed increase and distribution to countries involved in the Network. In 1984, we received and increased on the IRRI farm 12 varieties of maize from CIMMYT, Indonesia, Thailand, and IPB; 10 of pigeonpea from ICRISAT; 18 of mung bean from AVRDC and IPB; 22 of soybean from AVRDC and IPB; 20 of cowpea from IITA; 9 of groundnut from IPB; and 10 of sorghum from ICRISAT and IPB.

Groundnut was grown after rice with residual moisture. Yield levels were very low in some locations, but there are some entries as good as or better than the control. The early-maturing varieties of pigeonpea are especially promising as dual-purpose (grain and fodder) crops after rice. We are presently screening materials from Australia and ICRISAT. From ICRISAT we have also received a medium-maturing chickpea. We evaluated the entries under upland conditions during the dry season. Yield levels were higher than in previous trials. All the entries were better than the control: IC 78002.

## Crop-livestock Systems Research

One of the new collaborative research activities in the Network that started in 1984 is an integration of crop-livestock in five sites involving the Philippines, Thailand, Nepal, Sri Lanka, and Indonesia. Groundnut is involved in the cropping systems. The work in Sri Lanka will start in 1986, either in an irrigated or rainfed 'rice area' where groundnut is one of the crops.

In the Philippines, an on-farm crop-livestock farming trial is in progress at the Corosucan and Malanay sites. In the irrigated and upland test site in Malanay, it has been possible to undertake whole-farm research because of the stability of the existing rice-rice cultivation pattern.

At the rainfed test site, cropping pattern trials are conducted to intensify the farmers'traditional sole-rice cropping. Fitting in such upland crops as groundnut after rice, to take advantage of the residual soil moisture, is the main thrust of the research team. The team at the site classified the rainfed site as having (a) a medium-light soil but being drought-prone, and (b) having a heavy soil and being poorly-drained and flood-prone. Groundnut is one of the crops that could be cropped after rice in the lighter soils.

At the site in Santa Barbara in the Philippines we are evaluating pigeonpea varieties after rice. We will also test five pigeonpea varieties after rice in 10 crop-livestock farming systems sites.

A crop-livestock systems research was started in Thailand in June 1984. Improved cropping patterns being tested include groundnut + cassava, cowpea + cassava, maize-rice, cowpea-rice, and rice-fodder crops.

The cropping systems research in Nepal, at Pumdi Bhumdi village, Kaski district, has been expanded to accommodate crop-livestock systems research. Here the major focus is on cattle for milk.

# ACIAR's Food Legume Research Program

**E.S. Wallis, G.J. Persley, and E.T. Craswell**

*Australian Centre for International Agricultural Research*

## Introduction

Food legumes are one of the major areas of concentration in the research programs supported by the Australian Centre for International Agricultural Research (ACIAR).

ACIAR supports several projects concerned with the improvement of such food legumes as pigeonpea, groundnut, soybean, mung bean, and cowpea in Southeast Asia.

The ACIAR food legume program operates mainly in Indonesia, Malaysia, the Philippines, Thailand, and Australia and there is collaborative research between Australian scientists and their colleagues in Southeast Asia on problems of mutual interest. Although ACIAR primarily supports bilateral projects, programs are designed to complement ongoing programs such as those of the Consultative Group on International Agricultural Research (CGIAR) Centers. ACIAR supports research on legume crops of interest to ICRISAT (pigeonpea and groundnut), and to IRRI (in its farming systems program, as pre- and post-rice crops).

The Australian government has provided financial support for this present meeting under the ADAB/ACIAR Australian Special Purpose Grants to the CGIAR Centers. These grants are provided by the Australian Development Assistance Bureau (ADAB) to the CGIAR Centers to facilitate collaboration between ACIAR research projects and the CGIAR Centers.

There appear to be good prospects for collaboration among scientists working in ACIAR's food-legume projects, ICRISAT, IRRI, and other related activities in Southeast Asia.

The purpose of this paper is to outline the scope of ACIAR's existing research projects on food legumes, to outline limitations to food-legume improvement in Southeast Asia, and to identify areas for possible future collaboration with ICRISAT and IRRI.

## ACIAR-supported Research on Food Legumes

ACIAR is currently supporting 10 projects on various aspects of food-legume research. These are listed in Table 1.

**Table 1. ACIAR-supported Research Projects on Food Legumes.**

**Plant Improvement**
Pigeonpea improvement
Legumes for farming systems in Northeast Thailand
Soybean and mung bean improvement
Groundnut improvement
Legume drought-stress measurement

**Plant Protection**
Plant virus identification
Bacterial wilt disease

**Plant Nutrition**
Measurement of biological nitrogen fixation
Ecological studies of root-nodule bacteria and the use of legume inoculants
Phosphorus and sulfur efficiency in tropical cropping systems
Micronutrient requirements for biological nitrogen fixation and growth of legumes

The projects are concerned with (a) crop improvement chiefly in relation to the development of improved varieties and agronomic practices for pigeonpea, groundnut, soybean, mung bean, and cowpea in selected Southeast Asian countries; (b) specific disease problems, where these are a major limit to yield, such as bacterial wilt of groundnuts in Indonesia; (c) plant-nutrition problems affecting food legumes, associated with micronutrient requirements for biological nitrogen fixation, and phosphorus and sulfur nutrition; and (d) the ecology of *Rhizobium.*

## Areas for Collaboration with Other Agencies

### *Modeling genotypic responses*

There are many genotypic evaluation trials conducted throughout Southeast Asia in food-legume crops. There is a need for more critical analysis of these trials, particularly in the assessment of genotype x environment (g x e) interactions, to enable plant breeders to make rational selections of promising breeding materials.

A complementary approach to the analyses of g x e interaction is to use simple dynamic predictive models to provide information on crop growth and development in particular environments, and the response to environmental, edaphic, and cultural treatments.

It would be extremely useful if those countries and international agencies interested in crop improvement agreed to establish cooperative trials so that such analyses could be conducted and the results fed back into relevant plant improvement programs.

The target crops could be the presently important food-legume and oilseed crops in Southeast Asia (soybean, mung bean, and groundnut) and potential new crops (pigeonpea and cowpea).

ACIAR is proposing to establish a resource base to ensure that useful information is sent to the central improvement programs in the projects, in collaborating institutions, and the international research community. It is proposed to have a small central project, manned by an experienced plant improvement scientist, to coordinate multienvironmental testing with ACIAR projects, to ensure that an appropriate minimum data set of plant factors related to environment is collected, and to analyze data by the most appropriate means (g x e analyses, crop models, etc.) for use in the projects.

We would welcome active participation by the CGIAR Centers or other institutions in this project, and undertake to incorporate analyses of multienvironment testing of suitable data sets and prepare feedback to the improvement programs of all interested bodies.

### *Pests and diseases*

Pests and diseases are a major limitation to food-legume production in Southeast Asia. In the case of potential new crops such as pigeonpea and cowpea, pests and diseases are likely to increase with expansion of cropping areas.

In pigeonpea, ICRISAT's expertise would be most valuable in assessing those pests and diseases that may become important in Southeast Asia. ICRISAT could then identify sources of resistance for incorporation into local breeding programs to avoid these potential problems.

## Economics

The economics of production of food legumes is an important issue in Southeast Asia, where food legumes have to compete with other crops for a place in the existing farming systems, which are largely rice-based. Although existing data are limited, it is clear that costs of production of certain crops are high and this must be reduced if locally-grown legumes are going to be able to compete with imported sources.

## Joint Planning and Review of Activities

Joint planning and review of activities of projects conducted by ACIAR and CGIAR Centers and other international agencies in the region should be coordinated by organizing workshops, such as this one, or individual program meetings, where other interested parties are invited. For example, in ACIAR's pigeonpea improvement project, ICRISAT personnel have been involved in Thailand and Indonesia, in planning and review work, and germplasm exchange.

## ACIAR Food Legume Workshop, September 1986

ACIAR is sponsoring a workshop on the limits to productivity in food legumes in Southeast Asia, to be held in Khon Kaen, Thailand, from 1 to 5 Sep 1986. The aims of the workshop are to describe the major limits to adaptation and productivity of food legumes and to identify ways in which these limits might be overcome. The theme of the workshop will be "Why have there not been major gains in the productivity of food legumes, analogous to those achieved with wheat and rice?"

## Conclusion

Food legumes are major crops in Southeast Asia, because of their role as major export crops, such as mung bean in Thailand, potential new export crops, such as pigeonpea in Thailand, and import-substitution crops, such as soybean in Thailand. However, yields are low, and there are many opportunities for research to increase production efficiency.

(Editorial note. Not summarized.)

# Review of ICRISAT and ACIAR Work

# Review of ICRISAT's Groundnut Work in Relation to the Recommendations of the 1983 Meeting

**R.W. Gibbons**

*Groundnut Improvement Program*
*International Crops Research Institute for the Semi-Arid Tropics*

## Visits and Training

Since December 1983 Groundnut Improvement Program scientists have visited eight Asian countries to undertake disease and pest surveys, to participate in various workshops and conferences, to familiarize themselves with local problems, and to discuss possible research cooperation. A number of visitors have come to see the Program's work at ICRISAT Center, and an international group of scientists met there in September 1984 to discuss the problems of groundnut rust.

Specialist training has been given by scientists of the Program at ICRISAT Center to scientists from several Asian countries. These visitors have spent up to several months, as In-service Fellows, working in various subprograms, acquiring expertise in specific fields. These have included breeding methods, screening for resistance to pests, diseases and drought, virus identification, aflatoxin analysis, and the production and application of *Rhizobium* inoculum.

## Supply of Germplasm and Breeding Materials

Increasing contact with groundnut scientists, and development of collaborative agreements with organizations such as IDRC, Peanut CRSP, and ACIAR has stimulated germplasm exchange. Materials were sent to 14 countries. Interest in wild *Arachis* species, and in derivatives of crosses between these and the cultivated groundnut, is still limited; but germplasm accessions, breeding lines, and segregating populations from requested crosses are being provided in increasing numbers. Several international trials have been organized and sent to cooperators in the region.

### *Drought*

Screening of genotypes for tolerance of drought was continued in the 1983/84 and 1984/85 postrainy seasons, using the line-source sprinkler system. The physiology of drought is being investigated. Timing and duration of the stress are important. Preliminary results suggest that it should be possible to select high-yielding genotypes with resistance to early and midseason droughts.

### *Nitrogen fixation*

At ICRISAT the emphasis on symbiotic nitrogen fixation has been on the rainfed crop. Some work has been done on Vertisols and on irrigated crops, and contact has been maintained with NifTAL and the research being done in rice-based farming systems.

In earlier work it was found that yields of genotypes Robut 33-1, JL 24, and ICGS 27 were increased by inoculation with *Rhizobium* strain NC 92, and that Robut 33-1 also responded positively to fertilizer nitrogen. Five more genotypes have been shown to respond positively to inoculation with NC 92, and three of them also respond to fertilizer nitrogen.

### *Iron deficiency*

Chlorosis caused by iron deficiency is common in groundnuts grown in heavy soils of high pH where there is an excess of bicarbonates. A limited range of genotypes has been screened for iron efficiency on Vertisols, where chlorosis is common, and eight iron-efficient lines have been identified.

### *Earliness*

Short-duration cultivars are required to fit into multiple-cropping systems for regions where the rainy season is short and for growing on residual soil moisture, particularly in the rice-based systems of Asia. The genotype ICGS(E) 67 outyielded the control cultivar Chico at all times of harvesting and gave its maximum yield at 90 days after sowing. In this work it was found important to evaluate the genotypes early, as competitive advantages could be lost if they were kept too long in the ground before harvesting. An international trial has been sent to several countries in the Asian region during 1985, and preliminary results received so far have been encouraging.

### *Foliar diseases*

The important foliar diseases of groundnut in Asia caused by fungi are rust *(Puccinia arachidis),* late leaf spot *(Phaeoisariopsis personata),* and early leaf spot *(Cercospora arachidicola).* Rust and late leaf spot are particularly damaging in southern and central India, in Southeast Asia, and in the south of the People's Republic of China.

Over the last 2 years, 46 more genotypes have been found with resistance to rust and/or late leaf spot, and many of the interspecific hybrid derivatives from the cytogenetics program are also showing high levels of resistance to these diseases. The question of race occurrence in rust is still not resolved.

An Information Bulletin has just been released on the leaf spots and this, together with the previously published one on rust, provides a good basis for further research on these diseases and advice on their management. Cultivars with resistance to rust and late leaf spot, and with commercially-acceptable yield and quality, are in advanced tests in the AICORPO system. They have also been supplied to many cooperators in the region.

## *Virus diseases*

From surveys and published data it is clear that virus diseases of groundnut are important constraints to groundnut production in several Asian countries. Bud necrosis caused by tomato spotted wilt virus (TSWV) is serious in parts of India and Malaysia; peanut mottle virus (PMV) is present in all groundnut-growing areas; peanut stripe virus (PStV) is now known to occur in the People's Republic of China, Malaysia, Thailand, Indonesia, and the Philippines; yellow spot virus (YSV) occurs at high incidence in India and Thailand; and witches' broom (caused by a mycoplasma-like organism) can do serious damage in the south of the People's Republic of China, Taiwan, and Indonesia. The ICRISAT Principal Virologist, in cooperation with Peanut CRSP, surveyed virus diseases in Thailand, the Philippines, Indonesia, and Papua New Guinea.

Researchers at ICRISAT have identified three germplasm lines and one breeding line that have no seed transmission of PMV. A line with tolerance to PMV has also been found. Screening germplasm under high incidence of bud necrosis disease (up to 90% incidence in susceptible control cultivars) has resulted in the identification of several field-resistant genotypes with less than 10% incidence. Cultural control of this disease has been successful in India.

## *Pests*

Of the many species of insect that attack groundnut, few are widespread or cause serious damage. However, white grub *(Lachnosterna fissa),* leaf miner *(Aproaerema modicella),* jassid *(Empoasca kerri),* and termites (*Odontoterme* spp) are regarded as constraints to groundnut production in Asia. Recent surveys have shown jassid and aphid *{Aphis craccivora)* to be widespread in India, Thailand, and the Philippines. Thrips *(Frankliniella schultzei* and *Scirtothrips dorsalis)* are important as vectors of TSWV and YSV, and white flies *{Bemisia* sp)as vectors of cowpea mild mottle virus (CMMV).

In the past 2 years, genotypes have been screened at ICRISAT Center for resistance to jassid, leaf miner, thrips, and aphids. Four genotypes have been found on which aphids have reduced growth rates. Several genotypes have been identified with jassid resistance. Resistance has also been found to leaf miner and thrips. Breeders are incorporating these resistances into high-yielding commercially-acceptable cultivars, and several lines with good resistance to thrips and jassids have outyielded control cultivars.

## *Bacterial wilt*

Bacterial wilt *(Pseudomonas solanacearum),* important in Southeast Asia and in the People's Republic of China, has not been found in India. Germplasm accessions reported resistant to the disease are being collected and multiplied for screening in national 'hot-spots'. Available literature has been reviewed. Cooperative research is being considered following a conference on bacterial wilt held at Manila in 1985 under the auspices of ACIAR.

### *Aflatoxin contamination*

There is increasing interest in the problem of groundnut seed invasion by *Aspergillus flavus* and contamination with aflatoxins. Scientists from India, Thailand, the Philippines, Sri Lanka, and the People's Republic of China have had training in resistance-screening methods and in analytical methods for detection and quantification of aflatoxins. Several genotypes with resistance to seed invasion by the toxigenic *A. flavus* have been identified and are being used in a breeding program. Genotypes that are poor substrates for aflatoxin production if seeds are invaded, have also been identified and crosses made in the hope of combining the different resistances.

# Review of ICRISAT's Pulses Work in Relation to the Recommendations of the 1983 Meeting

**Y.L. Nene**

*Pulses Improvement Program*
*International Crops Research Institute for the Semi-Arid Tropics*

## Chickpea

**Wilt, root rots, and ascochyta blight diseases.** We have made considerable progress in research on wilt, root rots, and ascochyta blight diseases. Sources of resistance to wilt and several root rots (e.g., dry rootrot, wet root rot, black root rot, collar rot, etc.) have been identified singly and in various combinations. The seeds of these lines are being shared freely with cooperators. Also, advanced generation lines with wilt and root-rot resistance are being sent for regional testing.

We have a project in Pakistan funded by the Asian Development Bank to specifically breed chickpeas with resistance to ascochyta blight.

**Pod borers.** ICRISAT entomologists have toured most of the important chickpea-growing areas of southern Asia and found that *Heliothis armigera* is the most important pest on this crop.

ICRISAT's search for resistance to *H. armigera* in chickpea has been successful. We now have several genotypes that carry resistance to this pest. In India, ICCX 730038-8, a resistant selection from ICRISAT, has been at the top in combined yield and resistance in multilocation tests over the past 3 years. It has now been recommended as a parent in the national crossing program.

**Lack of cultivars adapted to saline soils.** Further pot screening of a range of genotypes for salinity tolerance has been carried out. Advanced lines have been screened to determine if any were supersensitive to salinity. Plans are in hand to develop uniformly saline field plots for mass screening for salinity tolerance.

**Lack of cultivars adapted to late sowing.** Screening of genotypes, many of which were obtained from ICARDA, for this trait has been done at Hisar (India) during 1983/84 and 1984/85.

**Adaptation trials.** Chickpea seed samples were supplied by ICRISAT to South and Southeast Asia in 1984 and 1985. We sent 75 trials/nurseries and over 2000 seed samples to our cooperators in nine countries of the region, excluding India.

**Stand establishment.** A recent survey has indicated that this is a major limitation to chickpea yield in India. Screening tests for ability to germinate from suboptimal seedbed moisture, using soil packed into trays and adjusted to particular moisture contents, have confirmed genotypic differences in chickpea, and superior genotypes have been identified. Advanced chickpea lines are regularly screened for this character. So far no significantly inferior lines have been identified.

**Visits to field trials.** ICRISAT scientists visited experiments and held very useful discussions with scientists working in Bangladesh, Burma, India, Indonesia, Malaysia, Nepal, Pakistan, and Thailand.

**Cropping systems.** We are collaborating in rice-based cropping systems research with IRRI. Promising chickpea lines (ICCC 37 and 42) are being currently tested in this program.

## Pigeonpea

**Sterility mosaic and wilt.** These two diseases cause an annual loss of US $ 113 million in India alone. Wilt *(Fusarium udum)* is usually present wherever pigeonpeas are grown, but sterility mosaic has been observed only in Bangladesh, Burma, India, Nepal, and Sri Lanka, and possibly Thailand. Many excellent sources of resistance have been identified, with single as well as combined resistance, and several of these have been used in the breeding program. We now have wilt and sterility mosaic resistant lines with good agronomic backgrounds. Seeds of these lines are being shared with cooperators.

**Insect pests.** *Heiiothis armigera* is known to be a major pest of pigeonpea in all of Southeast Asia where this crop is grown. However, there are many other insect pests on this crop. In a tour of several countries in the region in 1983, an ICRISAT entomologist recorded that *Maruca testulalis,* a lepidopteran insect that causes substantial losses on many legumes, but particularly on cowpeas, was very common and damaging on pigeonpea in Thailand and in the Philippines. This pest was also seen on groundnuts in Thailand.

ICRISAT believes that host-plant resistance will be the major component of pest management on pulses in the future. ICPL 332 is one example of a pigeonpea genotype that has been selected for resistance to pests at ICRISAT and is now in its 2nd year of testing in the All India Program.

In 1984 seeds of some resistant selections were tested in the Philippines and at least one of these, PPE 45-2, performed very well.

**Drought.** Postmonsoon irrigation is necessary to maximize ratoon-harvest yields of short-duration pigeonpea on Alfisols in peninsular India. With medium-duration pigeonpea, screening trials to identify tolerance to terminal drought stress are being conducted.

**Water management.** Optimum irrigation requirements for short-duration pigeonpea and chickpea in peninsular India have been worked out.

**Lack of cultivars adapted to saline soils.** Field-and pot-screening tests have been continued to identify pigeonpea genotypes better adapted to saline conditions (e.g., ICPL 227).

**Cropping systems.** We have increased collaboration with the cropping-system group at ICRISAT, particularly in studies of crop water requirements and residual nitrogen effects of chickpea and pigeonpea on cropping systems. We are also screening pigeonpea genotypes for their suitability for intercropping (i.e., to be able to withstand competition by the companion cereal crop).

**Mechanization of production.** Agronomic systems for short-duration pigeonpea that would be potentially suitable for mechanization have been developed.

**Yield-gap analysis.** We are currently testing methods to identify limitations posed by mineral-nutrient deficiencies and toxicities and lack of appropriate rhizobia in particular regions. We are in the process of strengthening our collaboration with ICRISAT agroclimatologists in better defining the climatic constraints to chickpea and pigeonpea.

**Utilization and demand.** We are attempting to develop large, white, sweet-seeded lines that will be more readily accepted as a high-quality substitute for green peas.

We are also developing high-protein lines that could fit into a special market for extracting protein industrially or as feed to substitute for the large amount of soybean imported into Thailand and, perhaps, other countries in the region.

**Germplasm and breeding material.** In 1984 and 1985 we have provided 39 trials and 329 samples of advance pigeonpea breeding material to countries in the region outside India.

One of the trials sent was the Pigeonpea Observation Nursery. This contains about 20 diverse lines covering all maturity groups, disease- and insect-resistant and susceptible lines, and many morphologically different types. This nursery allows scientists who are not familiar with the crop to see what types might fit their requirements.

In the same period we have received results from pigeonpea trials and reports that included the performance of ICRISAT material. Some of the lines have performed very well, as in the case of Thailand (3-5 t $ha^{-1}$), Philippines (3 t $ha^{-1}$), IRRI (3 t $ha^{-1}$), and Burma (2-3 t $ha^{-1}$).

ICRISAT pigeonpea breeders have made 10 monitoring tours to 7 countries in South and Southeast Asia outside India since our last meeting. The trips to Indonesia and Thailand have mostly been in conjunction with ACIAR scientists. Results have been shared among scientists and future trials in those countries planned.

**Links with international organizations.** Pigeonpea breeders from ICRISAT have participated in the monitoring tours and planning sessions for future pigeonpea research in Thailand mainly, but to a lesser extent in Indonesia.

**Training.** Pulses Improvement Program staff have been actively involved in the training of cooperators from the countries in the region.

# ICRISAT's Training Activities in Grain Legumes in South and Southeast Asia

**D.L. Oswalt and A.S. Murthy**

*Training Program*
*International Crops Research Institute for the Semi-Arid Tropics*

The training program conducted by the research and training staff enabled the Institute to accommodate an increased number of participants from the Asian region. There were 198 participants from 41 countries who received training related to pigeonpea, chickpea, and groundnut improvement during 1983-85, with 94 of the participants from the Asian region (Table 1).

The largest number of participants received instruction and practical experience in groundnut research (Table 2). The pigeonpea and chickpea pathology 2-week program in January 1985 had participants from Bangladesh, India, Pakistan, and Thailand. The Peanut CRSP program sponsored six participants from the Philippines and four from Thailand for groundnut-breeding and entomology training.

Practical training in chickpea is scheduled from 15 September to 15 March, which is the growing season at Hyderabad. Pigeonpea training may be up to 10 months, i.e., 15 May-15 March, or limited to 6 months from 15 September to 15 March when the crop is flowering and harvested. Groundnut improvement programs are conducted from 15 May through 15 November under rainfed conditions. A limited number can receive training from 15 September to 15 March, with emphasis on drought screening and management with restricted irrigation.

Table 1. Participants from Asian countries in ICRISAT Training Programs, 1983-85.

| Country | ISF[1] | Wks | IS | Wks | RF | Wks | RS | Wks | Ap | Wks | Total | Wks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bangladesh | 4 | 5 | | | | | | | | | 4 | 5 |
| Burma | | | 5 | 134 | | | | | | | 5 | 134 |
| India | 6 | 27 | 13 | 51 | 10 | 888 | 13 | 491 | 2 | 20 | 44 | 1477 |
| Indonesia | | | 4 | 80 | | | | | | | 4 | 80 |
| Nepal | 1 | 2 | | | | | | | | | 1 | 2 |
| Pakistan | 1 | 2 | | | | | | | | | 1 | 2 |
| People's Rep. of China | 4 | 34 | 6 | 154 | | | | | | | 10 | 188 |
| The Philippines | 5 | 29 | 8 | 113 | | | | | | | 13 | 142 |
| South Korea | 1 | 4 | | | | | | | | | 1 | 4 |
| Sri Lanka | 2 | 8 | | | | | | | | | 2 | 8 |
| Thailand | 1 | 2 | 8 | 99 | | | | | | | 9 | 101 |
| Total | 25 | 113 | 44 | 631 | 10 | 888 | 13 | 491 | 2 | 20 | 94 | 2143 |

1. ISF: In-service Fellow. IS: In-service Trainee. RF: Research Fellow. RS: Research Scholar. Ap: Apprentice. Wks: Weeks at ICRISAT.

Table 2. Participants from Asian countries in pigeonpea, chickpea, and groundnut training programs, 1983-85.

| Country | Pigeonpea | Chickpea | Groundnut |
|---|---|---|---|
| Bangladesh | 4[1] | 4 | - |
| Burma | - | - | 5 |
| India | 24 | 23 | 25 |
| Indonesia | 1 | 1 | 4 |
| Nepal | 1 | 1 | |
| Pakistan | 1 | 1 | - |
| People's Rep. of China | - | - | 9 |
| The Philippines | 2 | - | 11 |
| South Korea | 1 | - | - |
| Sri Lanka | - | - | 2 |
| Thailand | 4 | 4 | 4 |
| Total | 38 | 34 | 60 |

1. Individuals may have participated in more than one crop.

The educational level of participants has been increasing. Almost all the 1983-85 participants from the Asian region have a B.Sc. or higher degrees (Table 3). An intensive 8-week course to improve English has been provided annually from 15 March to 15 May. However, there have not been many Asian grain legume participants in this program.

Table 3. Educational level of the 1983-85 participants from Asian countries.

| Country | Diploma | B.Sc. | M.Sc. | Ph.D. |
|---|---|---|---|---|
| Bangladesh | - | 1 | 3 | - |
| Burma | 3 | 2 | - | - |
| India | - | 6 | 22 | 16 |
| Indonesia | 1 | 3 | - | - |
| Nepal | - | - | 1 | - |
| Pakistan | - | - | 1 | - |
| People's Rep. of China | - | 10 | - | - |
| The Philippines | - | 5 | 6 | 2 |
| South Korea | - | - | 1 | - |
| Sri Lanka | - | 1 | - | 1 |
| Thailand | 1 | 8 | - | - |
| Total | 5 | 36 | 34 | 19 |

It is anticipated that the costs will be US$ 700 per month in 1986-87. These include an incidental allowance, room, food allowance, medical insurance, book allowance, educational visits, homeward-journey allowances, and training supplies. Transport costs to ICRISAT and return are covered separately.

(Editorial note: Not summarized.)

# ACIAR's Pigeonpea Improvement Program

**E.S. Wallis, D.E. Byth, R.J. Troedson, and J.S. Meekin**

*Department of Agriculture, University of Queensland, Australia*

## Introduction

The ACIAR Pigeonpea Improvement Program, initiated in December 1982, is a collaborative research project based at the University of Queensland with components in Fiji, Thailand, Indonesia, and Australia. In addition, close collaboration has been maintained with ICRISAT, and genetic materials have been made available to a number of countries.

A primary thrust of the program has been to investigate factors influencing the productivity and adaptation of short-season pigeonpea, including environments and countries in which pigeonpea is not currently grown as a field crop.

The introduction of a new crop to any country is a slow process. It requires that the crop not only be able to perform well in new environments but also that the end uses of the products be defined, that the crop be profitable to farmers, and that its adoption meets national goals.

The program was reviewed by ACIAR in Sep 1985 and a second 3-year phase, that commenced on 1 Dec 1985, was recently approved by ACIAR's Board of Management.

### Philosophical Approach

The program has actively collaborated since 1982 with university and governmental institutions in Thailand, Indonesia, and Fiji, as well as ICRISAT. The approach taken by the program was to convene a discussion group or workshop in each country prior to the initiation of collaborative research.

The methodology adopted to evaluate the pigeonpea crop in Indonesia and Thailand was similar, and was directed at the evaluation of its potential as a nontraditional crop, as follows.

a. A series of sowing-date studies were conducted at several locations with a broad range of genetic material (some of which was supplied by ICRISAT) from different phenological groups.
b. A "best bet" agronomic package (lines, sowing dates, densities) for early- and medium-maturing production systems was chosen and evaluated at several sites.
c. A range of materials was included in a genotypic evaluation at a number of sites.

This approach was designed to enable the collaborating scientists to develop an understanding of the crop, and also to identify genetic material that met the requirements of existing (or new) cropping systems.

These studies have demonstrated that pigeonpea can perform well in a range of environments, and that the crop can be incorporated into existing cropping systems as well as become a component in new systems. In Fiji, the approach was modified by the existing knowledge of the crop and its potential value as a locally produced substitute for other imported pulses for human consumption.

## Limitations to Production and Adoption of Pigeonpea in Thailand, Indonesia, and Fiji

As a result of the collaborative research in Thailand and Indonesia, the following limitations have been identified as requiring further research before adoption of pigeonpea in these countries can be expected. Similar limitations are anticipated to exist in other countries of the region in which pigeonpea is not a traditional crop.

### *1. Adaptation to acid soils*

Pigeonpea is widely grown in India on neutral-alkaline soils, and relatively little research has been conducted to date in Southeast Asia on adaptation to acid-soil conditions.

In Fiji, excellent vegetative growth of pigeonpea can be obtained on acid soils with an aluminium saturation of up to 55%. Seed yield has been below expectations, but other limitations (climatic, environmental, and disease) may be involved.

Further research is required into aspects of adaptation and productivity of pigeonpea on the low-fertility, acid soils of Southeast Asia before the potential of the crop can be fully assessed.

### 2. *Cropping patterns*

Further research is required to define suitable production systems in areas where good potential has been demonstrated.

### 3. *Incidence and management of insect pests*

Damage caused by insect pests has been shown to be a major limitation to productivity and adaptation of pigeonpea, and will limit adoption of the crop by the small farmers of Thailand, Indonesia, and elsewhere in the region. Research is therefore required to determine appropriate insect management practices for the small farmers of the region. This is an area where ICRISAT could help. The possibility of host-plant resistance should be evaluated in the region as a priority activity.

### 4. *Incidence and management of diseases*

Stem canker caused by *Botryosphaeria xanthocephala* is a major problem in pigeonpea in Fiji. In Thailand and Indonesia, disease problems have been relatively minor to date, but this favorable situation is unlikely to continue.

### 5. *Utilization of the crop and its products*

Pigeonpea is a new crop in many countries of Southeast Asia. Thus the plant and its products are not components of current human or animal diets. The best prospects of utilizing pigeonpea as human food may exist in Indonesia, while in Thailand its use as animal feed is more likely. However, the degree of adoption in each country will depend upon a number of factors including productivity, suitability for cultivation in specific farming systems, acceptability, and socioeconomic factors.

**Use as a locally consumed food.** Pigeonpea has relatively little potential as a human food source to be consumed locally in Thailand. But in Indonesia the situation is quite different. Pigeonpea has been shown to be a potential substitute for soybean used in the production of the fermented product "tempeh". In 1980,1.2 million t of soybean were used in Indonesia for tempeh production.

**Potential as an export crop.** India is the major producer of pigeonpea (approximately 90% of total world production). Currently only very small amounts of pigeonpea are traded on the world market. Consequently a realistic price for the product, if traded in large quantities, is impossible to determine.

No definitive studies on the potential of pigeonpea as an export crop have been completed. This is a serious deficiency which needs to be addressed in the near future.

**Potential as animal feed.** Pigeonpea could enter the diet of either intensively-raised animals (pigs or poultry) or as a source of feed for grazing animals. Considerable potential exists for inclusion of pigeonpea in these compound feeds in both Indonesia and Thailand, provided the price per unit is competitive with other local alternatives.

Before any valid conclusions are made on the prospects of pigeonpea, the costs of its production and its value relative to other locally available alternatives must be matched to its animal production performance and its acceptability as a feed source.

### *Proposed Phase II Activities of the ACIAR Pigeonpea Program*

In the second phase of this program, collaborative research is proposed to continue in Fiji, Indonesia, Thailand, and with ICRISAT, and is to be initiated with the Indian national program.

In Fiji it is proposed to continue research to determine the factors causing excessive flower and pod abscission in some genotypes. In addition, studies will begin on identification of genetic material resistant to *B. xanthocephala,* the mode of inheritance of this disease, and introgression of resistance into adapted genotypes. Studies of aspects of its crop management and of its adaptation and productivity on low-fertility, acid soils with high aluminium saturation will also receive emphasis.

In Indonesia research will be continued into adaptation and productivity, particularly on the outer islands where low-fertility, acid soils are important limitations to crop production.

In Thailand, areas of research include the adaptation and productivity of the crop on low-fertility, acid soils of the Northeast, and appropriate control methods for pests (and possibly diseases), both on and off research centers. In addition, utilization of pigeonpea as a food, feed, or export crop will be evaluated. This will involve an economic analysis of pigeonpea production in some potential farming systems. It is proposed that these studies be carried out in collaboration with ICRISAT.

In Australia detailed studies will continue in two major areas, agronomy/physiology and plant breeding/genetics. In the plant breeding/genetics area, studies will concentrate on developing an improved understanding of the inheritance and heritability of important characters and their introgression into improved genotypes. Studies will continue in the analysis of multienvironment adaptation in all collaborating countries.

# Analysis of Data from Multienvironment Trials

**R. Shorter, Queensland Department of Primary Industries, Australia;**
**D.E. Byth, University of Queensland, Australia; and**
**V.E. Mungomery, Queensland Department of Primary Industries, Australia**

## Introduction

Plant performance reflects the interplay of genetic and nongenetic factors so that, for many plant characters, the relative performance of genotypes may vary in different environments. This is termed genotype x environment (g x e) interaction. As a result of g x e interaction, comparisons of performance among genotypes are confounded with the test environment.

These multienvironment genotype trials are frequently expensive and time-consuming. Efforts should be made to extract as much useful information as possible from them. Detailed analysis using appropriate methodology can assist with evaluation of genotypic performance in such trials to provide an explicit summary of results.

The aim of this paper is to consider briefly the advantages and disadvantages of some of the methods that have been used to examine results from these trials. The methods considered are as follows.

1. Analysis of variance within environments.
2. Characterization of g x e interactions.
   - A. Analysis of variance across environments.
   - B. Identification of patterns of g x e interactions.
     - a. Linear regression analysis of genotypic responses.
     - b. Pattern analysis of genotypic responses.
     - c. Characterization of environments' effects.

## Within-environment Analysis

It is normal to analyze variance of data from individual trials and to publish tables of genotype means in each environment, together with appropriate criteria for detecting significant differences. These analyses obviously are required for determining the reliability of data from individual trials and for detecting differences in genotypic performance within environments. Such a presentation of results, however, does not readily facilitate meaningful comparisons among genotypes across environments.

## Analysis of Variance Across Environments

Factorial experimentation has led to the statistical partitioning of total variation in multienvironment trials into components due to main effects (genotypes and environments) and their joint action (g x e interaction). In some models environments are stratified on observable differences such as altitude or fertility differences.

Genetic, environmental, and interaction components of variance obtained from these analyses have provided valuable information on the nature and relative magnitude of g x e interactions. This has sometimes led to a more rational sampling of test environments in future trials, as well as to an understanding of the biases such interactions may cause in plant breeding and selection programs.

These statistical procedures have been less useful than initially envisaged for plant breeders, partly because g x e interaction has been regarded as a statistical confounding factor rather than as an expression of genetic and partly heritable differences in genotypic response. These analysis of variance procedures provide population estimates of g x e interaction variances, but do not provide insight into the behavior of specific genotypes or the effects of particular test environments.

## Identification of Genotypic Patterns

Various methods of analysis of multienvironment trials have been developed to overcome the major deficiency of variance partitioning methods, i.e., failure to characterize the response surface exhibited by a genotype across environments. Two main forms of analysis exist, distinguished by whether the techniques *describe* or *summarize* the patterns of response.

### *Linear regression analyses*

Techniques that describe genotypic response patterns attempt to characterize g x e interaction in terms of an underlying model. Interaction sums of squares are partitioned according to the model, and descriptive statistics are the basis of comparison among genotypes.

Linear regression models have been used widely by plant breeders and others to describe the production response of individual genotypes in multienvironment trials. The procedure is based on the regression of genotypic performance, or of g x e interaction effects for the genotype on an index of the test environments.

While the linear regression approach is a powerful and simple procedure for describing adaptation responses and discriminating among genotypes where percentage linearity is high, this appears to be rarely so. In these circumstances this method of analysis is inappropriate, relatively uninformative, and of little value.

### *Pattern analysis of genotypic responses*

The actual performance of a genotype across environments can be plotted against an index of these environments. No underlying model of genotypic response is assumed. Differences in response patterns of genotypes to environmental change can then be examined by comparing these performance plots.

Pattern analysis techniques attempt to summarize the actual responses of all genotypes across all environments and so simplify the interpretation problem. Cluster analysis (classification) has been used to form groups of genotypes that differ in mean performance and/or in the form of environmental response. Within groups, genotypes often are relatively homogeneous for mean performance and response.

The summarized genotypic-response patterns may be visualized by plotting the genotype group mean performance against an environmental index. Also, responses of individual genotypes within particular groups may be plotted. This process may assist identification of general and specific differences among and within the responses of the genotype groups. In international and national trials such an analysis of genotypic responses may be a useful tool in identifying productivity constraints, particularly those below ground.

### *Characterization of environments*

**Interpretation of genotypic response differences.** An approach to identifying factors that account for differences in genotypic response is to use productivity characteristics of environments to ascertain the importance of specific environments or sets of environments. For particularly important environments, features that may have caused the genotypic response differences can be sought. For this to be effective, as much information as possible should be collected on the test environments. The pattern analysis approach assists the generation of hypotheses regarding aspects of genotypic adaptation.

**Selection of future evaluation environments.** Considerable attention has been devoted in the literature to choice of future test environments in genotypic evaluation trials. Variance partitioning methods can indicate the relative importance of sampling years, locations, or combinations of years and locations. However, as was the case with genotypic analysis, these methods are relatively uninformative regarding particular environments or their effects.

Various authors have used the cluster analysis of environments, based on productivity data, to investigate whether there existed regional or temporal environment groups within which relative genotypic performances were similar.

Other authors have used climatic and soil factors to cluster environments. Linear-regression techniques describing the production response of environments across genotypes are then applied within the derived groups to identify sites that consistently provide data by which to discriminate among genotypes.

## General Considerations

Data summarization by pattern analysis for ease of interpretation involves some conflict with information retention. For a number of data sets analyzed, the size of the data matrix was reduced. Thus relatively more loss of variation for g x e interactions occurred. However, in general, differences in the patterns of genotypic response were maintained, so it appears that information loss following data reduction may not be critical. A basic objective of the analysis is to separate pattern from "noise", i.e., systematic from nonsystematic variation. The degree of data reduction by pattern analysis may be varied to achieve the desired balance between simplification and information loss.

In any process of data analysis and interpretation, consideration should be given to the quality of the data included. Standard statistical procedures guard against inappropriate inferences by applying probability statements to observed variation. In classification procedures used for data summarization, such probability statements are generally not possible.

Groups, once derived and labeled, may tend to persist even if they are inappropriate, and this in turn may constrain the development of meaningful insight into genotypic adaptation. Poor-quality data should be excluded from the analysis, possibly on the basis of results from within-environment analyses of variance.

## Collaboration in Analysis of Environmental Interactions

Most national and international institutions associated with crop improvement conduct multienvironment evaluation of genetic material, with the objective of determining the performance of the material in different environments and of disseminating that material to cooperators. An objective of ACIAR is to provide, via this meeting, a forum for discussion of ways in which multienvironment testing may become a more deliberate and objective procedure, and one by which greater information of value in plant improvement can be extracted from the results of such a series of trials.

It is important that duplication of investment in multienvironment testing trials by different organizations be avoided. Appropriate agreements for collaboration in planning, conduct, and review of such programs are required. Relatively little attention currently is directed to ensuring effective data collection and analysis, and the interpretation of results. There is thus a need for the improved interpretation of such results, which could lead to more objective design and conduct of multienvironment research. Discussion is required to determine ways in which cooperation among institutions in this process can be achieved, perhaps with joint support from ICRISAT, IRRI, and the ADAB/ACIAR fund.

# Statement of Current Status and Recent Research by Country / Region

# Grain Legume Production in Bangladesh

**M. Matiur Rahman**

*Bangladesh Agricultural Research Institute (BARI), Regional Agricultural Research Station, Ishurdi, Pabna*

## Introduction

Pulses are important food crops of Bangladesh. They occupy 0.3 million ha, i.e., 2.34% of the total cropped area and contribute about 1.07% of the total grain production of the country. The production target of pulses in the Second Five Year Plan (1980-85) was fixed at 476 000 t, and later revised to 300 000 t. Unfortunately, the target set for pulses in the Plan has not been achieved. Production decreased by 16%) during the decade ending 1981-82, and the trend is most probably continuing.

Chickpea is the third most important pulse in hectarage and production, contributing 17% of the total pulse production. Its area has been reduced by 26% and production by 38% during the last decade. Pigeonpea is a minor pulse in the country and is seldom grown as a sole crop. Groundnut is regarded as an oilseed in this country, and hence not discussed in this paper.

Coordinated research work on six pulse crops—lathyrus, chickpea, lentil, black gram, mung bean, and pigeonpea, was initiated in 1979 under BARI's Pulses Improvement Programme. IDRC provided financial support from 1979 for the research work, laboratory equipment, and manpower development. Research linkages with ICRISAT and ICARDA have been established, with particular regard to the receipt of germplasm and breeding materials.

The Pulses Improvement Programme of BARI itself does research on seven pulse crops (including cowpea) over three seasons a year. Also, the Bangladesh Institute of Nuclear Agriculture (BINA) does mutation-breeding work on major pulses, and Bangladesh Agricultural University (BAU) has done some survey work on the diseases of pulse crops.

## Chickpea

### *Major constraints to production*

The mean yield of chickpea, 680 kg $ha^{-1}$, compares unfavorably with that of Boro rice (1200 kg $ha^{-1}$) and wheat (1960 kg $ha^{-1}$). Farmers therefore give low priority to the growing of chickpea.

The following factors contribute to poor yields.

**Poor plant stand.** The majority of the farmers' fields have less thanoptimum plant population. Some farmers sow their seed from the end of November to late December after harvesting T. Am an rice. They broadcast their seed, so some seeds germinate but others remain on the top of dry soil and do not germinate or are eaten by birds. Sometimes the farmers' seed is badly damaged in storage by fungal diseases. As these seeds cannot be distinguished from normal seed, their use for sowing contributes to poor germination.

**Lack of improved cultural practices.** No standard cultivation method, such as those used for rice or wheat, is available for chickpea. The use of inputs such as irrigation and fertilizer results only in luxuriant vegetative growth with fewer pods, inviting disease and pest attack. Farmers therefore avoid using such inputs, and do no weeding.

**Diseases and pests.** Collar rot has become a major threat, sometimes killing as many as 50% of the seedlings. No resistant genotype has yet been identified. Wilt and stunt are also important diseases. Botrytis has been reported in some years. Cutworm *(Agrotis ipsilon)* at early growth stages, and pod borer *(Heliothis armigera)* at later stages, cause substantial damage to the crop.

**Nitrogen fixation.** Soils in Bangladesh lack nitrogen-fixing rhizobia. This is a further reason for low crop yields.

### *Marketing problems*

Bangladeshi consumers prefer animal protein to pulses. Since the government does not have a fixed price policy for pulses, the farmers do not store their produce for long. Due to its vulnerability to bruchids and fungi, they are compelled to sell it soon after harvest at a low price. Moreover, as the yield of pulses is low, the farmers benefit little financially from growing pulses.

### *Progress made*

Research on pulses started in the early 1950s, when it was mostly confined to the collection and evaluation of local germplasm. Three varieties of chickpea—Sabur 4, Faridpur 1, and Bhangura 45—were recommended for cultivation around 1956-57. In 1979 a multidisciplinary approach was adopted by BARI in its crop research, and recently some progress has been made.

**Breeding.** In 1982 BINA released a high-yielding and high-protein chickpea variety named Hyprosola. BARI has identified a high-yielding line (S1) from germplasm introduced from ICRISAT in 1981-82; its release is expected soon. BARI's genetic resource unit, in collaboration with ICRISAT, collected about 260 germplasm accessions of chickpea from different parts of Bangladesh in 1984. Six entries selected from the ICRISAT materials are in advanced stages of testing.

**Plant pathology.** The BAU Plant Pathology Department has identified eight diseases of chickpea: wilt, collar rot/ root rot, blight, rust, leaf spot, stunt, leaf blight, and nemic disease (caused by *Trichodorus* sp).

BARI's Plant Pathology Division, after a countrywide survey of the damage caused by these diseases, concluded that wilt, collar rot, and blight are the major diseases of chickpea.

**Postharvest technology.** Staff of BARI's postharvest technology project have surveyed farmers' seed-storing methods and the extent of damage by storage pests and diseases. They identified two species of pulse beetle, i.e., *Callosobruchus chinensis* and *C. maculatus,* as the main insect pests. They also identified 15 genera of storage fungi in chickpea.

**Cultural management.** Staff of BARI's Soil Science Division have conducted fertilizer trials throughout the country and have recommended fertilizer doses on the basis of soil-fertility level.

### *Current research*

The Breeding Division has already initiated a hybridization program in 1984 with disease-resistant varieties to develop high-yielding, early, disease-resistant, and locally adaptive varieties.

The Plant Pathology Division has already developed a wilt sick plot in its screening work. The Pathology and Agronomy Divisions have jointly initiated experiments to minimize collar rot and wilt. They are also monitoring the incidence and severity of various diseases.

The Entomology Division is helping the breeders to screen their advanced lines against pod borer. It is also surveying the level of attack in farmers' fields, and developing a spray schedule by which to control the borer.

The microbiologists are trying to develop an inoculum for existing chickpea varieties, suitable fertilizer doses for increasing the efficiency of the inoculum, and are also screening advanced lines for better nodulation.

The Agronomy Division is conducting experiments on different methods of planting for the improvement of plant stands. They are also trying to develop appropriate seed rates for the farmers who plant chickpea up to late December.

The On-Farm Research Division (OFRD) is helping the breeders test their most promising lines in farmers' fields. Staff of the postharvest technology project are trying to develop a low-cost container for storing seeds, to reduce bruchid and fungal damage.

BARI has developed strong links with ICRISAT. The Breeding Division regularly receives germplasm, segregating materials, and advanced lines, and selects suitable genotypes. Similarly, the Pathology and Entomology Divisions are also receiving wilt-, botrytis-, and Heliothis-resistant nurseries. Earlier, BARI received some kabuli material from ICARDA that was found to be unsuited to the environment in Bangladesh.

***Proposed research***

Breeding research will focus on developing varieties that are tolerant of collar rot and resistant to wilt, having high yield and early maturity. This work will also include the breeding of varieties suitable for late sowing.

On the research station, the maximum yield obtained was 4800 kg $ha^{-1}$, whereas farmers' yields average 680 kg $ha^{-1}$. To minimize this huge gap, cultural management experiments will get top priority.

Large-scale production of inoculum will be undertaken for distribution among the farmers. The search for *Heliothis-resistant* varieties will continue.

A large-scale survey of the soil-nutrient status of the chickpea-growing area, and more fertilizer trials, will be done in order to prepare recommended fertilizer inputs.

## Pigeonpea

Pigeonpea is a minor crop in Bangladesh, grown in 1.3% of the total pulse area, with an average yield of 666 kg $ha^{-1}$. It is planted in April/May along with rice or millet. It requires about 300 days to mature. Its area and production is on the decline. Being a minor crop, it has received little attention from researchers.

Only recently have some efforts been made to introduce postrainy season (rabi) pigeonpea. A time-of-sowing experiment has shown that September is the optimum time for sowing this crop. The crop requires 135 days to mature. The yield potential of experimental lines has been found to be about 1500 kg $ha^{-1}$. But they are prone to pod borer infestation. At least three sprayings are required to control this pest, much to the displeasure of farmers.

Since September is the optimum sowing time, it will be difficult to introduce this crop into existing cropping patterns. The only option will be to introduce it as a mixed crop with black gram or mung bean. Our future research work will be focused on these options.

# Production Technology from All India Pulses Improvement Project

**S. Chandra**

*Directorate of Pulses Research, Indian Council of Agricultural Research*

Systematic and concerted research work on pulses started with the inception of the All India Coordinated Pulses Improvement Project (AICPIP) in 1966. With its network of 28 research centers situated in various agroecological zones of the country, its work has helped in understanding the basic problems limiting pulse production in the country, and in developing efficient varieties and their related agrotechnology that are capable of doubling present production levels.

## Varietal Improvement

### *Disease resistance*

Realizing the fact that traditional varieties of pulses are not only poor yielders but highly vulnerable to many lethal diseases, the major emphasis in AICPIP's work was on disease-resistance breeding. National programs were initiated to identify diverse donor parents and to test the yield potential of disease-resistant varieties of various crops. Consequently, several varieties resistant to such major diseases as wilt and sterility mosaic of pigeonpea, and ascochyta blight and wilt of chickpea, have been developed. Farmers therefore now have available a choice of varieties of pigeonpea suitable for growing in different zones of India that have resistance to a range of diseases, with average yields between 1.7 and 2.3 t $ha^{-1}$. Similarly, there are four recommended varieties of chickpea that are resistant to wilt (1.8-2.1 t $ha^{-1}$), and four that are resistant to ascochyta blight (2.0-2.3 t $ha^{-1}$).

### *Early maturity*

Breeding for early maturity continues to be a thrust area in pigeonpea research. Many early maturing varieties, such as UPAS 120, Manak, Sagar, Pusa 84, 1CPL 87, and ICPL 151, with a yield potential of about 2 t $ha^{-1}$, have been bred. When sown by the end of June, these genotypes vacate the field by early November, and facilitate timely sowing of other crops, e.g., wheat. As a result, a pigeonpea-wheat rotation has become very popular in northern India.

### *High yields*

Besides disease resistance a n d early maturity that offer stability of production, breeding efforts are consistently made to develop high-yielding varieties. There are two varieties of pigeonpea that have been recommended for their high yields in various zones (1.7-1.8 t $ha^{-1}$) and 12 varieties of chickpea (1.7-2.8 t $ha^{-1}$).

## Production Technology

The role of legumes in sequential cropping with cereals in the nitrogen economy and total productivity has been well documented. On average, pulses in rotation economize the equivalent of 30-40 kg of nitrogen $ha^{-1}$ for the following cereal crop, depending upon the level of management (Table 1). However, not all legumes have an equally beneficial effect on the succeeding cereal.

Table 1. Energy saving through nitrogen economy by different legumes.

| Preceding leguminous crop | Succeeding crop | N economy (kg $ha^{-1}$) | Energy saving (J $ha^{-1}$) x $10^8$ |
|---|---|---|---|
| Chickpea | Maize | 56-68 | 45-54 |
| Chickpea | Pearl millet | 40 | 32 |
| Pigeonpea | Wheat | 40 | 32 |

### *Intercropping*

In the North Plains West Zone, under irrigated conditions, early pigeonpea + black gram and early pigeonpea + mung bean with uniform-row sowing proved more productive and efficient than other combinations. Similarly, in the Central and Peninsular Zones, sorghum/pearl millet / groundnut + pigeonpea combinations under paired-row sowing were found to be most efficient under rainfed conditions. Finger millet + pigeonpea in Karnataka has also been found to be quite remunerative. In the North Plains East Zone, sorghum/maize + pigeonpea under paired-row sowing gave better yields than sole cropping.

During the postrainy (rabi) season, chickpea-based intercropping, such as chickpea + mustard in the North Plains East Zone, and chickpea + safflower / linseed in the Peninsular Zone, have been found highly attractive in comparison with sole chickpea.

### *Production inputs*

Studies on the relative contribution of production inputs in the last 3-4 years have conclusively shown that efficient weed management and fertilizer use are most important, both for rainy-season (kharif) and postrainy-season (rabi) pulses. In the case of pigeonpea, efficient weed management increased productivity by 39% over the control. Fertilizer was next in order of importance. Further, there was a synergistic effect when weed management, fertilizer use, and plant protection were combined.

In the case of chickpea, fertilizer use (18-46-0) was found to be the most important input, followed by weed management. In the absence of fertilizer, the yield declined by 35.6%, and without weed management by 27.3%.

At Rahuri, Gulbarga, Dholi, and Sehore, application of a full dose of fertilizer (18-46-0) to pigeonpea and no fertilizer to the intercrop proved more profitable than fertilizer application to both the component crops. At Badnapur, Kanke, and Varanasi, application of half of the recommended dose to both the crops proved highly efficient.

### *Supplemental irrigation*

Recent experiments on the effect of irrigation on productivity of pigeonpea and chickpea revealed that one irrigation to early pigeonpea at the bud/pod development stage, on an average, increased grain yield by 34% over the control. Similarly, in the case of chickpea one irrigation at the flowering stage increased yield by 23% over the control.

## Plant Protection

### *Chemical control of insect pests*

Studies on the relative efficacy of various chemicals and pesticides of plant origin have revealed that, if chickpea and pigeonpea are sprayed at their flowering stages, the chemicals are quite effective against major pests. Neem-seed kernel and neem-leaf extracts have proved as effective as chemical insecticides.

Among spraying equipment used and tested, the ULV applicator has been found to be the most efficient and easy to handle.

### *Biological control*

Parasites and predators of insect pests of various pulse crops have been identified. The application of nuclear polyhedrosis virus along with half the dose of insecticide has proved to be effective against the *Heliothis* pod borer, especially in peninsular India.

### *Pest avoidance and host-plant resistance*

Insect-ecological studies have helped to identify and exploit the host-avoidance phenomenon. Demonstrations showed that borer damage can be reduced considerably by manipulating the host-avoidance phenomenon. By the time the pod borer attains its population peak, the pigeonpea variety Bahar reaches pod maturity and thereby avoids damage. Similar varietal features exist in a number of other genotypes.

### *Disease management*

Effective and cheap methods of control of certain diseases have been evolved. Seed treatment with fungicides at 2 g $kg^{-1}$ seed has been found quite effective against such seed- and soilborne diseases as wilt, root rot, and dry root rot.

## Priorities in Research

- Response of pulses to high inputs such as irrigation, fertilizer, high plant density, etc.
- Identification of suitable plant types for high plant density, and tolerance of salinity, drought stress, waterlogging, alkalinity, and low fertility.
- The sympodial habit is advantageous in high-yielding legumes such as soybean and faba beans. Research is required to establish if this character can be transferred to pulses through genetic engineering.
- Examination of genetic dormancy in seed, as well as the factors influencing the expression of prolificity in major pulse crops.
- Agroclimatological factors in relation to instability of yield in pulses. Cold tolerance has special significance in chickpea and late pigeonpea.

- Soil-water-plant relationships in relation to different stages of plant growth and yield.
- Phosphate solubilization, and the synergistic effect of mycorrhiza in association with rhizobia.
- Nitrogen fixation; specificity and efficiency in different environments.
- Efficient partitioning of nitrogen and dry matter.
- Nutritional quality and antinutritional characteristics.
- Genetics and cytogenetics of important traits.
- Development of a breeding methodology suitable for different environments and for disease and pest control.
- Ecological aspects of pests and diseases in relation to environmental factors and plant types.

# Groundnut Research in India

**T.P. Yadava**

*Directorate of Oilseeds Research, Indian Council of Agricultural Research*

**Introduction**

Groundnut production in India accounts for 39% of the crop's global area and 29% of the world production. About 7.3 million t (1983-84) of groundnut is produced in India from 7.6 million ha. India stands seventh in the world in groundnut productivity (953 kg $ha^{-1}$), and the crop accounts for 40% of India's annual oilseed production.

The Directorate of Oilseeds Research initiates, coordinates, and plans research activities in groundnut nationally. There are 18 groundnut research stations and many cooperating centers throughout the country's groundnut-growing areas. The National Research Centre on Groundnut has been established at Junagadh. It is mainly engaged in the maintenance of germplasm and conducting basic research.

Groundnut is cultivated in India during the rainy season (kharif) as well as during the postrainy (rabi) season.

## Rainy-season Groundnut

### *Breeding and genetics*

**Germplasm evaluation and maintenance.** This is the responsibility of the National Research Centre on Groundnut that serves as a national repository. ICRISAT's Genetic Resources Unit has become a primary source of germplasm for the Centre. More than 10000 lines, which have been screened for various economic characters, are widely available for research and development.

**Improved varieties.** Sixty-one improved varieties have been released, and are recommended for various agroclimatic zones within India. An additional 12 genotypes are at the final stage of testing.

### *Agronomic research*

In the rainy season about 92% of the crop is grown under rainfed conditions. It grows well in areas receiving 500-1000 mm of well-distributed annual rainfall. Through the All India Coordinated Research Project on Oilseeds (AICORPO) a workable agro-production technology, covering many aspects of groundnut, has been evolved. Precise recommendations are available for sowing times, seed rates and spacing, nutrient application, irrigation requirements, and intercropping.

Seventy-eight farmers' adoptive trials were conducted for demonstration purposes in the 1982 rainy season. In these trials the average increase in yield varied from 10% (Kadiri) to 83% (Ludhiana). During 1983, 19 field trials were conducted in which yield increase ranged from 20.6% in the Aliyarnagar region to 98% in Ludhiana region. In the Latur area farmers obtained yield increases ranging from 45.7 to 85.7%.

### *Pathological research*

Diseases such as leaf spot, rust, and bud necrosis are economically significant. Early leaf spot *(Cercospora arachidicola)* and late leaf spot *(Phaeoisariopsis personata),* either singly or together, can cause 15-50% loss in pod yield. However, in severe infections yield losses of up to 70%, caused by combined attacks of foliar diseases, have been recorded. Bud necrosis disease occurs throughout the country and yield loss will be total if young plants (up to 50 days) are infected. Recently reported yield losses caused by this disease in seven districts of Andhra Pradesh alone were estimated at Rs 45 million.

**Foliar diseases.** In India, late leaf spot is currently predominant in both seasons. The disease usually appears 10-18 days after germination. It is established that the fungus survives in plant debris in the soil and is also seedborne. As the secondary spread takes place through windborne conidia, disease spread could be checked by the use of effective fungicides.

Rust *(Puccinia sp)* is widespread in India, and the crop is susceptible at any stage of growth. Research aimed at developing resistant cultivars against rust is more advanced than research into leaf spots, and a number of resistant sources have been reported. Attempts are being made at ICRISAT, as well as at certain AICORPO centers, to transfer resistance from several wild species into the cultivated groundnut, and certain advanced lines have been bred.

**Seed and seedling diseases.** In the pre-emergence rots, the diseases have been found to originate from infections already present in the seed at sowing, or from direct invasion of the seed or seedling by fungi established in the soil. Collarrot *(Aspergillus niger)* and aflaroot *(A. flavus)* are the most common postemergence seedling diseases of groundnut. Recommendations for fungicidal seed treatments have been developed.

Virus diseases. In India, eight virus diseases have been recorded under natural conditions. But only three are considered to be of economic importance: tomato spotted wilt virus (TSWV), peanut mottle virus (PMV), and peanut clump virus (PCV).

Recent studies show that the majority of viruses reported earlier on groundnut are strains of TSWV, which is mechanically sap-transmitted. Thrips *(Frankliniella schultzei* and *Scirtothrips dorsalis)* are the transmission agents. Recommendations for controlling TSWV, by adopting cultural practices such as date of sowing, intercropping, and plant spacing, have been developed at ICRISAT Center.

Peanut mottle virus causes up to 60% yield loss. This disease is aphid- and seed-transmitted. Use of virus-free seed is one of the best control measures.

Peanut clump virus, transmitted by the fungus *Polymyxa graminis,* is present in the sandy and sandy loam soils of some states of India. In screening experiments, several germplasm lines have been identified, and breeding for resistance is in progress.

### *Entomological research*

The groundnut crop is subjected to attack by a number of insect pests from sowing to storage. Losses caused by pests have been increasing in recent years, possibly due to overlapping cultivation seasons. It is estimated that annual losses caused by insect pests are about Rs 1600 million (US$ 133 million). The major groundnut pests in the field are leaf miner, white grub, thrips, aphid, and jassids, and, in storage, rust-red flour beetle, groundnut seed beetle, rice moth, saw-toothed grain beetle, and figmoth. Research by AICORPO includes survey and surveillance, identification of resistant genotypes, breeding for insect resistance, and insecticidal trials for chemical control. Lines have been identified by ICRISAT scientists that are resistant to jassids, thrips, and leaf miner. These are being tested in the breeding programs at many AICORPO centers.

## Postrainy-season Groundnut

The area under postrainy-season groundnut during the last decade has almost doubled. But there are constraints to productivity that limit yields. These are: the nonavailability of varieties that are high-yielding, early-maturing, thermoinsensitive, and responsive to high doses of nutrients; the inadequate maintenance of plant populations; problems of nitrogen fixation, particularly in rice fallows; attack by leaf miner/webber, *Spodoptera* sp, and rust; the poor availability of such micronutrients as iron, zinc, sulfur, and molybdenum; shortages of irrigation water; and the loss of seed viability in postrainy groundnut produce.

### *AICORPO research achievements on postrainy-season groundnut*

**Evolution of high-yielding groundnut varieties.** Prior to 1980 there were no groundnut varieties specially bred for postrainy-season cultivation. Accordingly, early-maturing bunch varieties, which were being grown during the rainy season, were pooled and evaluated for postrainy-season use. Subsequent varietal recommendations are Kadiri 3, GG 2, ICGS 11, RSHY 1, and Co 1 in different zones. All these cultivars have high-yielding potential and possess such excellent quality characters as high-shelling percentage, high 100-kernel mass, high percentage of sound mature kernels, and high oil content. Additionally, ICGS 44 has been recommended for adoptive trials.

**Agronomic practices.** In recent years trials have been conducted to work out recommended agronomic practices with regard to optimum plant density, sowing time, nutrient requirements, the isolation and use of suitable *Rhizobium* strains, scheduling of irrigation, and postharvest management of postrainy produce to maintain seed viability, etc. It was recommended that Kadiri 3 should be sown in the last week of September to the 1st week of October in the Telengana region of Andhra Pradesh. Similarly, it was recommended that postrainy-season groundnut should be sown in early December in northern Karnataka. Sowing postrainy-season groundnut at close spacing was found to improve yields. Postrainy-season groundnut responded well to nitrogen, phosphorus, and farmyard manure. However, a high cost-benefit ratio was obtained with the lowest dose of phosphorus. Irrigation trials proved that 11 irrigations, evenly distributed during the crop-growth period, gave the highest good-quality pod yield.

Rapid loss of seed viability in the produce of postrainy-season groundnut is a major problem. It has been suggested that, in high-humidity areas, seed should be stored in polythene bags.

(Editor's note. The full paper includes a statement of the future strategies for groundnut research in India.)

# Grain Legume Production in Indonesia

**Sumarno, S. Somaatmadja, and B.H. Siwi**

*Bogor Research Insitute for Food Crops, and Central Research Institute for Food Crops, Indonesia*

## Introduction

The important grain legumes grown in Indonesia are soybean, groundnut, and mung bean. Pigeonpea is still a minor crop, and chickpea is not common. Due to the small size of landholdings, farmers do not normally regard grain legumes as being major crops. This means that most of Indonesia's grain legume crops are sown during the off-season or on marginal land.

The average yields from grain legumes remain low: 0.9 t $ha^{-1}$ for soybean, 0.9 t $ha^{-1}$ for groundnut, and 0.51 $ha^{-1}$ for mung bean. No data are available for pigeonpea.

In 1984, Indonesian farmers harvested a total of 522 000 t of groundnut (dried grain). In the past 5 years, Indonesia has imported between 7000 and 63 000 t of groundnut a year, and has exported small quantities (1000-4600 t). Groundnut has received little extension attention. Despite this, the government production target is 724 000 t for 1988, a 39% increase over present production levels.

The Central Research Institute for Food Crops (CRIFC), Bogor, is responsible for grain legume research in Indonesia. CRIFC coordinates six research institutes in different locations in the country. Groundnut research is conducted in collaboration with such agencies as ACIAR, ICRISAT, the Asian Rice Farming Systems Network coordinated by IRRI, and IDRC.

## Groundnut

### *Major constraints to production*

**Use of low-yielding varieties.** Nine improved groundnut varieties have been released in Indonesia (five of them since 1983), that cover 40% of the groundnut-harvested area. The improved varieties require optimum management and adequate inputs to yield well. As these are often not available, the improved varieties frequently yield less than the local ones. This discourages the farmers. The CRIFC breeding strategy is to use both local and improved varieties in a hybridization program, and to select lines that are adapted to farmers' management levels.

**Poor seed supply and quality.** It generally takes more than 5 years for new varieties to become commonly used. The multiplication of groundnut seed is relatively slow, while the seed rate per hectare is high. A seed production and distribution policy is therefore needed.

**Inadequate crop management.** Groundnut competes for management and inputs with the major staple crops as well as with higher-value cash crops. Land preparation is usually minimal and little fertilizer is applied.

**Pests and diseases.** Rust *(Puccinia* sp) and brown leaf spot *(Cercospora* sp) are the most common diseases of groundnut in Indonesia. The estimated yield losses range from 25% to 50%. Only the new varieties, Rusa and Anoa, are tolerant of these two diseases.

Virus diseases are frequently observed but the yield loss, in most cases, is insignificant. Bacterial wilt *(Psueudomonas solanacearum)* is not a problem in farmers' fields where crop rotation, involving nonhost crops, is practiced. The improved groundnut varieties released are resistant to bacterial wilt. Other diseases include sclerotial blight (caused by *Sclerotium rolfsii),* gapong (causal agent unknown), other fungal diseases, and nematodes.

Insect pests do not appear to be a major constraint but research attention is needed on the leaf roller *(Stomopteryx subsecivella), Plusia chalcites, Spodoptera litura,* and *Lamprosema indicata.*

**Drought.** Groundnut frequently experiences drought stress as it is often planted in the dry season after the rice harvest. No effort has yet been made to breed drought-tolerant varieties.

**Intercropping.** On dryland, groundnut is generally intercropped with other taller food crops, such as cassava and maize. Shading up to 30% by these other crops reduces groundnut yield. Varieties suited to such conditions are not available.

**Planting on marginal land.** The groundnut area is being expanded on red-yellow podsolic soils outside Java; but yields are low because of nutrient deficiencies of the soil.

**Nonagronomic constraints.** Although groundnut is a cash crop with a reasonably stable and high price, farmers do not grow it as a main crop. One reason may be the small size of farms, forcing subsistence farmers to grow their staple food crops on most of their land. The widely scattered distribution of groundnut farms makes extension work and the supply of seed and fertilizer difficult.

### *Progress of research*

Research on groundnut at CRIFC is under way in the disciplines of agronomy, plant breeding, plant pathology, entomology, physiology, farming systems, socioeconomics, and postharvest technology. In attempting to raise crop productivity, attention is focused on varietal adaptability and yield stability.

Five groundnut varieties developed by CRIFC have been released since 1983. These are tolerant of rust disease and bacterial wilt, yield 1.8-2.1 t $ha^{-1}$, and mature in around 100 days.

Recent research has shown that medium-input levels can markedly improve groundnut yields. Deep cultivation (20-30 cm) before planting, for instance, increased yields by 19%.

Although most fertilizer studies in groundnut show no response, it seems that in poor soils the response to fertilizer can be large. On poor red-yellow podsolic soils, for instance, medium rates of fertilizer raised groundnut yields by as much as 51%. Liming also raised groundnut yields on red-yellow podsolic soils. In general, varietal screening shows that groundnut is surprisingly tolerant of acid soils.

The preliminary results of varietal screening for disease resistance have revealed a number of lines resistant to either leaf spot or rust disease.

### *Current research*

**Varietal improvement.** Segregating populations of improved genetic materials are distributed among CRIFC institutes for further testing and selection.

**Agronomy.** Improving farmers' cultural practices and cropping systems is emphasized in CRIFC's agronomy research on groundnut. Research covers fertilization with macro-and microelements, liming on acid soils, irrigation, and spacing.

**Plant pathology** research focuses on the most important diseases of groundnut: *Cercospora* leaf spot, rust, virus, and bacterial wilt diseases.

**Entomology** researchers are attempting to identify pests that may be associated with groundnut seeds.

### *Collaborative research with other institutions*

A number of collaborative projects are being carried out between CRIFC's institutes and various foreign institutions. A disease survey has been initiated in collaboration with ACIAR. At two of the sites, the introduced varieties were heavily damaged by bacterial wilt. In the other four locations this disease caused less damage, but the local varieties performed better than the introduced lines. At all six sites, all the groundnut lines were infected by peanut mottle virus. This research is continuing.

With funding from IDRC, varietal yield tests are being conducted in association with the Asian Rice Farming Systems Network, coordinated by IRRI.

### *Proposed research*

Research will focus particularly on optimum crop management for marginal land with acid soils and low fertility, and on breeding for high yields and resistance to *Cercospora* leaf spot, rust, and virus.

## Pigeonpea

The total annual production of this crop is estimated at only about 50 t of dry seed. Its main use is as human food. Local varieties are perennial, 1-2 m tall, and profusely branching. They are harvested after about 8 months. No major pests or diseases have been reported.

Considerable potential for pigeonpea exists in Indonesia, especially in the drier eastern islands, and in rotation with other crops such as cotton. Pigeonpea could prove to be an acceptable substitute for soybean in people's diets. This is especially relevant if we consider that Indonesia currently imports about 400 000 t of soybean each year.

### *Research progress since 1983*

CRIFC has been collaborating with ACIAR and ICRISAT since 1983 in pigeonpea research on varietal adaptation/yield tests, population studies, water management, and optimum sowing dates.

The highest yield obtained from these trials has been 2.5 t $ha^{-1}$. In most cases, however, yields have been low (0.4-1.0 t $ha^{-1}$) due to insect damage and viruses. Among the entries from ICRISAT, ICPL 155 and ICPL 312 yielded up to 2.5 t $ha^{-1}$ under full pest control and irrigation. The maintenance of plant spacing, pests (*Heliothis* sp and *Maruca* sp), and diseases (bacterial wilt, sterility mosaic virus, and mycoplasm) are the major constraints to higher yields.

### *Proposed research*

Research is required with regard to: crop management on marginal land; pest management; cropping systems involving pigeonpea; and varietal yield testing.

# AARD/QDPI Groundnut Improvement in Indonesia (ACIAR Project 8419)

**M.J. Bell, K.J. Middleton, R. Shorter,**
***Queensland Department of Primary Industries, Australia***
**S. Sadakin, and M. Machmud**
***Bogor Research Institute for Food Crops, Indonesia***

## Introduction

Despite the importance of groundnut in the diet of many Indonesians, production of the crop is less than the demand and yields are low by international standards. In addition, there has been a move to expand groundnut production in areas outside Java, as a response to changing priorities in agricultural research and development after self-sufficiency in rice has been achieved.

Yield constraints have been identified in three broad categories, with the research effort in each of these areas interacting to achieve a durable, satisfactory resolution of those constraints. These categories are genetic adaptation and breeding, crop agronomy and water use, and plant pathology. The research will provide a sound basis for breeding improved groundnut cultivars and the development of appropriate agronomic and disease management systems in Indonesia. A more detailed understanding of factors influencing ecophysiological adaptation of groundnut will benefit groundnut improvement programs and production in countries throughout the tropics and subtropics.

This project is seen in a complementary role to the research programs being carried out by national and international institutes. It is hoped that close collaboration with these other programs will allow the research resources of this project to make significant contributions to groundnut-yield improvement, both in Indonesia and other areas, without duplication of effort.

# Proposed Research

### *General*

The research activities associated with the groundnut improvement project are considered in two ways. These are (a) to assess the yield potential of local and introduced germplasm in Indonesia and identify yield-limiting factors (e.g., nutrition, cultural practices, or diseases), and (b) to investigate aspects of crop adaptation and disease management.

The first area of research will be conducted almost entirely within Indonesia, with extensive collaborative research between Indonesian and Australian scientists. It is desirable that this research be undertaken in consultation with other research bodies active within Southeast Asia, so that the experience, expertise, and materials available within those bodies can be utilized.

The second area of research, crop adaptation, involves activity in both Australia and Indonesia. Improved cultivars developed in one region of the world are often tested in other areas to see if they outperform local cultivars. Thus crop adaptation is a research area of particular importance for efficient and successful introduction of germplasm with improved yield potential.

Indonesian cropping systems may not facilitate the use of disease management techniques common in developed countries, so the information necessary to implement acceptable techniques will be sought.

### *Applied research in Indonesia*

Groundnuts are currently grown in a complex range of monocrop and intercrop situations. The aims of the program are to both intensify production within existing areas, and to assist in the development of groundnut production in new areas throughout the country.

Research towards these goals will be developed initially in two specific areas. These are (a) to characterize different production environments (in terms of physical attributes, cropping systems, irrigation potential, etc.), assess factors other than genotype that may limit yield in those environments, and determine research priorities for overcoming those yield limitations; and (b) to use serial sowing-date studies with local and introduced germplasm, to collect data on crop growth and development and final yield under "nonlimiting" conditions with respect to variable inputs such as fertilizer, fungicides, and irrigation. Subsequent research will use results from both sources to investigate practical agronomic and genotypic options for groundnut yield improvement.

Factors already identified as being of importance in limiting Indonesian yields include nutrition, diseases, moisture stress and plant population. Research into these areas will initially be along the following lines.

**Nutrition.** The primary objective in this area is to determine which nutritional factors limit productivity in particular regions or cropping systems.

**Diseases** are considered to be one of the most serious constraints to groundnut production. Yet accurate assessment of their impact on yield, or even thorough characterization of the causes of some diseases, are lacking. This work will be undertaken, and appropriate strategies for disease management evaluated.

**Drought stress.** Groundnut in Indonesia is grown under varying degrees of drought stress. Hydrologic modeling will be undertaken using existing climatic records (where available), to identify different production systems with respect to moisture availability, and further research will be undertaken to determine optimal agronomic inputs under various conditions.

**Plant population.** Optimal plant populations are likely to vary for different production environments; and, as seed represents a large proportion of variable costs for groundnut production in Indonesia, determining the yield-population response for various environments is of considerable importance.

### *Fundamental research in Indonesia and Australia*

Extensive collections of groundnut lines exist in various centers throughout the world, and active breeding programs for yield improvement are already under way. However, for the efficient breeding of cultivars with high-yield potential for particular sets of environmental and cultural conditions, detailed knowledge of the range of physiological responses within existing germplasm to particular factors characteristic of those environments is needed. Fundamental research will be undertaken in Australia and Indonesia in the following three areas.

**Cultivar adaptation.** The effects of radiation, photoperiod, and temperature on groundnut growth and phenology are important in cultivar adaptation, and therefore need to be investigated to assist with the breeding of cultivars for particular ecological zones. The approach will involve (a) a definition phase, in which the range of genotypic responses to a set of environmental regimes is studied; (b) a detailed study of responses of a defined subset of genotypes to specific environmental challenges and agronomic practices; and (c) an attempt to model plant growth and development. Detailed fundamental studies in the field have already begun.

**Drought stress and crop yield.** Research in this component of the program will utilize information generated from research by ICRISAT and other national and international institutions regarding genotypic variation in drought-stress tolerance, and will seek to identify mechanisms that contribute to this tolerance. These studies will be carried out in greenhouses, and in the field with rain shelters. Subsequent field studies will evaluate a range of agronomic options that will allow maximum yield development for cultivars with different degrees of stress tolerance, and for different timing and duration of stress. The latter can be selected for different environments based on the results of the hydrologic modeling process.

**Diseases and crop yield.** Virus diseases found to cause significant yield losses will require basic investigation to determine possible ways of reducing incidence or lessening their impact. If necessary, genetic resistance will be investigated and utilized.

Indonesia is one of the two countries where bacterial wilt is a serious problem in groundnut. The background level of resistance currently available in Indonesian cultivars must be maintained. To do this requires an understanding of the pathogen and inheritance of bacterial wilt resistance, together with access to the sources of resistance available.

Foliar diseases (leaf spot and rust) may have a greater impact on the yield of Indonesian groundnuts than is presently realized. The effect of disease control should be investigated experimentally using fungicides, and this information should be used to form decisions on the need for disease resistance in the cultivars grown.

## Conclusions

To make significant long-term gains in crop production, we believe that a holistic approach to crop-improvement research is of considerable benefit. It is for this reason that much of the adaptive research to be carried out in Indonesia is dependent on the identification of yield-limiting factors under specific cropping systems and conditions. The approaches chosen for research into specific problems will be determined after detailed consultation with appropriate specialists or research programs.

This project presents an opportunity to evaluate groundnut performance across a wide range of genotypes and environments, and to provide detailed information necessary for efficient breeding and selection of cultivars for particular target environments that exhibit specific challenges to yield achievement. The data generated from this collaborative research program, combined with data from other studies, will be used to evaluate or expand existing dynamic crop-growth models, or begin the development of a predictive-yield model if necessary. Although a final fundamental model will not be achieved during the course of the project, it is hoped that, by its conclusion, development will have reached a stage where some validation and assessment of the predictive capabilities of the model will be possible. The implications of model development for research in other areas are considerable.

# The CGPRT Centre and Grain Legumes

**J.W.T. Bottema**

*Economic and Social Commission for Asia and the Pacific,*
*Regional Coordination Centre for Research and Development of Coarse Grains,*
*Pulses, Roots, and Tuber Crops, Indonesia*

## Introduction

The Regional Coordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber (CGPRT) Crops in the humid tropics of Asia and the Pacific was established in 1981 as a subsidiary body of the Economic and Social Commission for Asia and the Pacific (ESCAP) of the United Nations. In 1983, the CGPRT Centre moved to Bogor, Indonesia.

Because of limited resources, the Centre has initiated only a modest research program since 1983, of which one component falls directly within the scope of this Review and Planning Meeting for Asian Regional Research on Grain Legumes, and of which five components bear a direct relation to the theme of grain legumes development. In accordance with the Centre's mandate, the studies are socioeconomic in nature, although agronomic elements are not excluded.

## Study of the Potential for Pigeonpea in Indonesia, Thailand, and Burma

This study is funded by the Australian Development Assistance Bureau (ADAB) and explores the potential for development of pigeonpea, taking agronomic and economic factors into account. The study is being carried out by an interdisciplinary team from the University of Queensland.

## The Soybean Commodity Systems in Indonesia

This study was completed in October 1985, and the report is in press. The study analyzes the development of soybean in Indonesia as a commodity, utilizing microeconomic as well as macroeconomic data and methods of analysis. Major constraints are identified: seed supply, farmers' incentives in relation to government policy, and marketing. It is concluded that the objective of attaining self sufficiency, although commendable, may not be achieved within a short period.

## Socioeconomic Studies on Soybean-based Farming Systems at Village Level in Indonesia

Farmers' bookkeeping methods have been studied in order to gain insight into the flow of money, goods, and labor within the village economy. The major objective is to identify the position of the present major cash crop of soybean in relation to constraints at household and village level in a general sense.

Farmers' and household decisions will be evaluated against alternatives in order to arrive at an overview of household priorities.

## Study of Soybean Yield-gap Analyses in Indonesia

The objective of this study is to compare farmers' use of inputs, and the yields they achieve, with potential attainable yields on-farm and on research stations. After completion of the explorative phase, on-farm trials and research may form part of the study. Finally, recommendations for improved technology and input levels will be made within the framework of the soybean production development program

## Studies of Constraints to Increased Production and Productivity of Selected Crops in Selected Asian Countries

The first phase of these studies has been completed. It included a study of the supply and demand of selected crops, including soybean, maize, and lentils in seven Asian countries. In the second phase microeconomic information will be collected on a number of relevant crops. The study is funded by the UNDP and FAO within the framework of the RAS/82/002 program.

## Study of the Demand for Selected Crops in Indonesia and Bangladesh

A demand study for human consumption as well as animal feed has been carried out in Indonesia, using secondary as well as primary data. The purpose of the study is to assess the viability of production systems, based on the projected demand for soybean, maize, and other secondary crops. The study in Bangladesh is expected to be finalized in 1986.

## Summary

The CGPRT Centre, following its research programs on production systems, demand/supply, and marketing, plans to initiate regional research programs that are sectoral and more macroeconomic in nature. A program on CGPRT and nutrition has already started.

The Centre's resources and capacity have expanded since 1983. Presently, the core staff of the Centre numbers four economists and one agronomist; additionally the Centre utilizes, where possible and appropriate, national consultants in its study projects. The Centre remains actively interested in the field of grain legumes. In general, the Centre follows a policy of cooperation and of sharing resources with national and international agricultural research centers, as well as with other institutions involved in similar activities.

(Editor's note: Not summarized.)

# Summary Information on the FAO/UNDP Project RAS/82/002

**B.H. Siwi**

*Central Research Institute for Food Crops, Indonesia*

Project RAS/82/002-TCDC, for the Research and Development of Food Legumes and Coarse Grains in the tropics and subtropics of Asia, is a UNDP-funded project executed by FAO.

## Objectives

The long-term objective of countries participating in the project is to substantially increase the production of food legumes and coarse grains in the tropics and subtropics of Asia, in order to bridge the gap between the growing demand and the production of these crops. The operational objectives are as follows.

- To establish, in the spirit of Technical Cooperation among Developing Countries (TCDC), a cooperative network among the participating countries in the tropics and subtropics of Asia, that produce coarse grains and food legumes, to support and promote national research and development programs.
- To establish intraregional country-to-country assistance programs on a TCDC basis for the support of national field-oriented and action programs related to plant breeding, agronomy, biological nitrogen fixation, integrated pest management, and seed production.
- Through networking to improve and disseminate known technologies for adoption by cooperating countries; to establish network contacts where they are nonexistent; and to intensify and expand the extension services in countries having development programs concerned with the production of coarse grains and food legumes.
- To undertake in-depth analyses of socioeconomic constraints to production and distribution, and to evolve strategies to exploit economic, employment, and nutritional potentials of coarse grains and legumes, within different farming systems.

## National Coordination

The Central Research Institute for Food Crops (CRIFC) at Bogor, Indonesia, serves as the Project headquarters, and the Director of CRIFC has been designated as Project Coordinator.

In 1983 cooperating governments were approached, through FAO/UNDP representatives, to nominate a national coordinator. These coordinators were asked to act as the focal point for Project activities at the national level, and to establish national coordination committees to review the activities and progress in related research and development programs. By December 1985 10 countries (Bangladesh, Indonesia, the Republic of Korea, Laos PDR, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam) had nominated national coordinators and/or national committees. India may also join the network, and is likely to designate a national coordinator.

Five working groups concerned with maize, legumes, biological nitrogen fixation (BNF), integrated pest management (IPM), and seeds have been established. These working groups have reviewed the present status of research and development, indentified constraints and research priorities, and made proposals for action.

## Constraints in Development

Development of food legumes and coarse grains is constrained by numerous factors, many of which are of a socioeconomic nature, related to production, consumption, utilization, or marketing. The scarcity of reliable and comprehensive information on food legumes and coarse grains calls forin-depth studies of all these aspects, as well as of the main food grains in most developing countries of the region. ESCAP has been subcontracted to undertake studies of the socioeconomic implications of these crops. The initial focus was on maize and soybean in Southeast Asia, and on two or three pulses in South Asia.

## Technical Cooperation and Training

The areas of technical cooperation among the participating countries have been identified. They include the following.

- Exchange of germplasm.
- Exchange of rhizobial strains.
- Variety trials with maize and soybean under different agroclimatic conditions and of sufficient duration to identify suitable cultivars for different zones.
- Regional training on seeds, *Rhizobium,* and integrated pest management, to strengthen staff expertise in cooperating countries.
- Workshop(s) on improved seed production, postharvest handling and prevention of losses, germplasm management and utilization, including regional varietal testing, rhizobial technology, integrated pest management, and socioeconomic aspects.

The exchange of germplasm has been initiated among several participating countries. A germplasm catalog for the dissemination of information to participating countries is under preparation. Based on this catalog, specific activities in germplasm exchange by individual countries will be strengthened.

Regional varietal trials of soybean in different agroecological conditions are being organized. Similarly, in the case of maize and *Rhizobium* strains, material is being collected for regional testing. It was agreed to initiate trials on mung bean, sorghum, chickpea, and other selected coarse grains and legumes.

A regional training course on seed technology, to train manpower to meet the demand for skilled personnel, was organized in April-May 1985 in the Philippines at the International Training Centre on Seed Technology.

Regional training programs on *Rhizobium* technology, improved maize production, and techniques for screening against diseases, including viruses, are planned. These training courses have been identified in collaboration with NifTAL, BIOTROP, CIMMYT, IRRI, and IITA.

A proposal for the design of seed-drying facilities that are relevant to village-level conditions, and involve locally available materials, is being considered in Thailand in collaboration with the Asian Institute of Technology, and in the Philippines with the Regional (Asian) Network for Agricultural Machinery.

A workshop on germplasm management and utilization, in cooperation with IBPGR and ICRISAT, is also planned. ICRISAT has indicated its willingness to organize a training program on specific aspects of its mandate crops, in collaboration with project activities. Detailed terms of reference are under preparation. Similarly, Project staff are interacting with the IAEA with a view to arranging collaboration on specific aspects of the Project's activities.

(Editor's note: Not summarized.)

# Grain Legume Production and Problems in Nepal

**A.N. Bhattarai**

*Agronomy Division, Department of Agriculture, Khumaltar, Nepal*

## Introduction

Legumes are important crops in Nepal, both in terms of their contribution to human nutrition and as components of an indigenous cropping system for improving soil fertility. They are grown on 216 700 ha and the national production is 90 200 t (1983 data).

Among the important legumes grown in the country are lentil, grass pea, chickpea, horse gram, soybean, black gram, and pigeonpea. Chickpea comprises 16.1%, pigeonpea 6.0%, and groundnut 1.9% of the total legume crop production in Nepal.

### *Organization*

The National Grain Legume Improvement Program (NGLIP) deals with the research and development program of all the field legume crops except groundnut. In Nepal, the National Oilseed Development Program (NODP) has been given a mandate to work on oilseed crops, such as *Brassica* spp, linseed, sesamum, and groundnut. The Nepal Vegetable Ghee Factory has a capacity requirement of 20 000 t of groundnut per annum.

A long-term master plan for the legume program has been formulated. IDRC has agreed to support and strengthen legume research efforts in Nepal for 2 years initially. The USAID-supported Agricultural Research and Production Project will provide some infrastructural and training facilities.

## *Cropping patterns (by region)*

### Tarai

1. Rice/lentilor /+ chickpea or /+ grass pea.
2. Rice-rice/chickpea or /+ lentil or /+ grass pea.
3. Pigeonpea, alone in western uplands, and rice + pigeonpea on bunds.
4. Groundnut-fallow.

### Inner Tarai

1. Rice-(chickpea or lentil or grass pea) + mustard-maize.
2. Rice + pigeonpea on bunds-wheat.
3. Maize-chickpea + mustard/lentil.
4. Maize + groundnut-fallow.

### Hills

1. Rice + soybean or black gram on bunds-wheat.
2. Maize + soybean or black gram or horse gram.
3. Maize + groundnut-fallow.

### *Research capabilities*

There is considerable scope for strengthening research capabilities. There are 15 testing stations and 6 cropping-system sites in different parts of the country. More than 12 farming-system sites are planned to be established within 5 years. The NODP has some infrastructural facilities that need to be strengthened. The legume program has to develop its infrastructural facilities at its headquarters and the main subcenters.

### *Manpower*

All the discipline-based divisions are located at Khumaltar. Most of them have some research officers working on legume crops. The microbiological laboratory has about 10 research workers who are working on legume crops partially or fully. The NGLIP itself has four core research officers, two each at Khumaltar and Parwanipur. There are five scientists working in the NODP and they work mainly on *Brassica* in winter and groundnut in summer.

### Training

Training opportunities for the research workers have been very limited. Only one researcher from Nepal has been trained in grain legumes at ICRISAT.

### Linkages with international institutes and other aid-giving bodies

FAO had rendered assistance to the NODP. USAID-aided projects, such as the Integrated Cereals Project (ICP), have provided some nominal help for the legume program. Now IDRC has offered to support the legume research program. The Agricultural Research and Production Project (ARPP), funded by USAID and started in 1985, is planning to provide some infrastructural facilities at the proposed headquarters. The World Bank had provided some infrastructural facilities at the headquarters of NODP.

There has been close contact with IRRI under the Asian Rice Farming Systems Network. However, Nepal's contact with ICRISAT has been weak until recently. Our chickpea, pigeonpea, and groundnut programs have been receiving various materials from this Institute. Some ICRISAT scientists have visited Nepal, and some Nepalese scientists have visited ICRISAT on study tours and to attend conferences.

We are participating in the international crop testing program of ICARDA. Until now, the Nepalese legume program has not been strong enough to obtain full benefit from international institutes and donor agencies.

### Regional cooperation

IRRI's Asian Rice Farming Systems Network has taken some helpful steps to increase regional cooperation. It provides trial sets of groundnut and other legumes to participating countries. Promising varieties or materials from various countries and international institutes are included in this trial. Nepal is trying to establish a direct link with India, Pakistan, and Bangladesh for the exchange of promising materials.

## Major Constraints in Production

Rice, maize, and wheat are considered the main crops in Nepal, and legume crops as secondary crops. Groundnut, chickpea, and pigeonpea are grown under rainfed conditions, generally in less-fertile soils. Farmers pay less attention to the cultivation of these crops than to tending their main crops. However, with low wheat prices, and a recent rise in the price for pulses, chickpea is receiving more attention than before and its area of cultivation is increasing. The major constraints in increasing production and yield of these crops are as follows.

*Groundnut*

- Lack of organized marketing and price incentives.
- Lack of a recommended technology for high yields.
- Disease attack particularly by cercospora leaf spots, root rot, and viral diseases.
- Low pH in the hills.

*Chickpea*

- Lack of a recommended technology for growing irrigated chickpea.
- Disease attack, particularly wilt, botrytis, root rot, and insect attack, especially pod borer.
- Little care traditionally given to the cultivation of this crop.

*Pigeonpea*

- No recommended technology for improved production.
- Pod fly and borer damage.
- Little care given to the cultivation of this crop.
- Sterility mosaic virus disease.

## Progress Made Since 1983

A long-term proposal for the establishment of a well organized National Grain Legume Improvement Program has been prepared. The research program for each crop is going to be expanded from 1986. For oilseed crops, such as groundnut, a long-term program and a proposal for IDRC assistance is being planned.

**Groundnut.** Early-maturing ICRISAT varieties (e.g., ICGS 35, ICGS 36, and ICGS 37) have been identified as better yielders than the recommended variety B-4. These varieties have given 20-50% higher yields than B-4 and are being multiplied and popularized.

**Chickpea.** The local selections Dhanush and Trishul are still holding promise but these varieties have small seeds. Three others have shown promise and are proposed for release, followed by three more under selection. Maloran(®) 1.5-2.0 kg $ha^{-1}$ a.i. has given perfect control of weeds in chickpea and lentil without toxic effects.

**Pigeonpea.** Sowing pigeonpea as a winter crop is a new development and could produce up to 1 t $ha^{-1}$.

## Current Research

**Groundnut.** Coordinated varietal trials, plant protection trials, fertilizer trials, and cultivation trials are under way at the national level. National institutions are cooperating with ICRISAT in varietal testing and IRRI is conducting regional research trials.

**Chickpea.** Coordinated varietal trials, plant-protection trials, and weed-control trials are under way at the national level. ICRISAT nurseries are used and there is collaboration in ICARDA trials.

**Pigeonpea.** Local-material trials are under way at Nepalgunj. Research on ICRISAT material for summer and winter seasons is also in progress.

## Proposed Research

There will be emphasis on developing high-yielding and disease-resistant varieties of chickpea, groundnut, and pigeonpea. The prospects of breeding a pigeonpea for growing after early rice will be investigated. Cooperative programs with ICRISAT, IRRI, and ICARDA will be continued for varietal and other testing of these three crops. However, lack of trained manpower and good infrastructural facilities hamper research.

# Grain Legume (Chickpea and Pigeonpea) Production and Problems in Pakistan

**Bashir A. Malik**

*Pakistan Agricultural Research Council (PARC), Islamabad*

## Chickpea

Pakistan's requirement for chickpea during 1985-86 is estimated to be about 562 000 t. At the estimated consumption rate of 4.2 kg per capita per annum, production is expected to fall slightly short of requirements. As Pakistan's population is increasing at the rate of 3% per annum, chickpea production would also have to increase at the rate of 3% per annum, to maintain current consumption levels.

Chickpea production during 1984/85 was 524 000 t, obtained from 1 014 000 ha, an increase of 9% in area over 1983/84. The increase in production was nominal (0.4%) due to prolonged drought. The productivity and production of chickpea determines the availability of other pulses in the country.

### *Research status*

Despite the vital importance of chickpea in Pakistan, the crop has normally been associated with poor soils, poor people, and rainfed agriculture. Lack of research support for chickpea development in the past has resulted in the nonavailability of high-yielding, disease- and insect-resistant varieties, lack of trained manpower, literature, funds, and information.

### *Efforts to improve production*

The improvement of chickpea yield levels to equal those of cereal crops may not be possible because of the "caloric penalty", i.e., production of a unit of protein requires about twice the number of calories required for a unit of carbohydrate.

Countrywide experiments have indicated three possibilities for increasing production: (a) as a monocrop in rainfed areas; (b) as an intercrop or companion crop in rainfed areas; and (c) as a catch crop in irrigated areas.

Research for materials with higher-yielding potential, possessing built-in tolerance of drought, pests, and diseases, suitable for rainfed farming, and for input-responsive lines for integrated farming, is in progress and will be the major component of regional collaboration. With the increasing availability and viability of the necessary germplasm, it should now be possible for plant breeders in Pakistan to select high-yielding cultivars to suit different agroclimatic conditions.

### *Research capabilities and linkages*

Chickpea research in Pakistan operates at two levels, i.e., federal and provincial. Chickpea research is integrated through a Cooperative Research Program headed by a National Coordinator.

Establishment of research and production linkages at national and international levels are imperative. Linkages are provided at the national level through the National Coordinated Research Program on Grain Legumes in Pakistan. Similarly, excellent linkages currently exist with regional and international centers, such as ICRISAT, ICARDA, and ACIAR.

## Major Constraints in Production

Physical production constraints are as follows.

- Unreliable rainfall.
- Marginal soil types.
- Poor cultivation practices.

Technological production constraints are a lack of the following.

- Suitable cultivars.
- Recommended cultivation practices.
- Effective pest management.
- Input supplies.
- Effective technology transfer.
- Trained scientific manpower.

Economic production constraints are as follows.

- Inadequate resource allocations.
- Lack of labor.
- Inadequate credit.
- Inadequate transport and marketing facilities.

## Current Research

### *Chickpea breeding and agronomy, 1983/84*

Five thousand accessions of desi and kabuli chickpea from ICRISAT have been evaluated for seven different characters. On the basis of these data, 43 lines that showed better-than-average agronomic performance were selected for preliminary yield trials during 1983/84. As many as 199 lines were selected for breeding and were utilized in the hybridization program for the genetic improvement of yield components.

Other trials concerned off-season chickpea, fertility, inoculation, advanced-generation yield, national uniform yield, desi chickpea in multilocations, kabuli chickpea yield, and the effect of trace elements on chickpea physiology and yield.

### *Chickpea pathology during 1983/84*

**Germplasm screening for ascochyta blight.** At NARC, 3360 lines out of 4548 received from ICRISAT were screened for ascochyta blight resistance under artificial disease conditions.

**National and international chickpea screening nurseries for blight resistance.** Out of 70 test entries only 2 were found to be free from pod infection, and only 1 was free from seed infection.

In the international kabuli chickpea screening nursery, 42 out of 60 test entries were rated as resistant/tolerant. In the international desi, late-maturing chickpea screening nursery from ICRISAT, out of 50 test entries none was rated as 1-3 in the 1-5 scale. In the national ascochyta blight chickpea nursery, out of 306 entries none was rated as 1-2, but 6 were rated as 3.

In the international chickpea root rot/wilt nursery from ICRISAT at NARC, the root rot/wilt was not severe in the seedling stage, but the disease was more severe in phase II. Out of 60 entries tested, 3 were considered as resistant/tolerant.

At Faisalabad it was found that wilt, predominantly caused by *Fusarium* spp, and root rot also lessen the yield of the chickpea crop drastically. The problem is more severe with individual farmers in specific fields.

**Chemical control of chickpea blight.** Chlorothalonil (Daconil®) at the rate of 1.5 kg ha$^{-1}$ a.i. increased yield by 62% over the control.

**The nematode problem.** During the 1983/84 season two cultivars were found showing symptoms of poor plant growth, yellowing of foliage, and general stunting. On uprooting, several root knots were observed. The specimens were identified as *Meloidogyne incognita.* It is the first report of nematode on chickpea in Pakistan.

### *Chickpea pathology during 1984/85*

**Germplasm evaluation for resistance to ascochyta blight.** A hundred and ninety-six chickpea lines among the ICRISAT material selected as resistant/tolerant to ascochyta blight during 1983/84 were replanted in the 1984/85 winter season and were tested against blight. None of the lines was rated as 1-3.

**National/international ascochyta blight screening nurseries.** Three nurseries have been screened. In one, no line out of 442 was rated as 1-2. In a nursery from ICARDA 35 entries showed resistant/tolerant reactions against blight. And in a nursery of early-maturing desi chickpeas from ICRISAT, no resistant/tolerant lines were noted.

**Screening of breeding material.** Two hundred and twenty-five $F_4$ populations obtained from NARC breeders were tested against blight. There was wide variation between resistance and susceptibility.

### *Entomological work during 1983/85*

Studies on host-plant resistance of chickpea germplasm lines against *Heliothis armigera* were initiated in the 1983/84 season. Population studies with the aid of pheromone traps showed that the *H. armigera* population started rising from the 1st week of March 1985 and reached a maximum level in the 2nd week of April 1985. After that, trap catches gradually declined. Studies were also initiated to investigate the extent of parasitism of *H. armigera* larvae by its active parasite *Campoletis chlorideae.*

## Proposed Research Approaches and Problems Faced in Research

The aspects of research that require attention by national as well as regional collaborative research and production programs are as follows.

- Low productivity.
- Seed availability.
- Suitable genotypes for intercropping and monocropping.
- Crop management,
- Rhizobium.
- Seedling vigor and early establishment.
- Diseases (mainly ascochyta and the wilt complex).
- Insect pests (mainly pod borer and bruchid).
- Cultivation and postharvest mechanization.

- Inefficient iron utilization.
- Susceptibility to low temperatures at germination.

## Pigeonpea

No separate area and production statistics of pigeonpea have been recorded in Pakistan. It is grouped together with pulses. The high-rainfall areas of northern Punjab, North-West Frontier Province, and Kashmir have good potential for testing pigeonpea. Similarly, the irrigated areas of Sind and southern Punjab that do not grow cash crops economically need exploration. The basic requirement is for early-maturing crops. The perennial types of pigeonpea have scope in watershed catchment areas, and will be tested there.

# Groundnut Cultivation in Pakistan

**A. Rahman Khan and Naazar Ali**

*Pakistan Agricultural Research Council, Islamabad*

## Introduction

In Pakistan, groundnut cultivation dates back to 1949 and the crop is mainly grown as a cash crop because all the produce is consumed as roasted nuts. The crop is mostly cultivated in rainfed and river floodplain areas of the country. About 92% of the groundnut-growing area is in the province of Punjab, 7% in North-West Frontier Province, and 1% in Sind. In Punjab, 87% of the groundnut-growing area is located in Rawalpindi Division, and only a small area is irrigated. The total area under groundnut during 1983/84 was 72 600 ha, with a total production of 88 000 t. The average pod yield obtained during 1983/84 was 1.2 t $ha^{-1}$, which is lower than that of other groundnut-growing countries.

The average yield is decreasing yearly. However, if significant efforts are made to remove the constraints in crop improvement, the average yield can easily increase to 1.8-2.0 t $ha^{-1}$.

The Barani Agricultural Research and Development (BARD) project, sponsored by CIDA, has been entrusted with responsibility for national groundnut research since 1984. A groundnut adviser arrived in October 1984 from North Carolina State University, USA, and is working at the National Agricultural Research Centre (NARC) in close coordination with the provincial groundnut scientists.

## Production Practices

### Cultivars

Two main varieties are cultivated in the country, as follows.

**No. 334.** This is a runner type, released in 1972, and grown in Rawalpindi Division. It is medium-seeded with well filled pods, which makes it desirable for table use. Its shelling percentage is 60-70% and it has an oil content of 50% with a low free fatty acid value. It matures in about 200 days and the yield potential is 2.5-3.0 t $ha^{-1}$.

**Banki.** This is a bunch type released in 1973. It is medium-seeded and high-yielding. It has the good characters of no. 334, is less labor-intensive, cheaper, and easy to harvest. It matures in 180-200 days and has a yield potential of 3.0 t $ha^{-1}$.

### Sowing

The sowing time varies for different parts of the country. In Barani areas sowing starts from the end of March and continues up to June, depending upon the availability of moisture in the soil. Sometimes it is even sown in July after the onset of the rainy season. In irrigated areas the optimum sowing time is the 2nd fortnight of March.

On small farms, seeds are usually sown in furrows made by the desi plow. But some farmers broadcast the groundnut seed.

Farmers usually use 20-25 kg $ha^{-1}$ of seed for the spreading type, and 30-40 kg $ha^{-1}$ for the bunch type.

### Fertilization

Most farmers do not apply fertilizer to the crop, but some use fertilizer at the rate of 2.5 bags of di-ammonium phosphate per ha. Farmers usually apply farmyard manure before sowing.

### Crop Management

**Insect pests and diseases.** The major insects attacking groundnut are hairy caterpillars, thrips, termites, and grasshoppers. No insecticide is used to control these insects because of its high cost and nonavailability, and farmers' lack of knowledge of application techniques. Vertebrate pests are rats, wild boars, and porcupines. The damage caused by rats is sometimes more than 90%.

The most serious disease is late leaf spot *{Phoeoisariopsis personata).* The other diseases reported are root rot and fusarium wilt.

**Weeding.** Weeds pose a severe problem in groundnut cultivation. Usually no weeding is done by the farmers. In some areas farmers use weeds as fodder during the rainy season. Herbicides are not being used in groundnut fields.

**Rotation.** Groundnut is mostly planted after wheat. Usually the rotation followed is wheat-groundnut-fallow-wheat. In some areas, however, farmers use a wheat-groundnut-melon-wheat rotation.

**Intercropping.** Normally groundnut is cultivated as a monocrop. But a few farmers intercrop maize, pearl millet, and sorghum with the groundnut crop.

Harvesting. Most of the crop is harvested by hand, which is a costly operation. But some farmers are now using a tractor-mounted digger for groundnut harvesting, which is gaining in popularity.

**Curing.** This is being done by sun-drying the harvested crop for 8-10 days, to achieve the desired flavor and quality.

## Major Constraints in Production

- Damage by pests such as rats, wild boars, and porcupines.
- Lack of short-season varieties that could permit double-cropping with wheat.
- Nonavailability of quality seed.
- High harvesting costs and losses.
- Lack of credit facilities for the purchase of inputs by farmers.
- Wide fluctuation in prices and an inadequate marketing structure.

## Progress Made Since 1983

### *Varietal improvement*

Over 400 germplasm lines have been screened for high yield and early maturity. Promising lines have been selected and are under preliminary yield trials.

Two varieties from North Carolina have shown promising results in advanced yield trials. Their seed increase is in hand for on-farm testing.

A breeding program has been initiated at NARC, Islamabad, to develop early-maturing and high-yielding adapted varieties. In collaboration with ICRISAT, 30 high-yielding ICGS lines were evaluated in preliminary yield trials and 19 extra-early-maturing lines in IGEMCT were evaluated for yield and maturity.

### *Agronomic studies*

In a spacing trial with a bunch-type local variety, Banki, the results indicate that 30-cm row spacing gave the highest pod yield of 4.9 t $ha^{-1}$.

On the basis of these results, a ridge-versus-flat trial was done in 1985, and it was found that a 30-cm row spacing again significantly outyielded a wider row spacing of 60 cm. In this experiment, a four-row bed gave the highest pod yield of 2.7 t $ha^{-1}$.

Since 1983, sowing-date trials have been conducted at NARC and the cooperating provincial institutes, and optimum sowing dates have been established for various agroclimatic areas.

## Current Research

The following research activities are in hand at NARC, Islamabad.

### *Crop improvement*

- Evaluation of germplasm received from ICRISAT, Senegal, USA, and other sources.
- Evaluation of early-maturing varieties in preliminary and advanced yield trials.
- Improvement of local varieties through mass selection.
- Advanced yield trials of promising varieties.
- Development of high-yielding and early-maturing varieties through a groundnut-hybridization program.
- Production and multiplication of quality seed of improved varieties.

### *Agronomic studies*

- Evaluation of ridge-versus-flat sowing methods and row spacing.
- Evaluation of different sowing dates.
- Development and improvement in production practices to increase groundnut yield per unit area.

### *Cooperative research*

- Advanced national uniform yield trials are being conducted in provincial research institutes.
- The BARD project provides a groundnut expert to work at NARC in close collaboration with the provincial programs.
- Evaluation of high-yielding ICGS selections from ICRISAT.
- Evaluation of the International Groundnut Extra-early-maturing Cultivar Trial, 1985, from ICRISAT.

## Proposed Research

### *At NARC*

- Evaluation of exotic germplasm and promising lines.
- Screening for disease resistance and other agronomic characters.

- Determination of optimum sowing dates, spacing, sowing methods, weed control, and harvest time for locally adopted varieties.
- Development of improved vertebrate pest control techniques.
- Evaluation and development of a groundnut planter, thresher, and decorticator.

***Cooperative research***

- Screening of early-maturing and high-yielding selections from ICRISAT.
- Determination of the efficiency of different *Rhizobium* strains in cooperation with North Carolina State University, USA.
- Cooperation with UN advisers in the development of a groundnut thresher.
- Winter seed increase of promising ICGS(E) lines at ICRISAT to permit the multilocational testing of extra-early lines.

## Problems Faced in Research

- Lack of trained manpower.
- Inadequate coordination between national and provincial programs.
- An ineffective agricultural extension system.
- Lack of information on international seminars, conferences, and meetings on groundnut.

# Grain Legumes Research and Development in the Philippines: Current Status

**Dely P. Gapasin and Bethilda E. Umali**

*Crops Research Department, Philippine Council for Agriculture and Resources Research and Development, Los Banos*

## Introduction

One of the most widely grown grain legumes is groundnut, locally known as "mani". It has high priority in research and budgetary allocation. Pigeonpea and chickpea are considered as minor grain legumes. In 1984, 45 960 ha were planted to groundnut and produced 42 302 t. Although recommended varieties can produce 1.3-2.0 t $ha^{-1}$, the national average yield remains at 0.92 t $ha^{-1}$.

Farmers in the Philippines grow groundnut mainly in lowland rainfed and upland areas. It is important as a second crop in the rice-based cropping system. Many farmers intercrop it with maize, cassava, sugarcane, coconut, papaya, citrus, and rubber. There are no production data for pigeonpea and chickpea. These crops are grown mostly as backyard crops and as border crops on farms.

# Groundnut

### *Major constraints in production*

The major constraints in groundnut production in the Philippines are erratic rainfall patterns, marginal soils, lack of quality seeds, pests, diseases, lack of agricultural credit, limited transportation and marketing facilities, and lack of price incentives.

### *Current status of research*

**Varietal improvement.** The National Plant Genetic Resources Laboratory houses 12 300 accessions of 17 species of food legumes. Agronomic evaluation, including reactions to major diseases and insect pests has been done for groundnut, but only to a limited extent for pigeonpea and chickpea.

Currently, there are two groundnut production systems: monoculture (after rice), and mixed cultivation. Currently sown groundnut varieties are adapted mainly to upland, monoculture conditions. However, since 1982, emphasis has shifted to the development of new varieties suited to stress environments, rainfed areas, marginal areas, and those that fit well within different farming systems.

The Grain Legume Varietal Improvement Program aims to identify genetic sources for high yield, resistance to major pests, high nitrogen-fixing capacity, and tolerance to partial shade, drought, waterlogging, and paddy conditions.

The University of the Philippines at Los Banos (UPLB) also has implemented a collaborative project with North Carolina State University (NCSU), and is funded by the Peanut Collaborative Research Support Project (Peanut CRSP), started in 1983. Through this project, 177 new groundnut cultivars/accessions from ICRISAT and NCSU have been added to the germplasm collection.

Preliminary yield trials of ICRISAT lines were conducted after rice at the Pangasinan State University. Five high-yielding lines have been identified.

**Screening for shade tolerance.** Groundnut lines were screened using shade structures, where light intensity was reduced to effect 40% shade. Several promising varieties have been selected.

**Screening for enhanced biological nitrogen fixation (BNF).** In 1983, 64 groundnut lines were screened for enhanced BNF in the open and under partial shade. Three lines produced the highest ethylene $g^{-1}$ of nodule $h^{-1}$, by acetylene reductase assay.

**Screening for tolerance to acid-soil conditions.** In 1982-85, several experiments were conducted using such acid soils as Adtuyon clay (pH 4.21), Lipa clay loam (pH 4.55), and Antipolo clay (pH 4.8). Six lines showed potential tolerance of acid soils in Antipolo clay.

**Screening for pest resistance.** Three accessions were found resistant to rust while two were resistant to *Cercospora* leaf spot under natural field infection. Of the 68 entries from three yield trials none of the tested materials showed resistance to the groundnut leaf hopper. The 81 accessions from ICRISAT had higher levels of resistance to leaf hopper damage than materials from the Institute of Plant Breeding (IPB).

**Varietal improvement for the rice-based cropping system.** UPLB and IRRI conduct a joint varietal-improvement project for dryland legume crops suited to the rice-based cropping system. Seven lines of groundnut have been identified.

**Regional variety trials.** These regional trials evaluate the performance of selected breeding lines of legumes in 10 locations throughout the country. Three lines, after testing for four seasons, have been recommended for seed multiplication.

**Biological nitrogen fixation (BNF):** *Rhizobium* inoculation. Field trials on legume inoculation using several local and Hawaiian strains in Negros Occidental, Isabela, and Laguna were done in cooperation with the NifTAL Project of the University of Hawaii and the Peanut CRSP. Legume inoculation with *Rhizobium* had a fertilizing value either equal to or better than the application of 30 kg N $ha^{-1}$. Two lines and one cultivar were top dry matter yielders, and three *Rhizobium* strains produced the best results.

**BNF: Mycorrhizae.** Initially, six species of the vesicular-arbuscular mycorrhizal (VAM) fungus were collected, isolated, and identified from the rhizosphere soil and root samples in groundnut-growing areas. The mycorrhizal formation of various VAM fungi in three groundnut varieties were tested in pot experiments. Among the fungi tested, only *Glomus deserticola* gave promising results in terms of developed mycorrhizae and better plant growth.

### *Integrated pest management*

In a collaborative project with the Peanut CRSP and UPLB, groundnut lines are evaluated for resistance to major insect pests, the efficacy of *Bacillus thuringiensis* and selected insecticides, effect of calcium sources on insect population density, insect damage and yield of groundnut, and yield reduction.

University of Southern Mindanao researchers have found that the best control against weeds *(Rottboellia exaltata, Cleome rutidosperma, Boerhavia erecta, Amaranthus spinosus,* and *Ipomoea triloba)* was attained when hand weeding was done at 40 days after sowing, as a follow-up to pendimethalin (1.25 kg $ha^{-1}$ a.i.), off-baring, and hilling up.

### *Postharvest handling and utilization*

**Storage.** The UPLB is currently evaluating the effect of pretreatments on the shelf life of shelled groundnut stored at room temperature. These pretreatments include steaming-drying and steaming-drying-roasting.

**On-farm trials.** The on-farm trials comprise technology verification and component technology trials. These are means of evolving location-specific technologies that aim to improve existing farmer practices in productivity and net income. The on-farm trials conducted in 12 regions of the Philippines have been implemented and coordinated by the Ministry of Agriculture and Food's Regional Integrated Agricultural Research System. Many cropping patterns are being tested, the most important of which include: maize-maize-groundnut, rice-groundnut, and coconut + maize-groundnut.

## Pigeonpea

Little research on pigeonpea is being conducted in the Philippines. It is focused on germplasm collection, evaluation, and preliminary yield trials.

The Mariano Marcos State University in Northern Luzon has evaluated 24 pigeonpea lines from ICRISAT during the dry season (1984-85). The highest yield per 18 $m^2$ plot was 1.51 kg. At the Cagayan State University, three accessions from ICRISAT have been evaluated. Material from ICRISAT is also being screened at the Institute of Plant Breeding, UPLB, and at Bureau of Plant Industry stations at Bicol, Ilagan, and La Granja.

## Chickpea

The Ilagan Experiment Station of the Bureau of Plant Industry in Northern Luzon is evaluating 13 chickpea entries from ICRISAT in an adaptation trial. The highest yield among 13 entries was 1.48 t $ha^{-1}$.

## Updated Research Thrusts

During the First National Peanut Consultation Meeting and Peanut CRSP Review held in February 1985, the following priority research areas were identified for groundnut.

- Benchmark information and agroeconomic assessment of production, postharvest processing, utilization, and marketing.
- Improvement of postharvest handling techniques such as stripping, drying, and storage, to manage the aflatoxin problem; standardization and improvement of packaging to prolong shelf life and improve the acceptability of food products.
- Development of a low-cost technology to reduce high fertilizer and pesticide costs.
- Development, improvement, and utilization of village-level processing.
- Water and fertilizer requirements.
- Disease management, with emphasis on the epidemiology of viruses and the development of an integrated approach to the control of major diseases.
- Testing, evaluation, and improvement of farm tools and equipment suitable for small-farm conditions.

- Testing and evaluation of technology packages under various agroecological conditions.
- Development of technology transfer techniques.
- Development of integrated insect-pest management and the establishment of the economic-threshold level for major insect pests.
- Development of high-yielding, pest-resistant varieties that are also tolerant of stress conditions and suited to various cropping systems.

It is expected that these priories will be expanded soon to include studies on tissue culture, aflatoxin control, product improvement, and disease management.

# Grain Legume Production and Problems in Thailand

**Montien Somabhi**

*Khon Kaen Field Crops Research Center,*
*Field Crops Research Insitute, Department of Agriculture, Thailand*

## Introduction

Grain legumes are an integral part of Thailand's agriculture, but they are not exported. Over 100 000 t of groundnut are produced annually. Pigeonpea and chickpea are grown only in very small quantities.

Groundnut, an important food legume and commercial oil crop, is mainly grown by small farmers. The yield is low (about 1.2 kg $ha^{-1}$ in a normal year). If the quality can be improved, future industrial demand for groundnut is likely to increase substantially.

## Coordinated Groundnut Research Program

At a workshop held at Khon Kaen University in 1981, it was agreed in principle that the Department of Agriculture would be the core research institute within a coordinated groundnut research program, with participation from the universities. Outlines of future research and the role of individual institutes were specified after further discussions. In 1982, IDRC agreed to support Kasetsart (KU) and Khon Kaen (KKU) Universities, while the Peanut CRSP agreed to support the Department of Agriculture (DOA) and both the universities.

## Current Research on Groundnut

**Breeding.** The main improvement work has been done in Northeast Thailand at DOA and KKU research stations. These two institutes have concentrated their efforts on yield capability, resistance to rust and leaf spot, resistance to *Aspergillus flavus,* and earliness. Kasetsart University has been working mainly on *A. flavus* resistance and improving seed size in more fertile soils outside Northeast Thailand. Testing and screening of materials by the DOA has been done during the main rainy season and with irrigation in the dry season, while KKU has been testing the materials during the early part of the rainy season for use as a prerice crop, and also at the end of the rainy season as a postrice crop.

**Pathology.** The main activities of pathological research have been screening of materials for resistance to rust and cercospora leaf spots. A number of lines and cultivars have been identified as resistant. Attempts have also been made to screen for virus resistances. Some work was also done on race variation of rust, but no evidence of variation was found.

Progress on *A. flavus* resistance was marked by the development of the dry-seed inoculation technique for screening, and a large number of segregating progenies and breeding lines have been screened. So far no highly resistant line has been found; only lines with a moderate degree of resistance have been identified and further evaluated.

Increasing efforts have been made to monitor major groundnut diseases. This research reveals an increasingly high incidence of virus diseases. Chemical control of leaf diseases and crown rot have been tried with some success.

**Entomology.** Surveys of pests in major groundnut-growing areas reveal three major insects, namely, leaf miner, leaf hopper, and thrips. Storage pests were also surveyed and their biology studied. Field studies have been done for 3 years on major groundnut pests, their seasonal distribution, and their natural enemies.

Simulated defoliation studies were made in the field to assess yield loss and the economic threshold of natural pests for the formulation of control recommendations. Attempts were also made to gain more information about the subterranean ant, and to develop a cheap and practical way to control it.

Screening for resistances to jassid and leaf miner was carried out. Many lines were found, to some degree, resistant to the insects.

Some analyses of groundnut samples have been made to monitor pesticide residues. Certain samples were found to contain highly toxic residues, mainly of the chlorinated hydrocarbon group. Information gained from these studies will greatly help to formulate better and more practical recommendations in the future.

**Agronomy.** Studies have been made on ways to improve pegging, on irrigation during the dry season, and on interrow cultivation. Land preparation and depth of sowing were also studied to develop improved practices for groundnut grown after the rice crop without irrigation. A growth-retardant was tried to reduce excessive vegetative growth during the rainy season and to consequently increase pod yield. Yield increases ranging from 5 to 50% were obtained.

**Soils and nutrients.** The nutrient status of major soils from groundnut-growing areas were determined. In most cases phosphorus was identified as a limiting nutrient and in some locations some minor elements were found deficient.

On calcareous black soil, where groundnut plants showed severe chlorotic symptoms, iron was identified as the deficient nutrient. Iron chelates were found effective as remedial materials. Combinations of chicken manure or organic humus and ferrous sulfate also corrected the chlorotic symptom.

**Nitrogen fixation.** Efforts have been made to assess the role of *Rhizobium* in improving groundnut yield. The results of inoculation with *Rhizobium* to improve yield have been varied. Other research has been on strain selection, inoculation rates, inoculation methods, seasonal fluctuation of rhizobial populations in paddy soils, and effects of salinity on the nitrogen-fixing ability of *Rhizobium.*

**Postharvest research.** In research on grain quality, 181 samples were collected from farmers in Northeast Thailand, and some samples were found to contain more than 20 ppb of aflatoxin. A survey on farmers' postharvest handling of groundnut in Northeast Thailand found that inadequate pod drying was the main problem.

Seed quality studies were made on many factors that affect germination, e.g., seed size, seed maturity, shelling method, and storage conditions. Studies on seed storage at the farmers' level showed that satisfactory germination could be maintained over 8 months, if the pods were adequately dried and stored in plastic bags.

## Proposed Research on Groundnut

**Breeding.** The main breeding objectives include high yield, improved seed size, resistance to major foliar diseases, resistance to *A. flavus,* developing early varieties for certain cropping systems, and developing varieties for boiling purposes. Increasing efforts will be made to screen for virus and insect resistance.

**Pathology.** Pathologists will continue to work closely with plant breeders in screening materials for resistance to major diseases. The disease nurseries, currently maintained by KKU, will be gradually transferred to the DOA research center where research support is on a continuous basis.

**Entomology.** Future research in entomology will be directed toward developing integrated control measures, yield-loss assessment and economic thresholds of major insects, investigations about subterranean insects, pest monitoring, and insecticide residues.

**Microbiology.** Collection of native strains of *Rhizobium* will continue and selection for effective ones will be made from these collections. Promising strains from local collections and new introductions will be tested. More studies will be made on inoculation techniques, and mycorrhizae.

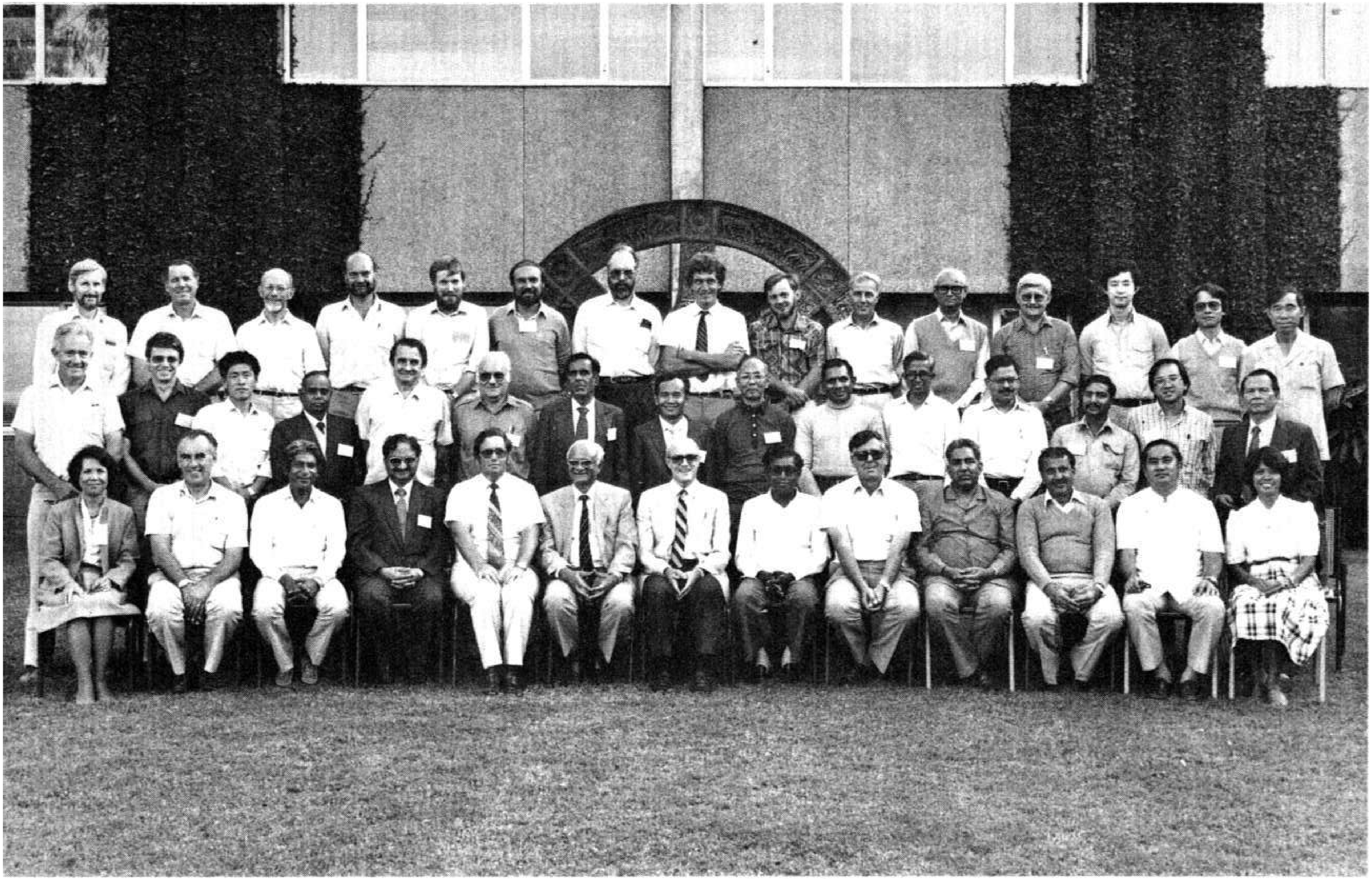
**Agronomy and soils.** Agronomic studies will be aimed at developing more effective practices acceptable to small farmers and with an emphasis on cost reduction. The potential of some growth regulators for yield improvement will be explored further. Studies will be made on factors involved in poor pod filling, with an emphasis on large-seeded groundnut.

Work will continue on identification of nutritional constraints to groundnut production in major groundnut-producing areas, to develop recommendations for fertilizer applications, and to determine the requirements of micronutrients for proper nitrogen fixation and growth of groundnut.

Research on weed infestation has been rather limited. There is therefore a need to undertake more studies in this field.

**Seed technology.** Research will focus on low-cost seed storage, and work will also be initiated on the dormancy of advanced breeding lines to reduce loss from sprouting at harvest.

**Postharvest technology.** There is a need for more research on the reduction of loss at harvest, more efficient and economical handling, and proper storage at the farm level.



Participants in the Review and Planning Meeting for Asian Regional Research on Grain Legumes, 16-18 Dec 1985.

# Participants

Dr M.K. Abbasi, Assistant Professor, Sind Agriculture University, Tandojam, Sind, PAKISTAN

Dr A.N. Bhattarai, Chief Agronomist, Department of Agriculture, P. O. Box 404, GPO Kathmandu, NEPAL

Ir. J.W.T. Bottema, Economist, CGPRT Centre, Jalan Merdeka 99, Bogor, INDONESIA

Dr D.E. Byth, Dean, Department of Agriculture, University of Queensland, St. Lucia, Brisbane 4067, AUSTRALIA

Dr V.R. Carangal, Head, Rice Farming Systems Program, International Rice Research Institute, P.O. Box 933, Manila, PHILIPPINES

Dr S. Chandra, Project Director (Pulses), ICAR, Kalyanpur, Kanpur 208 024, Uttar Pradesh, INDIA

Dr D.P. Gapasin, Acting Dy Executive Director for Research and Director, Crops Research Department, Philippine Council for Agriculture and Resources Research and Development, Los Banos, Laguna, PHILIPPINES

Dr K.T. Mackay, Program Officer, IDRC, P.O. Box 101, Tanglin, Singapore 1025, SINGAPORE

Dr B. A. Malik, Coordinator (Pulses), Pakistan Agricultural Research Council (PARC), National Agricultural Research Centre, P.O. National Institute for Health, Park Road, Islamabad, PAKISTAN

Dr V.E. Mungomery, Assistant Director of Agriculture (Agronomy), Queensland Department of Primary Industries, GPO Box 46, Brisbane 4001, AUSTRALIA

Dr M. M. Rahman, Principal Scientific Officer, Program Leader, Pulses, Bangladesh Agricultural Research Institute Regional Agricultural Research Institute, P.O. Ishurdi, Pabna District, BANGLADESH

Dr K.W. Riley, IDRC Program Officer, Crops and Animal Production Systems, 11 Jorbagh, New Delhi 110 003, INDIA

Dr R. Shorter, Senior Plant Breeder, Department of Primary Industries, P.O. Box 23, Kingaroy, Queensland, AUSTRALIA

Dr R.W. Smith, Agricultural Research Adviser, Overseas Development Administration, Eland House, Stag Place, London SW1E 5DH, UK

Mr S. Somaatmadja, Researcher, Bogor Research Institute for Food Crops, Jalan Cimanggu 3A, Bogor 16114, INDONESIA

Dr M. Somabhi, Director, Khon Kaen Field Crops Research Center, Mitra Parb Road, Khon Kaen 40000, THAILAND

Dr Sumarno, Legume Breeder, Bogor Research Institute for Food Crops, Jalan Cimanggu 3A, Bogor 16114, INDONESIA

Mr E.S. Wallis, Food Legume Research Program Coordinator, Australian Council for International Agricultural Research (ACIAR), Department of Agriculture, University of Queensland, St Lucia 4068, AUSTRALIA

Dr T.P. Yadava, Project Director, Directorate of Oilseeds Research, ICAR, Rajendranagar, Hyderabad, A.P. 500 030, INDIA

## Participants from ICRISAT

N. Ae, Associate Microbiologist
J. Arihara, Associate Physiologist
L.O. Cudapas, In-service Trainee (Philippines)
D.G. Faris, Principal Pigeonpea Breeder
R.W. Gibbons, Principal Plant Breeder and Program Leader, Groundnut
B.C.G. Gunasekera, Principal Soil and Water Scientist (International Cooperation)
R. Jambunathan, Principal Biochemist
C. Johansen, Principal Agronomist, Pulses
J.S. Kanwar, Director of Research
D. McDonald, Principal Plant Pathologist, Groundnut
J.P. Moss, Principal Cytogeneticist, Groundnut
A.S. Murthy, Senior Training Officer
Y.L. Nene, Principal Plant Pathologist and Program Leader, Pulses
N. Okada, Associate Principal Microbiologist
C.K. Ong, Principal Agronomist, Cropping Systems, Resource Management Program
M.S. Rahman, Principal Chickpea Breeder/Plant Pathologist (Islamabad)
D.V.R. Reddy, Principal Plant Virologist, Groundnut
W. Reed, Principal Entomologist, Pulses
Murari Singh, Statistician
W.H. Skrdla, Germplasm Botanist and Acting Program Leader, Genetic Resources Unit
L.D. Swindale, Director General
T. Takenaga, Principal Agricultural Engineer
H.A. van Rheenen, Principal Plant Breeder, Chickpea
B.K. Verma, Chief Plant Quarantine Officer
M. von Oppen, Program Leader, Resource Management Program
J.A. Wightman, Principal Entomologist, Groundnut
J.H. Williams, Principal Plant Physiologist, Groundnut
J.B. Wills, Research Editor

**RA-00123**

**ICRISAT**

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

ISBN 92-9066-120-8

ICR 86-0036