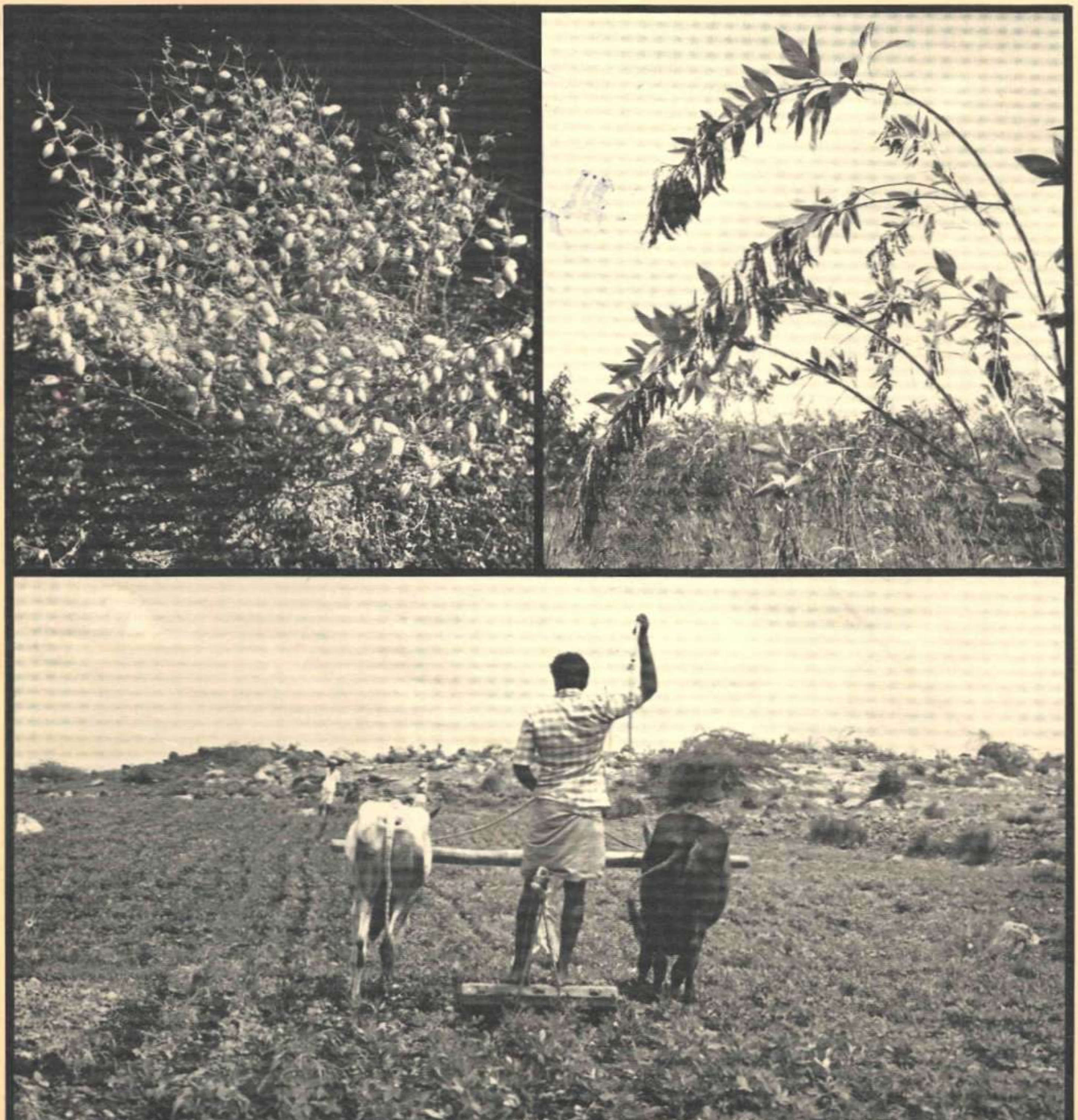
Grain Legumes in Asia

Summary Proceedings of the Consultative Group Meeting for Asian Regional Research on Grain Legumes, 1983



International Crops Research Institute for the Semi-Arid Tropics

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) 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, France, India, Italy, Japan, Mexico, the Netherlands, New Zealand, Nigeria, Norway, Sweden, Switzerland, United Kingdom. United States, and the following International and private organizations: Asian Development Bank, European Economic Community, Ford Foundation, International Bank for Reconstruction and Development, International Development Research Centre, International Fertilizer Development Center, International Fund for Agricultural Development, the

Trust, the Organization of Petroleum Exporting Countries, the Rockefeller Foundation, and the United Nations Development Programme. Responsibility for the information in this publication rests with ICRISAT. Where trade names are used this does not constitute endorsement of or discrimination against any product by the Institute.

Correct citation: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1984. Grain Legumes in Asia: Summary Proceedings of the Consultative Group Meeting for Asian Regional Research on Grain Legumes (Groundnut, Chickpea, Pigeonpea), ICRISAT Center, 11-15 December 1983. Patancheru, A.P., India: ICRISAT.

Grain Legumes in Asia

Summary Proceedings of the Consultative Group Meeting for Asian Regional Research on Grain Legumes (Groundnut, Chickpea, Pigeonpea)

held at ICRISAT Center, India 11-15 December 1983

ICRISAT

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS
Patancheru P.O., Andhra Pradesh 502 324, India

1984

Objectives of the Meeting

- To develop an understanding of ongoing national and regional grain legume research programs
- To develop plans for ICRISAT's participation in supporting and strengthening research programs on groundnut, chickpea, and pigeonpea

Organizing Committee

Y.L Nene	Chairman	M.H. Mengesha	Member
D.G. Faris	Member	W. Reed	Member
B.C.G. Gunasekera	Member	J.B. Smithson	Member
D. McDonald	Member	S.M. Virmani	Member

Editorial Subcommittee

J.B. Wills	Convenor	D. McDonald	Member
D.G. Faris	Member	Y.L Nene	Member

The Proceedings: Explanatory Note

These proceedings of the meeting comprise a statement of the recommendations supported by executive summaries of the papers presented. They are published in this form to permit early availability of the Group's findings. Readers requiring copies of the complete text of one or more of the contributed papers may obtain them from the Program Leader, Pulses Improvement Program, ICRISAT, Patancheru P.O., A.P. 502 324, India.

Except where required in the naming of organizations or projects, "groundnut" is used in place of "peanut" throughout. Similarly, "grain legumes" has been used for "food legumes", for consistency.

The latin binomials for the three principal grain legumes in these proceedings are as follows.

Groundnut: *Arachis hypogaea* L.
Chickpea: *Cicer arietinum* L.
Pigeonpea: *Cajanus cajan* (L.) Millsp.

Selected acronyms used in the text are as follows.

International Agricultural Research Centers
- AVRDC: Asian Vegetable Research and Development Center
- CIAT: Centro Internacional de Agricultura Tropical
- ICARDA: International Center for Agricultural Research in the Dry Areas
- IFPRI: International Food Policy Research Institute
- IRRI: International Rice Research Institute

UN Agencies
- FAO: Food and Agriculture Organization
- UNDP: United Nations Development Programme

Other International Agencies/Groups
- ASEAN: Association of South-East Asian Nations
- EEC: European Economic Community
- IADS: International Agricultural Development Service
- IDRC: International Development Research Centre
- SEARCA: South-East Asian Research Center for Agriculture

Contents

Presentations by International Organizations

RECOMMENDATIONS

The following recommendations from the Consultative Group are derived from two documents submitted for adoption during the final plenary session by two committees, the core membership of which had been selected on a geographical basis. Their members and chairmen were as follows.

Committee 1 (for India, Nepal, and Pakistan)

Dr S.M. Virmani (Chairman)
Mr Achyut N. Bhattarai
Dr Satish Chandra
Dr Rajman P. Choudhary
Dr Abdul Rahman Khan
Dr Bashir Ahmed Malik
Mr M. Marieu
Dr Y.L. Nene
Dr P.S. Reddy
Dr W. Reed
Dr K.W. Riley
Dr R.B. Singh
Dr T. Takenaga
Dr L.J.G. van der Maesen
Mr B.K. Verma
Dr M. von Oppen
Dr J.H. Williams

Committee 2 (for Indonesia, Malaysia, the Philippines, and Thailand)

Dr T.S. Walker (Chairman)
Mr N.R. Abu Bakar
Mr Joji Arihara
Dr G.R. Banta
Dr Douglas Beck
Dr Vichitr Benjasil
Dr J.R. Burford
Dr D.G. Faris
Dr (Ms) Dely P. Gapasin
Mr Azmi Ibrahim
Dr D. McDonald
Dr Y.L. Nene
Dr Shiro Okabe
Dr R.K. Pandey
Dr (Ms) G.J. Persley
Dr R.B. Singh
Dr Sadikin Somaatmadja
Mr Preecha Suriyapan
Mr E.S. Wallis

Organization

- Crop improvement and related cropping systems and socioeconomic research has already achieved useful results in the region, and the concept of an Asian Regional Legume Research Program concerned with groundnut, pigeonpea, and chickpea is endorsed. A Coordinator should be appointed by ICRISAT soon, to assume leadership of the Program from a base at ICRISAT Center.

- The Coordinator should have the following roles and responsibilities.

  a. To intensify ICRISAT's research work in relation to existing national research activities in the region, and to coordinate and catalyze research work overall as well as in respect of specific research problems.

b. To establish a collaborative network comprising international, regional, and national research organizations by arranging meetings, seminars, and workshops, and by enhancing the exchange of materials, methods, and information between ICRISAT and national programs.

c. To develop links between regional and national programs and donor organizations.

d. To coordinate the training of staff from national programs by ICRISAT.

e. To facilitate the transfer within the region of germplasm required for crop improvement.

Research Needs and Strategies

Constraints to Production and Related Research Priorities

Research activities should be coordinated in keeping with the major and minor priorities indicated in the following schedule.

Groundnut

Major constraints: Leaf spots, rust and bacterial wilt; drought; lack of early-maturing cultivars; lack of cultivars responsive to irrigation and fertilization; lack of cultivars with strong peg attachment.

Minor constraints: Collar rot, root rot, bud necrosis, witch's broom, and bacterial wilt; damage by white grub, leaf miner, jassid, termites, rats, and wild boar; iron chlorosis; lack of seed dormancy in Spanish types.

Chickpea

Major constraints: Wilt and ascochyta blight; damage by pod borers.

Minor constraints: Root rot diseases; iron chlorosis; lack of cultivars adapted to saline soils; lack of cultivars adapted to late sowing.

Pigeonpea

Major constraints: Drought; damage by Heliothis, podfly and other pod borers; sterility mosaic and wilt.

Minor constraint: Lack of cultivars adapted to saline and acid soils.

Subjects Requiring Intensified Research

Research should be intensified in the following areas for all three crops.

- Cropping systems
- Water management
- Stand establishment
- Mechanization of production
- Yield gap analysis
- Utilization and demand
- Postharvest technology: shelling, processing, storage

The need to conduct research in other subjects will arise as the work of the Coordinator develops. These should be dealt with, as research requirements, with priorities appropriate at that time.

Germplasm and Breeding Material

1. In the Group's discussions most interest was centered on adaptation trials with elite lines to rapidly identify high-yielding adaptive materials. Interest was also expressed in using high-performing segregating populations with resistance to major yield-reducing factors.

2. It was considered desirable to expand coverage of ICRISAT disease and pest nurseries in the region. Efforts should also be made to facilitate the screening of ICRISAT germplasm for local important diseases, e.g., bacterial wilt of groundnut in Indonesia and Malaysia.

3. ICRISAT should assign priority to producing a comprehensive catalogue of available germplasm and breeders[1] lines, to insure that requests for germplasm and breeding materials from national scientists are as relevant as possible to national ecological conditions.

4. ICRISAT and national program staff should visit field trials within the network on a regular basis. The need to obtain minimum data sets, including environmental and yield component information, was emphasized. Facilities should be made available to permit full discussion and exchange of these results at both the national and regional levels, and to plan future research activities on a routine basis.

Cropping Systems

The ICRISAT Groundnut and Pulses Improvement Programs should work in close cooperation with the IRRI Cropping Systems Program, particularly in areas where legume crops are grown in rice-based farming systems. ICRISAT Farming Systems Research scientists should be involved additionally in cooperative research with national research institutions and other international farming systems projects in the non-rice-based areas of the region.

Socioeconomic Research

1. A high priority was attached to demand and utilization studies, particularly for pigeonpea which is a promising crop in the region.

2. Research should also be carried out on the economic profitability/comparative advantage of producing groundnut vis a vis competing crops.

Links with International Organizations

The following potential areas of collaboration or coordination were identified.

1. Participation by ICRISAT staff in the regional program activities of the Regional Coordination Centre for Research and Development of Coarse Grains, Pulses, Root Crops, and Tubers (CGPRT) and the Regional FAQ programs and projects, to include the provision by ICRISAT of technical training in conjunction with these programs.

2. Cooperation with the ACIAR pigeonpea program in Southeast Asia, to include ICRISAT's close involvement with planning and the provision of materials and training.

3. Participation in NifTAL's network on rhizobial, mycorrhizal, and nitrogen budgets in these crops and associated cropping systems.

4. Coordination with IDRC's groundnut program in Thailand.

5. Coordination with Peanut CRSP's programs in Thailand and the Philippines.

Training

The need for technical training was emphasized. ICRISAT can carry out training in several ways within the regional program: formal and informal courses at ICRISAT Center; regional and national workshops; and specific short-term posting of ICRISAT staff to provide expertise and to strengthen collaborative research projects. The need for training in research management was also raised (but other institutions may be better situated to provide this facility).

Keynote Address: Need for Research on Groundnut and Pulses in the Asian Region

L.D. Swindale

Director General, ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India

Welcome and Introduction

Let me extend my welcome to all the participants in this Consultative Group Meeting for Asian Regional Research on Grain Legumes. We thank you for responding to our invitation and for coming to attend this meeting. We hope that you will find your stay at ICRISAT interesting and enjoyable. It is a lovely time of the year to come.

ICRISAT was established by the CGIAR in 1972 on the recommendation of its Technical Advisory Committee. It was created to fill a perceived gap in the agricultural research efforts in and for the developing countries. The CGIAR convinced itself, after calling for and studying a series of reports, that there was insufficient research attention to the rainfed and largely subsistence cereals of the semi-arid tropics and to the associated grain legume crops that many millions of people use as their main protein source.

ICRISAT was established to help redress this perceived deficiency. The responsibilities given to the Institute were to serve as a world center for the improvement of sorghum, pearl millet, pigeonpea, chickpea, and groundnut; to develop farming systems to help increase and stabilize agricultural production in the rainfed semi-arid tropics; to find what constraints exist to agricultural production in this region, and to determine what could be done about them.

Like all the CGIAR Centers, of which there are now 13 around the world, ICRISAT is required to work to strengthen and serve national agricultural research organizations and institutions, and not the farmer directly. Many of you have been to ICRISAT before—perhaps several times—and know well enough about our mandate and know that the semi-arid tropics cover a vast portion of the earth's surface—about 11% in all: much of Africa south of the Sahara, substantial areas in South and Southeast Asia, the northern quarter of Australia, and parts of Central and South America.

In my remarks today I will not dwell on this aspect of ICRISAT's work, but will speak instead of the crops that are our responsibility and particularly the three legume crops—groundnut, chickpea, and pigeonpea.

ICRISATs Mandate for Legume Crops

Grain legume production in Asia, including soybean and groundnut, is about 8% of that of cereals. Yet the qualitative importance of these crops far outweighs this production comparison because grain legumes provide an amino acid pattern that complements that of cereals to give a good balance for human dietary requirement. Some grain legumes, such as groundnut and soybean, also provide large amounts of vegetable oil.

Grain legumes also complement cereals since they generally can produce a crop under lower fertility and moisture conditions than required for cereals. Because they fix atmospheric nitrogen, they improve soil fertility. In addition, many grain legumes are well adapted to intercropping with cereals either because of their very short duration or because they can utilize moisture remaining after the cereal component has been harvested.

There is an urgent need in the developing countries of South and Southeast Asia to provide more of these crops. This was clearly shown in reports from the symposium on Grain Legume Production held at Chiang Mai, Thailand, in November 1980. That symposium pointed out that over the previous decade grain legume production in the region had fallen drastically behind demand, necessitating costly imports of these crops or their products. The participants at the Chiang Mai meeting concluded that this slow growth in production was partly due to slow expansion of the area planted to grain legumes because of competition for land by new high-yielding cereal varieties, and partly because of stagnant grain legume yields. The lack of increase in mean yields is the result of such factors as the allocation of grain legumes to marginal rainfed land, government policies that emphasize cereal production, and low economic returns.

ICRISATs Collaborative Research Network

As you know, ICRISAT claims to have global responsibility for the improvement of yield and productivity of these crops. But what exactly does that mean? Global responsibility clearly does not mean global presence. ICRISAT does have scientists now in several places, but it certainly does not operate a worldwide network. How many of your countries have resident ICRISAT scientists?

ICRISAT has but one large research center—the one at which we are meeting today. Through an arrangement with the Indian Council of Agricultural Research and four agricultural universities, ICRISAT does have four additional locations in India where it conducts significant portions of its program, but these are small, a few hectares in each case. The major locations are at Haryana Agricultural University, Hissar, at 29°N latitude, at Gwalior in

Madhya Pradesh State on the research farm of the College of Agriculture at 26°N latitude, at Dharwar in Karnataka State on the research farm of the College of Agriculture at 16°N latitude and, finally, at Bhavanisagar on a research farm of the Tamil Nadu Agricultural University at 11°N latitude. These collaborative stations provide us with the opportunity to expand the range of latitudes, of daylengths, and of environments in which we do certain aspects of our work. We are also developing a research center in West Africa in a hot, dry, and sandy area mainly for research on pearl millet but with some attention to groundnut.

The CGIAR does not want or expect us to fulfill our global mandate by setting up little bits of ICRISAT all over the world, nor do we have the administrative capacity to do this. We do try to help some countries in solving specific short-term problems, as we expect to do soon in Pakistan working on the problem of ascochyta blight of chickpeas. But for the most part fulfilling our global mandate means largely carrying out research here at ICRISAT Center on issues of global significance and working on problems that occur in several countries and regions. Thus we best serve countries who are interested in our work by transferring the products of our research efficiently. Scientific reports are a well known and useful way to do this. Better, is to send our seeds or other plant materials that have been improved in some particular way to the countries concerned. Better still is to use these seeds and plant materials in cooperative research between ICRISAT and the scientists in national programs so that they may make the most of the improved results that we have obtained.

Mutual Research and Development Needs

In these three crops, groundnut, chickea, and pigeonpea, there is something of interest to all of the countries here represented. Each country has a major interest in one of them and several have an interest in a second or an awareness of its potential importance. A few like India have interest in all three.

The statistics of the production of these crops in India dominate the statistics of their production in the region. India produces about 57% of the groundnut, 80% of the chickpea, and virtually all of the pigeonpea in the region. But we can turn these figures around. We can say that other countries produce 43% of the groundnut and 20% of the chickpea, thus reflecting the current interest of other countries in the region in the crops of ICRISAT.

Groundnut is the most important of the three. It is important for its oil and as a valuable cash crop. The haulms and cake are valuable livestock feeds. It fixes much nitrogen, with benefits to subsequent crops. Demand is high. It is calculated that the demand for oilseed crops in the world will grow at nearly 4% annually over the rest of this century. Annual growth in the supply of groundnut is increasing at less than 1%, less than 0,25%

of the projected demand for oilseeds. There is ample room for increased production.

Chickpea is next, particularly in the more northerly countries of the region. It is a major source of protein to many millions of people. It is the most important pulse crop in the world.

Pigeonpea, although the least important of the three is, in my view, a much underestimated crop. It can simultaneously satisfy the need for food, feed, and fuel. It ameliorates the soils in which it grows. It is a remarkably hardy crop, tolerant of difficult conditions, and fits extraordinarily well into intercrop systems. Several of you are well aware of this and are exploring the possibilities of the greater use of pigeonpea in your countries. It is interesting to recall that in 1978 a report prepared for the US National Science Foundation by SaLUT and the US National Technical Information Service stressed the potential of pigeonpea for production in the United States, pointing out that it was a crop that had several uses and excellent market potential.

Action for Improved Collaboration

Because of our commonality of interest in these legume crops, ICRISAT is hoping that you will agree to work with us and each other in strengthening regional cooperation on their research and, eventually, their production. We wish to encourage this development because we have worked on two of these crops for 10 years and the third one, groundnut, for about 7. We have many interesting and valuable results and we would like you all to get the maximum benefits from our work. My colleagues will go into the details. Also you will find much of interest in our Research Highlights and Annual Report for 1982, both of which are available to you.

I would like to bring to your notice some research highlights of 1983. First, in groundnut improvement—more than 4000 breeding lines, populations, and germplasm have been supplied to groundnut breeders in 16 different countries. Four ICRISAT selections that performed consistently well in the postrainy season have been advanced to the stage of prerelease evaluation here in India. Eight genotypes with resistance to rust and late leaf spot have yielded 2.5 times as much as any of the major released cultivars during last year's rainy season, and several drought-resistant genotypes have yielded much more than released cultivars under high drought stress in southern India. The breeding program is making successful use of derivatives from wild groundnut species with resistance to both leaf spot and rust diseases, and we have a few lines tolerant of peanut clump virus and two tolerant of peanut mottle virus. We are making some progress on resistance to jassids, and we have early-maturing lines with seed dormancy that have been selected from segregating populations.

In pigeonpea we have lines that have been released for use by farmers in different parts of India; and the University of

Queensland, utilizing materials derived from ICRISAT lines, has released a new cultivar in that country. We have developed male sterile materials for hybrids, and one early hybrid, ICPH 8, has been selected for All India Coordinated Tests. We have selected a substantial number of plants resistant to sterility mosaic, fusarium wilt, and phytophthora blight. Probably our work in pigeonpea has made the most advance of any of our crops in this area of multiple disease resistance. We have made crosses to increase pigeonpea resistance to the pod borer Heliothis armigera, and to combine it with resistance to fusarium wilt. Finally, I would like to mention that some pigeonpea varieties, particularly the ones that resist wilt and sterility mosaic, are proving most interesting in multiple cropping systems using ratooned pigeonpea, producing three harvests of the crop in 2 years and a substantial amount of firewood.

In chickpea the Government of Gujarat (India) has released one variety from ICRISAT for general cultivation in that state, and the Government of Syria has recommended the release of one cultivar, a kabuli type, which is the result of joint ICRISAT-ICARDA work. In chickpea, as in pigeonpea, we now have good resistance to Heliothis, and we are transferring this resistance into good agronomic material. Fusarium wilt, which is important in the Americas as well as in South Asia, has occupied a lot of our time, and we now have resistance which is conferred by two recessive genes that separately delay wilting but must be present together for complete resistance. We have 28 new lines resistant to this important disease. We have developed methods for screening for resistance to botrytis gray mold and developed 16 resistant lines that should be very useful in the more humid regions of this country, Pakistan, and Bangladesh.

The Practical Implications of Collaboration

Now you will have noted that the research highlights that I have outlined mention benefits to India in several instances. There is no doubt that India, currently, is the major beneficiary of ICRISAT's work. That is to be expected. Our Institute is located in this country, these crops are of great importance to it and to many millions of its citizens. And India works hard to gain benefits from ICRISAT.

- It worked hard for the establishment of ICRISAT here in India.

- It concluded an agreement with the CGIAR that enables ICRISAT to have an excellent research farm—on land it donated—and allowed us to develop fine facilities and equip them well.

- It provides many of our scientists and most of our support staff and allows us to establish terms and conditions for their employment that are conducive to agricultural research.

- The Government of India and the Government of the State of Andhra Pradesh support the institute in many ways.

ICRISAT Activities

ICRISAT's Research on Groundnut

D. McDonald

ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India

Introduction

Yields obtained by SAT farmers are very low, at around 800 kg/ha of dried pods. These compare unfavorably with yields of over 2500 kg/ha obtained on large-scale mechanized farms in countries with highly developed agriculture. However, even these yields are low when the yield potential of groundnut is considered. By growing released Indian cultivars under optimal conditions at ICRISAT Center, yields of over 7000 kg/ha have been obtained and much higher yields have been reported from Israel and Zimbabwe.

Constraints to Production

Diseases and pests are important production constraints worldwide and cause particularly serious losses in those tropical developing countries where the small farmer cannot afford, or is not technically equipped, to apply crop protection chemicals. Other important constraints are unreliable rainfall patterns and recurring droughts, lack of high-yielding adapted cultivars, poor agronomic practices, and very limited use of fertilizers. Very few research programs have concentrated on breeding for resistance to the factors that limit production. Accordingly, it is in the field of germplasm utilization and resistance breeding that ICRISAT groundnut researchers have been most active.

Germplasm Base

In December 1983 the total of groundnut germplasm accessions at ICRISAT was over 10,100. Asian countries in which collections have been made are India, Burma, Malaysia, and the Philippines. Future priority areas for collection in Asia are Thailand, Indonesia, and the Peoples' Republic of China.

Germplasm lines are maintained, multiplied, and evaluated. Botanists record a wide range of plant characters, over 30 measurements of morphological and agronomic characters being made in preliminary evaluation. Materials are also evaluated by Groundnut Improvement Program scientists who record reactions to pests, diseases, and drought stress, and nodulation capacity and yield potential. Over 19,600 germplasm samples have been sent to cooperators in 52 countries.

Disease Resistance

Foliar diseases. The most important foliar diseases of groundnut caused by fungi are the leaf spots (Cercospora arachidicola and Cercosporidium personatum) and rust (Puccinia arachidis). At ICRISAT Center rust and late leaf spot (C. personatum) occur each year in epidemic proportions. All released Indian cultivars are susceptible. Field screening of germplasm for resistance to these two diseases was started at ICRISAT Center in 1977. Breeders are now developing rust and late leaf spot resistant cultivars with stable agronomic characters. The biology of the pathogens has also been investigated and components of resistance have been measured.

Pod rot disease. Pod rots caused by a complex of soil-inhabiting fungi cause serious reduction in yield and quality of groundnuts. Losses of over 20% have been recorded. Field screening for resistance has been complicated by uneven disease incidence between and within fields but 11 genotypes have shown significantly lower incidence of rotted pods than susceptible check cultivars.

Aspergillus flavus and aflatoxins. Aflatoxins are toxic secondary metabolites produced by strains of fungi of the A. flavus group when growing on suitable substrates such as groundnut seed and groundnut products. Aflatoxin contamination can be minimized by adoption of farming and produce handling methods designed to avoid damage to pods and seeds, but few farmers in the semi-arid tropics follow the recommended procedures. Research has therefore focused on using genetic resistance, and several A. flavus resistant genotypes have been entered in breeding trials to combine the testa resistance factor with acceptable levels of yield.

Virus diseases. These are common and can be serious. At ICRISAT emphasis in research has been placed on the purification and precise characterization of groundnut viruses. Some 7000 genotypes have been screened for resistance to bud necrosis but all were susceptible. Wild Arachis species are now being screened and A. chacoense has been found resistant in mechanical and thrips inoculation tests. Almost 500 germplasm lines have been screened for resistance to peanut mottle using a field mechanical inoculation technique. Screening for resistance to the soil-borne peanut clump virus disease has been in progress for several seasons, but with conflicting results.

High-level resistance to groundnut rosette disease has been found in some West African germplasm and breeders in Senegal, Nigeria, and Malawi have been successful in developing rosette-resistant cultivars with good agronomic characters. Rosette-resistant genotypes are being used in several ICRISAT breeding programs, and the Institute is now involved in coordinated international research to resolve this problem.

Bacterial disease. The only important bacterial disease of groundnut is the wilt caused by Pseudomonas solanacearunu This disease is common and serious on groundnuts in East Asia but has not so far been found in India and has not therefore been investigated at ICRISAT Center.

Pest Management

Pests of worldwide importance are aphids, jassids, thrips, and termites. Insect pests may be of importance because of the direct damage they do or because of their role in transmission of virus diseases.

At ICRISAT the entomology research emphasis has been to effectively combine cultural practices and host plant resistance to develop integrated pest management systems. The effects of cultural practices on the incidence of important pests are being studied and particular attention is being given to the effects of intercropping.

Drought Tolerance

Field screening of germplasm for drought tolerance was started in the 1981/82 postrainy season with 200 lines being subjected to 21 combinations of time, duration, and intensity of drought using a line source sprinkler system. In the 1982/83 postrainy season, 484 lines were screened and genotypes with tolerance to mid-season and end-of-season drought stresses have been indicated. Interactions between drought and soil calcium levels, and drought and pod rots, are being investigated.

Nitrogen Fixation

At ICRISAT microbiologists and breeders are trying to manipulate both the Rhizobium and the host plant component in plant nutrition in an attempt to increase nitrogen fixation and so yields, and also to obtain residual benefits for subsequent crops.

A large number of Rhizobium strains have been collected and tested for nitrogen-fixing ability in combination with a range of cultivars and germplasm lines. Field trials in mainly rainfed parts of India have shown that it is possible to increase yields of groundnuts by inoculation with Rhizobium, even in fields where groundnuts have been grown for many years. More attention will now be given to nitrogen nutrition in irrigated groundnuts, especially in rice-based cropping systems.

Breeding for High Yield

Several breeding lines selected for high yield have been developed and have given excellent yields, e.g., lines ICGS 21, ICGS 30, and ICGS 37 gave yields of dried pods of over 7000 kg/ha. The line ICGS 11, developed for postrainy season use, is now advanced to the prerelease testing stage.

Utilization of Wild Species

Species in section Arachis have been cytogenetically analysed to develop a better understanding of species relationships and of the evolution of the cultivated groundnut, and this information has been used in planning the most effective routes for gene transfer. Most of these routes have been used, and a range of interspecific hybrids, from diploid to hexaploid, with many combinations of genomes, have been produced and backcrossed to A. hypogaea. Many have produced stable tetraploid derivatives.

The majority of species in the genus are not compatible with A. hypogaea. However, experiments with mentor pollen and hormones showed that hormone application substantially increased peg numbers from incompatible crosses. Such pegs do not consistently set pods, but a satisfactory pod set can be obtained by treating pegs with auxin or kinetin. These pods rarely mature and, to obtain viable hybrids, ovules or embryos have to be removed from the young pods and cultured in vitro where there may be production of callus and eventually of plantlets. To date, hybrid calli and plantlets have been produced in five cultivars of A. hypogaea crossed with three species of Eurhizomatosae and in three wild species hybrids.

It is hoped eventually to gain access to all useful genes available in the genus Arachis and so expand the genetic base for resistance breeding.

ICRI SATs Research on Pigeonpea

D.G. Faris

ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India

Introduction

Pigeonpea is a fascinating crop with great potential. It is grown throughout the tropics on about 3 million ha, 85% of which are in India. Although pigeonpea can be found growing in many other Asian countries, the only country with a sizable production area is Burma.

Pigeonpea is different from most other pulses because, although normally grown as an annual shrub, it is a perennial crop the plants of which may grow for several years and develop into small trees. Pigeonpea has great compensatory ability under adverse conditions. It gives additional yield after the first harvest if sufficient moisture is available, and it has great flexibility in a wide range of cropping systems. Pigeonpea tolerates drought stress well and is thus an ideal crop for the semi-arid tropics. It also grows well in the subhumid tropics, and performs well in temperatures up to 38°C. However, it will not tolerate frost.

The crop has a wide range of maturity periods. There are cultivars that mature in less than 100 days, and others that form mature seed only after 250 days from sowing. Time to maturity can be greatly affected by photoperiod and temperature. Thus there exist maturity types of pigeonpea for many different cropping conditions.

Pigeonpea is a superb intercrop for planting with cereals and many other crops, which explains why over 80% of pigeonpea is already grown as an intercrop. Early-maturing cultivars are favored for sole-cropping, and are often grown as part of a rotation. Pigeonpea is a very efficient plant that has deep roots. It grows well even on soils with a low phosphorus level, and fixes atmospheric nitrogen. Rarely does its seed need to be inoculated because pigeonpea can nodulate on Rhizobium naturally present in most soils. Because of its efficiency pigeonea is usually relegated by farmers to marginal areas, where the average yield is around only 700 kg/ha. But we know that pigeonpea can yield over 5000 kg/ha of dry seed, given proper conditions and crop management.

Pigeonpea is most widely eaten in the form of dhal (split peas). Used this way it contains about 22% protein with an amino acid profile similar to that for soybean. Green pods and green seeds from pigeonpea are also used as a vegetable. Other uses include fodder, fuel, and green manure.

ICRISAT Research Activities

Our objective at ICRISAT is to identify the factors that influence the yield of pigeonpea in order to provide farmers with the practices and material for optimum production.

Environment. Because pigeonpea is so drought-tolerant, it is usually grown where moisture limits its yield. Thus our research has shown that adequate moisture and appropriate cropping patterns can increase pigeonpea yields significantly. For example, in 1982 an experimental plot at ICRISAT Center that was given moisture plus other inputs, and was picked three times, yielded 5400 kg/ha in 217 days.

Pests. Insects, chiefly pod borer and podfly, can drastically reduce yields if their attacks are not controlled. At ICRISAT we are attempting to develop an integrated pest management system. Though pod borers can be controlled by one or two sprays, we attach more importance to selecting lines for resistance traits. We have recently identified lines that exhibit a lower-than-average level of pest attack, and these have been successfully crossed with elite material to combine resistance with high yield.

Diseases. Pigeonpea yield can also be severely reduced by disease. Wilt appears to be widespread in Asia, while sterility mosaic seems less extensive. Other diseases may be important in countries other than India. Simple screening procedures developed at ICRISAT have enabled us to identify several sources of resistance to wilt, sterility mosaic, and phytophthora blight. This resistance has been included in elite breeding material, some of which has given high yields and is now in advanced yield trials.

Cultivars. Besides developing lines resistant to pests and diseases, ICRISAT's breeders have developed lines superior in yield to existing check cultivars. They have also pioneered the production of hybrids in pigeonpea using genetic male sterile lines. Current indications are that certain hybrids could give a considerable boost to pigeonpea yields. More combinations can now be used in experimental work because we have transferred the male sterile character into several parents known to have good general combining ability and other valuable characteristics.

International Collaboration

Germplasm. At ICRISAT we have a wide range of germplasm and elite breeding material of pigeonpea available for distribution. The Genetic Resources Unit has a collection of about 10,000 pigeonpea accessions. These have been evaluated, using several descriptors, and this information is now available from computerized records. Most accessions, however, are from India, there being relatively few from other Asian countries.

Nurseries. Breeding material from a number of international nurseries is also available from ICRISAT. These include the Pigeonpea Observation Nursery (for determining the class of material suited to a location), yield trials of elite breeding lines for more specific requirements, bulks from different crosses developed by single-pod descent (for selection by plant breeders), yield trials of elite lines with resistance to wilt and sterility mosaic disease (for areas where disease can reduce yields), and a trial with large-seeded vegetable pigeonpea lines (for areas where vegetable pigeonpea is important). Additional nurseries can be constituted to meet special needs—such as material resistant to or tolerant of pests and diseases, for use as fodder, and for saline soils. We are reasonably confident that breeding material now available provides a satisfactory base for matching the crop to such factors as differences in daylength, rainfall, temperature, insect and disease attack, cropping pattern, and the use to be made of the produce.

The Future

We have shown that pigeonpea has a high yield potential under a wide range of tropical conditions, is suitable for use in many different cropping systems, and produces a nutritious pea that can be used in a variety of ways. This means the crop could be grown much more widely than at present. However, a major constraint to pigeonpea's wide acceptance is that farmers and their families are not familiar with its utilization. Thus, if the crop is shown to be well adapted to a particular environment, attempts to introduce it as a new crop must be accompanied by a plan to develop increased demand for its products in internal or external markets.

ICRISAT's Research on Chickpea

J.B. Smithson

ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India

Introduction

The annual world production of chickpea is about 7 million tonnes of dry grain from an area of 10 million ha. Some 85% of production stems from South Asia, but the cropping area extends westwards from Afghanistan, through West Asia and the Mediterranean basin, into Ethiopia and East Africa, the Americas, and Australia. In FAO data chickpea is not listed at all for Southeast Asia, except Burma.

There are two main types, distinguished principally by their seed characteristics: desi, grown in South Asia, Burma, Ethiopia, East Africa, and Mexico (85-90% of world production); and kabuli, grown to a small extent in South Asia but accounting entirely for the crops of those other countries not listed above.

Adaptation

Chickpea is adapted to cool, dry environments and is basically a temperate or subtemperate crop grown in postrainy seasons in subtropical winters/springs or temperate springs/summers. The nature of its adaptation is best illustrated by the temperature and rainfall regimes of ICRISAT and ICARDA Centers that represent the extremes in which the crop is grown.

Maximum potential yields are obtained in north India or from winter-sown crops in the Mediterranean—more than 5000 kg/ha dry seed in 160-170 days during which temperatures of zero °C or less are recorded. In areas where temperatures are warmer, growing seasons and seed yields are reduced. In humid lowland tropical environments (e.g., Southeast Asia) performance can be expected to be especially poor.

Constraints to Production

Diseases. Wilts and root rots are prevalent in all chickpea-growing areas. Most important is wilt caused by Fusarium oxysporum f. sp. ciceri. Yield reduction in India amounts to an estimated 10% of total production.

Blight caused by Ascochyta rabiei is undoubtedly the major cause of crop loss. Disease development and spread are favored by cool, humid conditions and it is therefore found in epidemic form normally only in northwestern India, westwards into West Asia, and the Mediterranean basin. It has caused crop losses estimated at 50% in the Punjab and Thai areas of India and Pakistan and in 1981-82 caused substantial losses throughout north India.

Gray mold, caused by Botrytis cinerea, is also favored by humid conditions but is adapted to slightly warmer temperatures than those favoring ascochyta blight. It is endemic in northeastern India, extending into Bangladesh and probably Burma.

Stunt, caused by pea leaf roll virus, is widespread in higher latitudes. Incidence is generally low, but localized heavy losses can occur. Several other virus problems have been reported but their incidence and importance are presently negligible.

Pests. Losses due to pests are small relative to other pulses, probably due to the secretion by the crop of a highly acidic exudate. Only two major pests are recognized. (1) Heliothis spp damage vegetative parts and can cause complete defoliation but the crop usually recovers from vegetative damage and greatest losses arise from damage to flowers and fruits. The pest occurs throughout chickpea-producing areas. In India, losses between 0 and 30% are generally estimated but can be as high as 100%. Similar ranges have been reported elsewhere. (2) The leaf miner (Liriomyza cicerina) is distributed throughout West Asia and the Mediterranean basin. The extent of crop loss is uncertain but probably similar to that caused by Heliothis.

Various root knot and cyst-forming nematodes have been recorded on chickpeas. Losses have not been estimated but are locally severe.

Weeds. Although chickpea is grown on residual soil moisture, weeds are major problems in many environments. Estimates of crop loss due to weeds range between 22 and 100%.

Inadequate and excessive soil moisture. Seedbed moisture is frequently inadequate for seed germination and emergence and the most likely cause of the poor stands frequently observed in commercial plantings. Crop areas are also reduced when rainfall does not occur at sowing time. In South Asia and the Mediterranean basin evaporative demand is high throughout the growing season and the rapid depletion of soil moisture is one factor curtailing crop growth, thereby preventing the attainment of maximum productivity.

By constrast, in parts of northern India slightly more than adequate soil moisture inhibits flowering and fruiting and causes excessive vegetative growth. This leads to lodging, aggravation of disease problems, and reduced yields.

Inadequate soil nutrients. In common with other legumes, chickpea forms symbiotic associations with soil rhizobia that fix nitrogen from the atmosphere. In practice, nodulation and nitrogen fixation are frequently poor and responses to inoculation inconsistent, probably due to unfavorable soil conditions such as inadequate moisture or salinity.

Requirements for phosphate and responses to its application are small. Nitrogen requirements are greater and responses to nitrogen application are larger and more consistent. In the alkaline soils in which chickpea is generally grown, symptoms of iron deficiency are common. Zinc deficiency has also been reported. Chickpea is highly sensitive to salinity and alkalinity, which cause major crop losses in the Indian subcontinent.

Crop Improvement

Germplasm. There are more than 13,000 accessions in ICRISAT's chickpea germplasm collection. They originate from most areas where chickpea is grown.

Variation has been identified for many important morphological, physiological, and disease- and insect-resistance characters. Methods of screening have been developed, and are now being used in breeding programs, to incorporate the characters into improved agronomic backgrounds.

The morphological characters identified include: tall types; multiseeded pods; double pods; increased seed size; leaf shape; and foliage color. The physiological/phenological characters include: duration; adaptation to early sowing (South Asia); adaptation to late sowing (north India); adaptation to winter sowing (Mediterranean basin); ability to germinate with limited seedbed moisture; tolerance of moisture stress; tolerance of iron chlorosis; and tolerance of salinity. The disease resistance characters include: resistance to wilts and root rots; ascochyta blight; botrytis gray mold; and stunt. And the insect resistance character is resistance to Heliothis armigera.

Breeding. ICRISAT's germplasm has been made freely available to other institutions, and more than 70,000 seed samples have been distributed. In addition, sources of useful characters have been incorporated in breeding programs at ICRISAT and ICARDA and the products of these have been distributed to other institutions in the form of segregating populations or advanced lines, as trials or in response to specific requests. Sets of different trials are being distributed by ICRISAT and ICARDA. In 1983-84 more than 550 sets were supplied to over 60 countries.

Entries from the trials have been entered in national trials in several countries and are now in prerelease stage of testing. ICCC 4 has been released for general cultivation in Gujarat. ILC 482 is recommended for cultivation in Syria. Others are now being released for cultivation under names assigned by the centers who have identified them from ICRISAT materials, or are in on-farm trials (e.g., ILC 484 in Jordan).

Cropping Systems for Increasing the Production of Groundnut, Chickpea, and Pigeonpea in India

R.T. Hardiman and R.W. Willey

ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India

Introduction

In India between 1950 and 1980 yearly cereal production increased from 45.8 to 119.2 million tonnes, whereas pulse production increased by only *25%*, from 9.2 to 12.2 million tonnes. By comparison, cropping areas increased by only 25% for cereals and 18% for pulses. These data suggest that farmers find it more profitable to crop cereals than legumes, resulting in a net decrease in the total production of legumes in India in recent years. In addition attention has focused on the development of irrigated lands that have increased from 22.6 to 58.5 million ha between 1950 and 1980. Consequently, improvement of dryland farming has received proportionately less attention.

Related research work has concerned (1) the improvement of cropping systems, (2) the utilization of rainfed water resources in the rainy season, with particular reference to black soils, and (3) the development of new cultivars. This paper is concerned with the first two research subjects.

Three cropping systems are considered: intercropping, sequential cropping, and relay cropping. In all of them cropping in the rainy season is an essential component. Traditional agriculture does not generally include rainy-season cropping on tropical black soils (Vertisols) due to problems of waterlogging and crop management. An improved technology developed at ICRISAT has attempted to reduce these problems by employing a graded broadbed-and-furrow (BBF) system that permits adequate drainage in the higher rainfall areas and reduces waterlogging.

Groundnut

This crop is commonly grown with a cereal intercrop where it is the major component because of its importance as a cash crop. In ICRISAT studies, these systems are mainly represented by a millet/groundnut combination grown in a 3:1 row arrangement. This maintains the groundnut yield per plant at a level comparable with that in sole-cropping; as such the yield per unit area is about 75% of the sole crop. Yield per plant of pearl millet is much higher than in sole-cropping, although yield per unit area is only 50-60% of the sole crop.

The cereal/legume system is particularly advantageous under conditions of moisture stress and, averaged over 3 years, the relative yield advantage of a 1:2 row sorghum/groundnut intercrop is greater than 100% under severe stress conditions, but with yield levels still typical of many environments in the semi-arid tropics.

In addition, reduced incidence of rust and bud necrosis have been observed when groundnut is intercropped with a cereal. The cereal probably acts as a barrier to the spread of the disease itself, in the case of the air-borne rust, and to the insect vector, in the case of the bud necrosis.

Groundnut has also been examined as an intercrop with pigeonpea. Standard arrangements have been a single row of pigeonea at 120 cm or 180 cm, with 3 or 5 intervening rows of groundnut, respectively. Both arrangements have averaged about 80% or more of each component, giving a yield advantage of 60-70%.

Data on the nitrogen fixation of groundnut or pigeonpea have shown appreciable beneficial residual effects on subsequent nonlegume crops, equivalent to 30-40 kg/ha of applied N. When intercropped, residual effects of only 15-20 kg/ha N have been recorded for groundnut, most of which is not utilized by the supporting nonlegume intercrop (though there is contrary evidence elsewhere in India).

Chickpea

Chickpea is normally sown in the postrainy season in India and is a second crop where a sequential cropping pattern is employed. The crop is therefore usually grown on heavy soils, where postmonsoon moisture reserves are high.

Experimental fieldwork has shown the maize/chickpea combination to be a productive system, and gross returns (US$ 530/ha equivalent) are very similar to the cereal/pigeonpea system described below ($ 538/ha for maize/pigeonpea). However, net returns are rather lower in the sequential system ($ 306/ha) compared with intercropping ($ 365/ha) due to extra costs in establishing the second crop.

A possible compromise between the two systems is to sow chickpea following the harvest of maize in a maize/pigeonpea intercrop. In one year this gave an additional pulse yield of 528 kg/ha, which was 30% of the sole-crop yield, and with no yield reduction of pigeonpea. However, in a further year the chickpea crop failed. This three-crop system is perhaps best seen as optional, and the chickpea is added only when there is sufficient residual soil moisture for further growth.

Chickpea is commonly intercropped with wheat, sorghum, safflower or mustard. A 1:1 row arrangement of chickpea/ safflower gave yield advantages up to 15-20%, but none was achieved in a 1:2 row arrangement. It was thought that in the 1:1 row arrangement there was a small beneficial effect of shading on the chickpea. Similar yield advantages of 15-20% have been recorded with sorghum/chickpea at ICRISAT Center, where a 1:1 row arrangement was better than 1:2.

Pigeonpea

This medium- to long-duration crop is normally planted at the beginning of the rainy season. Its initial vegetative growth is slow and an intercrop can be grown with it to improve the overall use of resources. Experiments have shown that sorghum/pigeonpea combined in a 2:1 ratio give best results and can maintain up to 95% of the sole-sorghum yield and up to 72% of the sole-pigeonpea yield, thus providing a 60-70% yield advantage compared with growing sole crops. This advantage occurs because of greater total light interception and fuller use of moisture and nutrient resources.

The 2:1 sorghum/pigeonpea combination is particularly important in the incorporation of the BBF technology on Vertisols, increasing both absolute yield and allowing for two crops to be grown per year. It also negates the necessity for hurried cultivation and bed preparation that would otherwise be needed for the establishment of a postrainy crop. This intercropping pattern is equally applicable to the deeper red soils that occur extensively in India. Their lower water-holding capacity, however, demand a more even distribution of rainfall in order to avoid problems of drought.

Intercropping interactions between the sorghum and the pigeonpea have reduced the incidence of fusarium wilt in pigeonpea. Conversely, a sorghum intercrop may increase Heliothis attack due to the transfer of Heliothis to the pigeonpea after its initial population increase on the sorghum.

An alternative to intercropping pigeonpea is to sow a sole crop of an extra-early cultivar. Such dwarf cultivars sown in June in a 1-year trial has yielded 2000-2500 kg/ha at harvest in October and, left to regenerate, yielded a further 1200 kg/ha in December-January and 1000 kg/ha in March, thus totaling 4500-5000 kg/ha compared with a maximum of 2000-2500 kg/ha from conventional systems. This system not only produces high yields but reduces labor inputs considerably.

Similarly, pigeonpea may be sown as a perennial crop. This was previously not possible because of its susceptibility to sterility mosaic disease and wilt. However, newly developed lines (e.g., ICPL 1-6) are resistant to these diseases and can be established by planting after the monsoon. The ensuing crop is then well developed by the time of the following rainy season and has the added advantage that it suppresses weed growth throughout the year, thus reducing cultivation and labor inputs even further.

Conclusion

The results described above indicate that legumes can often be incorporated into present cropping patterns without causing a major decrease in cereal production. Moreover, the monetary returns that can be obtained by introducing these legumes are considerable and compete favorably with profits obtained from cereals. The cropping systems can be easily used by farmers without requiring major changes in traditional practices. Rainy-season cropping on deep Vertisols in the higher rainfall areas, however, requires careful preparation of the land to provide surface drainage for successful cultivation.

ICRISAT's Training Program

A.S. Murthy

ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India

Introduction

Agricultural research and development programs in the semi-arid tropics (SAT), aimed at improving the production and utilization of coarse grains in general and grain legumes in particular, are often hampered by an insufficient number of qualified and experienced scientific, technical, and service personnel. Scientists who are currently working on research problems within ICRISAT's mandate are usually geographically isolated and often without access to the adapted germplasm and the technology required for effective research work.

ICRISAT's training program was initiated in 1974 to provide educational opportunities for such personnel working in national, regional, and international agricultural research and development programs of the rainfed SAT.

Since 1974, 824 trainees from 66 countries have been enrolled in our training program. The total group from Asia was about 500. Our annual intake is about 60 persons for the rainy season (15 May to 15 November) and 15 for the postrainy season (15 September to 15 March).

The emphasis in training is on developing practical skills and providing theoretical support through consultation and classroom instruction. ICRISAT Center provides access to scientific literature, genetic resources, improved technology, modern equipment, and an environment typical of the SAT for practical educational experiences. The training courses link existing national and regional agricultural research and development programs with ICRISAT's scientific expertise, germplasm resources, collection of research findings, and facilities that are not readily available elsewhere. The personnel trained have strengthened their own regional research and extension programs as research workers, research administrators, trainers, and research-and-extension workers. Some have proceeded for higher studies leading to an M.Sc. or a Ph.D.

Training Categories

The Institute has established six categories of trainees, as follows.

International Interns are accepted from developed countries to work in the international agricultural research and development programs.

Research Fellows are from countries in the SAT and must have recently received an M.Sc. or Ph.D. degree. They are assigned to a specific research problem related to ICRISAT's overall research program. Research fellowships are generally held for 1 year, extendible to a maximum of 2 years.

In-service Fellows are employees in national research programs and are nominated by the country programs for short-term field and laboratory experience at ICRISAT Center, to enable them to improve their knowledge and skills. They should have a B.Sc. degree, but preferably an M.Sc. or Ph.D. They develop individual programs of work during their stay at ICRISAT, and work with the Center's research scientists. The duration of an in-service fellowship is 1-6 months, and fellows are paid a consolidated stipend.

The Research Scholar program is designed for M.Sc. or Ph.D. degree candidates from countries in the SAT or those interested in working in these countries. Candidates complete course work at selected universities and conduct research for an M.Sc. dissertation or Ph.D. thesis at ICRISAT or any other place supervised by ICRISAT staff. They are given a stipend while resident at ICRISAT.

In-service Trainees are nominated by their employers in national programs in countries in the SAT. They must have a degree or a diploma. They are offered an individualized 6-month instructional program with emphasis on the practical application of skills and technology for the SAT.

Apprenticeships are for individuals seeking vacation study programs between degree courses. They are offered practical experience in a specific area of interest within ICRISAT's mandate and facilities. The duration is from 1 to 9 months. They are self-supported.

We also offer special training programs for scientists, administrators, agencies concerned with agricultural inputs, and others connected with the transfer of technology to farmers.

ICRISAT's in-service training program offers training in three major areas: crop production, crop improvement, and farming systems. Up to December 1983 we have received 10 rainy season in-service groups and 4 postrainy season in-service groups. The groundnut training program is offered both in the rainy and postrainy seasons. The pigeonpea program is from 15 September to 15 March. The chickpea program is offered only in the postrainy season. From South Asia, we have had 22 in-service trainees, and 19 research scholars, and from Southeast Asia 68 in-service trainees, 7 research scholars, 4 research fellows, and 6 in-service fellows. Most of these trainees had a B.Sc. degree, and some had an M.Sc. or Ph.D.

Course Contents

Our training methods emphasize the development of practical skills and theoretical support through classroom instruction and consultation. A typical 6-month rainy season program starts with a general and cultural orientation. Nonanglophone participants undergo a prior intensive English training course for 8 weeks at Osmania University, Hyderabad. Each trainee lays out two experiments and an international trial or a demonstration. They develop skills in nursery management, taking observations, and recording and analyzing data. They have up to 8 weeks of laboratory practice in entomology, pathology, physiology, microbiology, and other disciplines, as required. The mornings are generally devoted to fieldwork and the afternoons to classroom activities and seminars. They are given opportunities to visit local extension programs, agricultural universities, research farms, seed-production programs, etc., in the SAT of southern India. They are given assignments to check their progress in understanding the lecture materials. The course ends with an evaluation of the trainee and the program.

Participation and Funding

Trainees are accepted on nomination by their employers, coupled with the expectation that their future work will be in the SAT. The training requested must be within ICRISAT's capabilities and be compatible with our research programs at ICRISAT Center, the Sahelian Center, and other collaborative stations in the SAT, The availability of staff and facilities at ICRISAT Center is an important consideration in accepting the trainees. Up to four persons per country are usually accepted for each cycle by selection from an ordered list of recommendations submitted by sponsors. Ability to communicate in English is an important requirement (to permit the trainees to benefit fully from interaction with local staff).

A large number of trainees have been supported from ICRISAT core funds (189). Some have been self-paid (36) or supported by governments (27), the World Bank (21), UNDP (21), and FAO (13). The IDRC, IADS, USAID, IMC, the Peanut CRSP, the Ford Foundation, etc., have also supported a few individuals.

The early 1984 cost of training is around US$600 per month, plus travel to ICRISAT and return. During their stay at ICRISAT Center the trainees are paid an incidental allowance of $55-75 per month depending on their category, and a food allowance of approximately $2.75 per day. Fellows who prefer to stay outside ICRISAT Center are provided allowances depending on the cost of local housing and, in some cases, support is given for families who accompany long-term scholars and fellows. Trainees are also provided a book allowance of $100-150.

Follow-up to training courses operates through personalized correspondence, visits by ICRISAT scientists to national programs, and the supply of seed material, publications, and reports from ICRISAT Programs.

(Editorial note: Not summarized. This is the complete paper, as presented.)

Country Papers

Groundnut in India: Present Status and Future Strategy

P.S. Reddy

All India Coordinated Research Project on Oilseeds, Punjabrao Krishi Vidyapeeth, Akola, Maharashtra 444 104, India

Present Situation

In India groundnut is cultivated over about 7.2 million ha (40% of the world area), with an annual production of 6.0 million tonnes of nuts in shell (33% of world production). Some 80% of the area and 84% of production is confined to the states of Gujarat, Andhra Pradesh, Tamil Nadu, and Maharashtra. The remaining 20% area and 16% production is scattered in the rest of the country.

Gujarat. About 80% of the groundnut area is under Virginia Runner types: Ah.334 and Punjab-1, both of which are slowly being replaced by GAUG-10. Spanish Bunch types are grown in about 20% of the area. J-11 is currently the popular cultivar; but it is being replaced by the recently released GAUG-1 and JL-24.

Andhra Pradesh. The principal improved cultivars grown in this state are Kadiri 71-1 (Virginia Runner) and Kadiri-2 and Kadiri-3 (Robut 33-1) (both Virginia Bunch types).

Tamil Nadu. About 92% of the groundnut area in the state is under Spanish Bunch cultivars, mostly TMV-2 but also TMV-7 and other improved and local cultivars. Potentially important new cultivars are Co-1, TMV-12, and JL-24.

Karnataka. Popular Spanish Bunch cultivars are Spanish Improved, S.206, and the recently released Dh.3-30. Kopergaon-1 and S-230 are the favored Virginia Bunch and Virginia Runner varieties.

Maharashtra. About 60% of the groundnut area is planted to Spanish Bunch cultivars. A further 35% is under Virginia Runners and the remaining *5%* is under Virginia Bunch. Popular Spanish Bunch cultivars are AK.12-24 and SB XI. The recently released Spanish Bunch cultivar, JL-24 (Phule Pragati), is rapidly replacing earlier cultivars. Additional Spanish Bunch cultivars are Kopergaon-3 or Tija, a Valencia type. Karad 4-11 and Kopergaon-1 are the most popular Virginia Runner and Virginia Bunch cultivars. The recently released cultivars M-13 and TMV-10 have been recommended for cultivation in this state.

Madhya Pradesh. Bunch types occupy about 70% of the area. The Valencia type Gangapuri is the most popular, followed by AK.12-24 and Jyoti, both Spanish Bunch. Virginia Runners (local and M-13) are grown in about 20% of the area. Virginia Bunch types occupy about 10% of the area. Gangapuri, Jyoti, and AK.12-24 are the most popular cultivars for irrigated cultivation.

Uttar Pradesh. About 90% of the area is covered by Virginia Runners (T-28, Chandra, and M-13) and the remaining 10% is under the Virginia Bunch group (T-64).

Rajasthan. Popular cultivars are AK.12-24 (Spanish Bunch), RSB.87 (Virginia Bunch), RS-1 and M-13 (Virginia Runner). In irrigated areas wheat follows groundnut, and Virginia Bunch cultivars RSB-87 and RS-138 are favored.

Orissa. Some 90% of the area is under Spanish Bunch types, particularly AK.12-24. The remaining 10% is covered by Virginia Runners, especially Punjab-1, TMV-3, and M-13.

Punjab. The entire area is covered by Virginia Runners, mainly Punjab-1 but also M-145 and M-13.

Research Accomplishments

Introduction. Research is being carried out under the All India Coordinated Research Project on Oilseeds (AICORPO) in 17 centers, in association with 25-30 voluntary centers.

Improved cultivars. Some 32 improved groundnut cultivars have been released in three habit groups: Bunch (Spanish/Valencia), Semi-spreading (Virginia Bunch) and Spreading (Virginia Runner). All these cultivars proved to possess high-yield potential coupled with good market qualities.

Time of sowing, spacing, and fertilizer doses. Recommendations are given in the full paper, by state. For best results sowing should be done between the 1st week of June and early July. The quantity of well-developed seed required at the recommended spacings will be about 110 kg/ha for Virginia group cultivars and 120 kg/ha for the Spanish Bunch group. Most farmers who use fertilizers apply only N and P_20_5 because most of the Indian soils are rich in K_2O. In virgin lands where groundnut is newly introduced, however, the application of rhizobial cultures through seed treatment is recommended.

Weed control. Weeds cause considerable losses in yield. A reduction of 25-45% has been recorded due to infestation, especially during early crop development. Weeds can be controlled effectively by the use of Lasso or Tok-E-25 weedicides.

Irrigation. The water requirement of the crop grown in red sandy loams has been estimated at 590-660 mm, whereas in black clay loams only 430 mm are required. The optimum number of irrigations necessary for raising a successful groundnut crop range from 8 to 12 depending upon the soil type, habit group, and plant density.

Control of pests and diseases. Aphids, jassids, leaf miner, red hairy caterpillar, white grub, and leaf-eating caterpillar are major pests. The major diseases are leaf spots (tikka), collar rot, dry root rot, stem rot, rust, bud necrosis, and yellow mold. Chemical and cultural control measures recommended for pests and diseases are given in the full paper.

Intercropping. Various cropping systems with groundnut have been found to be remunerative in different regions: with castor (ratio 2:1), hybrid sorghum (3:1), sunflower (4:2), pigeonpea (3:1), and black gram (3:1).

Results of Field Demonstrations

The production technology generated at different AICORPO research centers was field-tested by organizing field demonstrations of 1 acre (0.4 ha) each in the farmers' fields for 3 years (1980-82). Resulting data show that in all but one case the improved package recommended gave increased yields over the farmers' methods. The mean increase over the 3 years ranged from 26.9 in Gujarat to 100.8% in Rajasthan. A rough estimate shows that adoption of improved technology could increase rainy-season groundnut production from its present level of 5.3 million tonnes to 7.5 million tonnes—an increase by 2.2 million tonnes or 40%.

Research Gaps

The following are the research problems requiring priority attention.

Cultivar requirements. Early-maturing Virginia Runner cultivars for Gujarat, Punjab, and part of Maharashtra. Cultivars tolerant to early drought for Andhra Pradesh, Tamil Nadu, and Karnataka, and to late drought in Gujarat, Maharashtra, and Madhya Pradesh. Spanish Bunch cultivars with fresh seed dormancy to avoid yield losses when the matured crop is exposed to untimely rains. Cultivars responsive to irrigation and fertilization exclusively for postrainy- and dry-season cultivation, and cultivars with strong peg attachment to reduce pod losses in the soil.

Agronomic and physiological problems. Quick loss of seed viability in the case of dry-season irrigated nuts. And iron chlorosis in Gujarat, Karnataka, and Maharashtra (where groundnut is grown in black soils rich in calcium).

Entomological problems. White grubs in Uttar Pradesh, Rajasthan, and Punjab. Leaf miner in Andhra Pradesh, Tamil Nadu, Karnataka, and Maharashtra. And red hairy caterpillar in Andhra Pradesh, Tamil Nadu, and Karnataka.

Pathological problems. Leaf spots all over the country. Rust in Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, and Madhya Pradesh. Collar rot in Uttar Pradesh, Rajasthan, and

Punjab. Dry root rot in Uttar Pradesh and Rajasthan. Sclerotial rot in black soils (Gujarat, Maharashtra, and Karnataka). Bud necrosis in Andhra Pradesh, Madhya Pradesh, Tamil Nadu, Karnataka, and Maharashtra. And clump disease in Punjab.

Future Strategy and Research Links

Work on these research problems by AICORPO is in different stages. The solutions found for some of them are expensive and, for them, cheaper techniques need to be developed. For the control of pests and diseases more emphasis should be laid on cultural and biological measures than on chemical control. Resistance breeding programs are in their initial stages, but sources of resistance for the major pests and diseases are now available. These sources will be acquired either for direct introduction or for use in hybridization programs.

Status of Chickpea and Pigeonpea Improvement in India

Satish Chandra

Indian Agricultural Research Institute, Kanpur, Uttar Pradesh 208 024, India

Introduction

Chickpea is the most important and pigeonpea the second most important pulse crop of India in terms of area as well as production. The former occupies 7.79 million ha, with a production of 4.68 million tonnes annually, and the latter 2.76 million ha, producing 1.47 milion tonnes annually.

Twenty administrative districts have an average chickpea production of more than 1000 kg/ha. A regression analysis of country-wide trends for the decade 1970-71 to 1979-80 showed that this crop is losing hectarage at the rate of 50,000 ha yearly, resulting in an average decline of 22,000 t/yr. However, the average yield has risen annually by 2.8 kg/ha.

Annual data of pigeonpea production show great variability within states, as well as within the country as a whole. Analysis of cultivation data of this crop shows a positive trend, suggesting a rise of 27,000 ha/yr and of 17,000 t/yr, the average increase being 2.5 kg/ha per year.

Research work on both crops is being carried out within a national network of 29 research centers under the auspices of the All India Coordinated Pulse Improvement Project (of the Indian Council of Agricultural Research).

Chickpea: Research Achievements

Cultivation of this crop has been pushed into poor marginal lands because of the expansion of the area under high-yielding cereal cultivars, associated with the country-wide program to increase the use of irrigation. Nevertheless, there has been a small rise in its average productivity.

Improved cultivars. Important stable and widely adapted genotypes identified by the Project are: C 235, H 208, Radhey, K 850, and L 550 (a kabuli type). A few varieties that have resistance to wilt disease are also popular: H 355, Annigeri, and Avrodhi. There has been success with some new chickpea cultivars resistant to ascochyta blight in northwestern India (the Punjab), where G 543 and C 235 have been accepted for cultivation.

Researchers are also attempting to develop new cultivars of chickpea for irrigated areas, particularly those where high-yielding cultivars of rice are extensively grown. Lines BG 270, BG 268, and BG 276 have given very encouraging yields, i.e., more than 3500 kg/ha (and up to 5000 kg/ha), as compared with 3500 kg/ha (and up to 5500 kg/ha) for wheat. As price margins are favorable, and the total investment per hectare is less than with wheat, the cultivation of chickpea is attractive to farmers.

Improved crop management. Major gains in production are achievable through improved weed management, irrigation, and fertilizer application (20 kg/ha N plus 40 kg/ha P_2O_5), in that order of importance. Recommendations are available for optimum population densities and times of planting in dryland farming.

Crop protection. As much as 20% of the chickpea crop in India is devastated by pod borers. Very encouraging results have been obtained in controlling these pests by the application of insecticides. Endosulphan (0.07% spray) and monocrotophos (0.1% spray) applied at pod initiation stage control Heliothis armigera almost fully. Input/output ratios of 1:7 or 1:85 suggest that such chemical control is economically viable.

One reason for high fluctuation in chickpea production is disease attack. Wilt disease and sclerotinia rot cause serious losses. In the early 1980s botrytis gray mold and ascochyta blight also caused great losses. Reasonably good resistant lines for wilt and blight are now available, particularly C 235, G 543, H 75-35, and GNG 146, which in multilocation trials have shown a high level of field tolerance to ascochyta blight.

Rhizobial inoculation. Microbiological inputs of this low-cost biofertilizer in the form of Rhizobium strains have been significant in raising the productivity of chickpea. Field trials have shown increases ranging from 8 to 35%. Several rhizobial strains that perform well with given genotypes in given environments have been identified, and are recommended for field use. The most important widely adapted strain is H 75.

Pigeonpea: Research Achievements

This crop has a wide range of maturity periods, and is grown in many different agroclimatic zones and cropping systems. Most cultivars take more than 180 days to mature, and pigeonpea is generally intercropped with sorghum and pearl millet. If sole-cropped, cultivars maturing within 170 days are normally planted. Some early-maturing cultivars (140 ±5 days) are grown in rotation with wheat in high-input areas. There is also a small area where pigeonpea is planted in September and matures by mid-March or April, along with long-duration cultivars planted in June-July.

Improved cultivars. The average yields achieved with improved cultivars from AICPIP exceed 2000 kg/ha and, in longer-duration types, up to 3000 kg/ha. Popular cultivars are: UPAS 120, Pusa 74, Pusa 84, H 77-216, and AL 15 (120-140 days); C11, BDN 1, BDN 2, and Bahar (170-200 days); T 7 and Gwalior 3 (more than 200 days).

Improved crop management. Recommendations for plant population, irrigation and fertilizer requirements, and weed management have been developed by region. Optimum densities and intercropping systems have also been worked out, providing choices for crop diversification. Particularly recommended is the intercropping system for pigeonpea and groundnut as an alternative choice in light-soil areas where a pigeonpea/pearl millet intercrop is traditionally grown.

Crop protection. There has been a widespread increase in attacks from previously unimportant diseases such as sterility mosaic virus (SMV), in addition to attacks from existing serious diseases such as wilt. In developing resistant cultivars AICPIP use screening techniques and facilities developed at ICRISAT. Screening at the Badnapur Center focuses on these two major diseases, at the Kanpur Center on phytophthora stem blight, and at the Dholi Center on alternaria leaf blight, phytophthora stem blight, and SMV. Some promising lines from these programs are: DA 105(20), MA 2, PDA 10, BSMR-1, -2, ICPL 342, 343, 344, 345, and several others.

The most serious pest of pigeonpea is podfly (Melanagromyza), closely followed by Heliothis and Maruca. The best control is the application of insecticides at pod initiation stage, followed by a second application, if necessary, about 10-15 days later. In eastern Uttar Pradesh Heliothis populations are low from the end of December to mid-February. In this region the cultivar Bahar exploits this phenomenon by podding during this low-activity period. Other measures of integrated pest management are being investigated.

Rhizobial inoculation. The response of pigeonpea to the application of rhizobial cultures has been less than with other grain legumes. The reasons for this are not fully understood, and are being studied.

Future Research and Development

Breeding for disease resistance is AICPIP's first priority in its R&D work on chickpea and pigeonpea. Attention is focused on ascochyta blight, fusarium wilt, and botrytis gray mold of chickpea, and on sterility mosaic virus, wilt, and phytophthora and alternaria blights of pigeonpea.

Other breeding work with chickpea concerns the improvement of kabuli types, particularly to combine bold seed size with resistance to ascochyta blight and high yield. In improving cultivars for use under irrigation, the tall, fast-growing cultivars are mainly used in experiments, the aim being to achieve yields of 5000 kg/ha. Cultivars resistant to environmental stresses are also being developed.

In pigeonpea improvement work multicut cultivars that are early-maturing and photoinsensitive need to be identified. AICPIP's EXACT trial offers breeding materials of immediate potential. The introduction of pigeonpea into, say, the nontraditional areas of rice fallows offers considerable scope for increasing production. Other breeding work will seek to use such mechanisms as male sterility, genetic dwarfism, highly selfed breeding behavior, etc., to broaden the genetic base of breeding populations. In AICPIP's work with early-maturing pigeonpeas the aim is to achieve yield potentials of at least 3500 kg/ha, and of 5000 kg/ha in late-maturing cultivars.

Development of Grain Legumes in Indonesia

Sadakin Somaatmadja and B.H. Siwi

Central Research Institute for Food Crops (CRIFC), Jalan Merdeka 99, Bogor, Indonesia

Introduction

The major grain legumes grown in Indonesia are soybean, groundnut, and mung bean. They comprise the fourth most important group of food crops by harvested area after rice, maize, and roots/tubers, and are an important constitutent of the national diet. Pigeonpea and chickpea are at present minor crops, but have potential in the drier areas of eastern Indonesia, and as components of integrated cropping systems.

Soybean

Indonesia produced 652,000 tonnes of soybean in 1983. This represents an overall increase of 58.6% since the beginning of the first Five Year Plan (Pelita) in 1968 (though with considerable fluctuation in annual data). Most of the increase has been derived from additions to the cultivated area rather than from higher yields. About 800,000 ha are now cropped annually, and have yielded an average of 820 kg/ha over the third Pelita period. At the end of the fourth Pelita in 1988 it is projected that the cultivated area of soybean will be 1,381,000 ha producing a total of 1,746,000 tonnes, or 1260 kg/ha.

The low yields of this crop are due to a number of factors. Local unimproved varieties are generally planted, and germination rates are low (50-60%). Most farmers regard soybean as a minor crop, and so pay little attention to soil preparation and such fieldwork as weeding and pest control. The major pests are: Ophiomyia phaseoli at the seedling stage; Spodoptera litura, Plusia chalcites, Lamprosema indicata, and Phaedonia inclusa that attack leaves and young pods; and Nezara viridula, Riptortus linearis, and Etiella spp that attack the pods. Rust disease (caused by the fungus Phakopsora pachyrhizi) and viruses are the major diseases.

The Central Research Institute for Food Crops (CRIFC) has developed a number of soybean cultivars for release. These are no.29, Orba, Galunggung, Lokon, Guntur, and Wilis. In crop improvement work the aim is to achieve high yield, early maturity (70-80 days), resistance to lodging, rust, and virus diseases, wide adaptability to different soil and climatic conditions, and good seed quality and storage potential. With improved cropping practices, these cultivars can yield 2000 kg/ha.

From 1983 liming and rhizobium inoculation have been supported by the government. In 1984 3000 kg/ha of lime will be applied to 18,000 ha, distributed over a number of provinces, as a demonstration to farmers of the advantages of liming. It is expected that liming can increase yields to 1200 or 1500 kg/ha on certain soils. The rhizobium inoculant "Legin" will be used for seeding 200,000 ha, at a rate of 150 g/ha.

Groundnut

About 500,000 tonnes of shelled groundnuts are produced each year from slightly over 500,000 ha. Production has increased by 75% since 1964-68, but by only 2.5% since 1978. As with soybean, this increase has masked considerable variations from year to year. Yields are presently around 900 kg/ha, having risen by an average of 2.4% per year over the past 13 years. The cultivated area has grown by 3.1 % each year in the same period. Yields are projected to increase by *5%* per year, and the harvested area by *1%* per year, during the fourth Pelita. Such increases would result in a total production of 873,000 tonnes in 1988.

The yield-level of groundnut is low because of poor seed viability and the low-yielding potential of the local cultivars planted. The major pest is Aproaerema modicella; the most important diseases are wilt (Pseudomonas solanacearum), leaf spot (Cercospora sp), rust (Puccinia arachidis), and peanut mottle virus.

Nine improved groundnut varieties have recently been released or are awaiting release: Gajah, Banteng, Macan, Kidang, Rusa, Anoa, Tupai, Pelanduk, and Tapir. High and stable yields through resistance to major pests and diseases, and tolerance of drought and high rainfall, are the major breeding aims. Research in the relatively dry area of northern Aceh showed that groundnut is more tolerant of drought than is soybean. Groundnut thus has promise in this area for planting in rice fields normally left fallow in the dry season.

Mung Bean

Production of this crop rose from 100,000 tonnes in 1978 to 149,000 tonnes in 1983, an increase of 49%. Since 1969, production has quadrupled. An increase in the harvested area has accounted for most of this rise: the area is now 41% greater than in 1978, and is treble that of 1969. Yields are around 550 kg/ha, having risen from 470 kg/ha in 1969.

The newly released cultivars Nuri and Manyar are resistant to rust and leaf spot, and mature early and relatively uniformly, so that only two harvestings are required. Other varieties available are Siwalik, Bhakti, no.129, and Merak.

Pigeonpea

Pigeonpea is grown mainly in house gardens, and production data are not available. In East Nusa Tenggara it is commonly intercropped with maize, but with very low yields (175 kg/ha). Because the crop tolerates drought well, pigeonpea shows promise in the drier areas of eastern Indonesia, where it may produce 3000-4000 kg/ha. CRIFC researchers have tested pigeonpea in food-crop rotations on red-yellow podsols in Southeast Sulawesi. Intercropping pigeonpea with cotton in the dry season (May to August/September) is also being investigated. For this purpose, nonphotoperiod-sensitive cultivars resistant to pests (especially Heliothis) are required. Pigeonpea has potential as a substitute for soybean in making tempeh and tahu (fermented cakes), and young pods can be marketed as a vegetable.

Chickpea

No data on chickpea area or production in Indonesia are available. Chickpea may have value as ground cover in intercropping systems, and for consumption as a vegetable.

Problems and Research Responses

Seed supply. Good-quality seed of the three major grain legumes is not readily available to farmers. The viability of the seeds, especially of soybean, decreases rapidly, especially under farmers' storage conditions. The adoption of the farmers[1] seed network scheme "jabal", however, should improve seed viability. CRIFC will assist in the establishment of this system, and continue to supply breeder seed as "nucleus" for multiplication on seed farms. Research on seed technology and storage will also be intensified.

Pest and disease control. Research is focused on the use of pesticides and fungicides, and on integrated control with cultural practices. Major attention is also given to the production of virus-free seed. Screening for pest/disease resistance is an integral part of CRIFC's breeding program, and will be intensified in the future.

Cultivars. Existing local cultivars have low potential yields, while few improved cultivars are available that are adapted to farmers' cropping patterns, local soil and climatic conditions, and consumer preferences. Soybean especially appears to show regional and seasonal specificity. Most cropping patterns with soybean require rather early-maturing cultivars (70-75 days). CRIFC's breeding program aims to solve these problems; in addition, some local varieties may be officially recognized.

Extensification. The expansion of the harvested area envisaged in the fourth Pelita period necessitates research on aluminium toxicity, soil acidity, soil fertility, and rhizobium inoculation. Soil amelioration and the breeding of tolerant cultivars are two possible solutions to these problems.

Intensification. Existing recommended technology packages, consisting of improved cultivars, good-quality seed, and improved cultural practices, need to be further improved. These packages need to be tested in regional trials in cooperation with the extension authorities, and extended to the farmers. In particular, cropping systems that include a legume crop must be evaluated, and refined if necessary.

Extension and marketing. The training of extension workers needs to be intensified, and the quality and quantity of extension material require improvement. More direct government intervention in marketing may be necessary, through the manipulation of floor prices and the buying of produce by rural cooperatives. CRIFC is continuing its socioeconomic research on this subject.

Groundnut Production and Research in Malaysia

Noor Rawi Abu Bakar, Mohd. Azmi Ibrahim, and Ramli Mohd. Noor

Malaysian Agricultural Research and Development Institute,
MARDI Research Station, P.O. Box 3, Kuala Trengganu,
and MARDI Research Station, Serdang, Malaysia

Introduction

Groundnut is the most extensively grown grain legume in Malaysia. It is an important cash crop and is sole-cropped on river banks and in rainfed rice areas, or is intercropped with tree crops. The growing area in 1982 totalled 6149 ha.

Trade and Production

Most Malaysian groundnuts are marketed as fresh unshelled pods. More than 80% of this product is processed for sale as roasted nuts, and the rest are consumed as boiled nuts. It has been estimated that in 1985 the domestic demand will be 16,517 tonnes, and that meeting this requirement is achievable by increasing the present hectarage by another 22% (1359 ha), assuming an average fresh pod yield of 2200 kg/ha. Groundnut is planted under rainfed conditions and is usually rotated or intercropped with other crops. There are four major areas:

a. river banks, where the nuts are usually of poor quality and are grown to provide planting material for the subsequent crop;

b. the sole-cropped rainfed rice area, where groundnut is grown after rice during the off-season (there being insufficient water for cultivating a second crop of rice)—an area of good potential for groundnut production;

c. the rubber and oilpalm area, where groundnut is intercropped with oilpalm or is grown on land recently cleared of rubber trees;

d. the Bris soil area, where groundnut production is at present insignificant but where the crop can be rotated with tobacco.

The Malaysian Agricultural Research and Development Institute (MARDI) currently recommends three cultivars for use throughout the country: V-13, Matjam, and 47-5. However, where there are inadequate supplies, farmers plant such cultivars as Sungai Siput or Mengelembu, or others from Indonesia and Thailand.

Farmers usually prepare the land with one round of plowing and one or two rounds of rotovation. Row planting at 50 x 10 cm spacing, and fertilizer application at the rate of 34 kg N, 56 kg P_2O_5, and 56 kg K_20 per hectare, with 1000-2000 kg/ha of dolomitic limestone, are recommended for most soils. The use of a pre-emergence sprayed herbicide (alachlor), followed by manual weeding, is recommended for effective weed control. Farmers seldom use chemical controls for pests and diseases because the problems they cause are not usually serious.

Research Activities and Achievements

Priority is at present being given to the development of groundnut as a complementary or supplementary crop in areas a, b, and d (as above), though previously research was mainly centered on upland environments.

Current research comprises fundamental, applied, and project-development studies, and includes the verification of new technologies on farmers' fields. Recent highlights are as follows.

Breeding and varietal evaluation. Emphasis is being given to the hybridization program in which breeding aims to improve yield and quality. Nine lines have been selected as having potential for high yield.

Development of cultural and management practices. In east-river-bank areas, studies showed that 200,000-300,000 plants/ha, planted in 50-cm row spacing and harvested at 100-105 days after planting, produced optimum yield. Spatial crop arrangement, however, was found not to be critical. Row spacing at 50 cm is recommended for good *crop* management.

Nutrient requirement studies. The nutrient requirements for groundnut have been found to vary from place to place, depending on soil types and moisture regimes. Experiments are being carried out to explain and understand the mechanisms of crop response to the nutrient uptake, and NPK fertilizer trials are being initiated in the rainfed rice and Bris soil areas. Nodulation studies are also in progress.

Insect pest studies. Insect pest attack in the east coast of Peninsular Malaysia varies from season to season. For example, in the Kelantan river-banks area the major insect pests in the first-crop season are leaf feeders (Spodoptera litura and Heliothis armigera). These pests do not diminish yields; but in the second season leaf miner (Aproaerema modicella), aphids (Aphis craccivora), and thrips (Frankliniella schultzei) have been observed to affect yields adversely.

Disease studies. Wilt, caused by Pseudomonas solanacearum and Aspergillus niger, are the most important diseases. A screening technique for these pathogens is being developed. Cercospora leaf spot and rust often occur late in the growing season, and significantly affect yields. Groundnut mosaic virus is also common, but is not serious.

Weed control studies. Common weeds have been identified, and studies have shown that competition from weeds can result in up to 80$ yield loss. Chemical weed control with alachlor plus manual weeding, or two rounds of manual weeding, are recommended.

Crop physiology studies. Glasshouse and field research on water stress has been initiated. Results from field studies showed that yield could be reduced by 40-50% if moisture stress occurred during the flowering period. Studies on waterlogging at different growth stages are also under way.

Cropping system studies. In rotational planting in the river-bank areas there is not much yield variation between the groundnut plots previously growing other field crops or rice. Wilting was observed to be a problem in plots consecutively cropped with groundnut. Other parameters being studied include the effects of residual fertilizer and the build-up of pests and diseases in rotational cropping.

Production Constraints

Most farmers still grow unimproved imported cultivars. The cultivation methods they use are unsatisfactory: low planting density, very low or no fertilizer and lime applications, and inadequate weeding and pest and disease control.

Weeds are serious yield-reducers. Some plots are not harvested at all because of overabundant weeds. Most farmers do not carry out sufficient manual weeding because of labor shortages and associated high wage costs.

Labor shortages are increasing in the groundnut-growing areas. At present the only operations that are being mechanized are land preparation and, to a limited extent, planting. Other operations that need to be mechanized are harvesting and threshing.

Malaysian soils are basically of low fertility. In the river banks fertility is declining because flooding has been less frequent in recent years. In the paddy fields soils are exhausted after the rice harvest. Similarly, the inherently poor Bris soils cannot sustain proper crop growth if farmers do not apply enough fertilizer.

Erratic weather conditions, including frequent droughts and flash-floods, also reduce yields because the crop is entirely dependent on rainfall.

Expansion of groundnut production beyond the present hectarage depends very much on increasing the export market. Market analyses indicate that increased production is possible if imports are restricted and higher prices are offered for locally-produced groundnut.

Future Research

The research activities already described will continue, with emphasis on the breeding program for crop improvement. One research area requiring attention is the reduction of labor costs through mechanization. Another is the investigation of ways to minimize moisture stress or flooding. Related water management studies (irrigation and drainage) will be carried out in the rainfed rice and Bris soil areas. Also, because the main market is for roasted groundnuts, which have limited foreign outlets, there is a need to look for new ways of utilizing the nuts.

Legume Crops in Nepal

Rajman P. Chaudhary and Achyut N. Bhattarai

Agronomy Division, Khumaltar, Kathmandu, Nepal

Introduction

Legume crops in Nepal include soybean, mung bean, pigeonpea, cowpea, black gram, lathyrus, chickpea, lentil, and others. They play an important role in the cropping systems of Nepal and in human nutrition. Production data for all food legumes are available for 1976-77. These data (which have not changed much since 1977) are: production area—328,580 ha; average yields—346 kg/ha; total annual production—11,410 tonnes.

There is no systematic marketing of legume crops in Nepal. Legume products are sold directly to the local retail merchants, but it is known that since 1975 export to countries other than India has increased, especially to the Arab Republic of Egypt, UK, USA, and Singapore.

The recently established Nepal Vegetable Ghee Industry will in the future use groundnut to produce 600-800 tonnes/yr of vegetable fat as a substitute for butter and ghee. The factory uses soybean oil imported from India but, due to its high price and the low recovery of soybean fat, there is currently a need of about 20,000 tonnes/yr of raw groundnut. Some 16,000 - 18,000 ha of land will be required to meet this level of production.

Production Practices

Pigeonpea is cultivated either as a sole crop on upland areas or in rice bunds. It is late-maturing and is not suitable for cropping. The crop is usually planted in June-July.

Chickpea is grown either in relay planting (with no tillage operation) in standing rice paddy, or by normal planting methods involving land preparation. In the latter, chickpea may follow early rice or maize, or it may be intercropped with oat, mustard, linseed, or lathyrus. The most appropriate time for planting chickpea is 15 October to 15 November.

Both crops are susceptible to fusarium wilt and attack by Heliothis armigera. Additionally, chickpea is susceptible to rhizoctonia disease, and to attack by Lampides boeticus, Agrotis sp, Plusia orichalcea, and Callosobruchus sp.

Farmers do not generally use fertilizers, pesticides, or rhizobial inoculation. Both crops are grown in upland areas, and are rarely irrigated.

In the absence of an established market, groundnut cultivation was of limited extent until a few years ago. It has grown in importance as a sole crop after wheat, lentil, toria, barley, potato, and sweet potato, or as an intercrop with maize. Groundnut is generally planted between 21 May and 15 July. Fertilizer application in farmers' fields is not common, and the crop is rarely irrigated. However, it is recommended that fertilizer should be applied at the rate of 40:60:20 kg/ha of NPK. Additionally, if available, rhizobial inoculation can be used at the rate of 800 g/ha. The pesticide methyl parathion is recommended for use when needed.

The diseases of groundnut in Nepal include Cercospora arachidicola. C. personata, Rhizoctonia sp, Sclerotium sp, and Calonectria sp. The most serious pests are: Phyllophaga sp, Spilarctia casignata, and Spodoptera litura.

Research Activities and Needs

Cultivars. The following cultivars have been identified and released: Hardee and Hill (soybean); Pusa Baisakhi (mung bean); T9 (black gram); T36, P43, and Sindoor (lentil); Trishul and Dhanush (chickpea); and B4 (groundnut).

There remains a need, however, to develop better cultivars with desirable characters and resistance to major diseases and pests. Efforts are being made to increase germplasm collection and maintenance, initial evaluation trials, selections from international nurseries, coordinated varietal trials, farmers' field trials, and minikit programs.

Agronomy. Data on this subject are inadequate, even though initial recommendations on seed rates, plant populations and spacings, fertilizer applications, etc., have been drawn up. There is a prime need to conduct field studies systematically in several locations.

Diseases and pests. In addition to the routine screening of lines, breeding materials, and cultivars against major diseases and pests, efforts are also being made to conduct basic research on the management of diseases and pests, comprising cultural and chemical measures for their control.

Metacid has been found effective in controlling major pests of groundnut, chickpea, and pigeonpea. Research on suitable fungicides for use with chickpea and pigeonpea has not been carried out. For groundnut, however, Blitox 50 (copper oxychloride) at 2 g/liter, Dithane M-45 (maneb) at 2 g/liter, and Bavistin (methyl-Z-benzimidazolecarbamate) at 1 g/liter have been found effective in controlling Cercospora arachidicola.

Extension and Training

Outreach, cropping systems, and seed production programs. Various central and regional outreach and cropping systems programs have been set up to include farmers' field trials, minikit programs, and intercropping extension work. At present there is no separate farm in Nepal for the producton of breeder and foundation seeds for grain legumes. But seed multiplication programs have been initiated at various government farms and stations in the country.

Training. Most agricultual R&D staff are sent for further training to other countries. These training programs range from observation studies to higher education and degrees. Most trainees go to India, and the principal donors for training programs are UNDP, FAO, USAID, and the Colombo Plan. As a result of recent improvements in higher education in Nepal, degrees in agriculture are now obtainable within the country. But there remains a need to expand the type of postgraduate training available at ICRISAT.

Potential Collaborative Work

Nepalese scientists have collaborated with ICRISAT staff in collecting the germplasm of legume crops in Nepal. There is a need to extend this initial work to cover the whole of the country, on a similar collaborative basis. Exchange visits by their scientists—particularly with those who can assist in crop research program planning—are welcome.

Conclusion

Future prospects for groundnut, chickpea, and pigeonpea production are good in Nepal. If they are realized and production increases significantly, imports can be reduced, exports increased, and more nutritious food can be made available to the people of the country.

Improvement and Production of Grain Legumes in Pakistan

Bashlr Ahmed Malik

Pakistan Agricultural Research Council, National Park Road, P.O. National Institute of Health Labs, Islamabad, Pakistan

Introduction

Chickpea is grown as a postmonsoon "winter" crop in Pakistan. By land area planted to chickpea, the country ranks second in the world. But, until recently, inadequate attention has been paid to increasing its production, which is either stagnant or declining.

Production and Yield Data

In 1983 the cultivated area of grain legumes was 1.456 million ha. This was 9.8% of the area covered by cereals, cash crops, and oilseeds during the same year. Chickpea is cultivated on 70% of this area under grain legumes and, of the remaining 30%, 28% is covered by lentil, mung bean, black gram (Vigna mungo), and lathyrus. A few other legumes are grown on the remaining 2%. These are pigeonpea, moth (Phaseolus acontifolius), and cowpea.

The total production of grain legumes in 1983 was 712,000 tonnes, out of which chickpea alone contributed about 70%. These figures are expected to increase to 795,000 tonnes and 73% by 1988.

The national average yields of grain legumes are very low, and declining in some cases. For chickpea, the figure of 425 kg/ha obtained in 1983 has been projected to increase to 523 kg/ha by 1988. Yields of other grain legumes is similarly expected to rise from 381 kg/ha to 504 kg/ha.

Chickpea Production Zones and Practices

Pakistan can be divided into three agroecological zones where chickpea is grown: the Northern, Central, and Southern Regions. Differences in soil fertility, climate, and socioeconomic conditions have led to the development of the following pattern of crop rotation.

Rice—Chickpea (on residual moisture)—Rice.
Chickpea/lentil—Millets and mung bean/Maize—Wheat.
Wheat/mustard--Black gram/sorghum—Chickpea/lentil.
Mung bean/black gram—Chickpea—Maize/sorghum.
Groundnut—Wheat—Mung bean/black gram.

Soybean—Wheat—Mung bean/black gram,
Chickpea—Fallow—Chickpea (Thal Desert).
Wheat—Fallow—Cotton—Wheat.

Chickpea is planted in seedbeds that are free of large clods and trash. Some 80-90% of the farmers provide their own seed. The seed rate ranges between 80 and 100 kg/ha, and sowing occurs between mid-September and November. Two new cultivars, CM-72 and C-44, were released in 1982. Others commonly used are C-727, C-612, C-12/34, Local, Sanyasi, and Sindhi White. Tillage operations are mostly performed with bullock-drawn implements.

Most farmers do not use chemical fertilizers in growing grain legumes. However, phosphatic fertilizer is recommended, at a rate of 50 kg/ha. It is usually broadcast.

Harvesting is done manually. Plants are left in the field in small piles to dry, and are later gathered into large heaps in the threshing yards. The threshing, with bullocks and subsequent manual winnowing, is labor-intensive and produces unsatisfactorily cleaned seeds.

Constraints to Chickpea Production

Soil and climatic conditions. The crop is grown on marginal sandy land poor in fertility, almost exclusively under rainfed conditions in areas of low rainfall. The potential for higher yields is therefore governed by this harsh environment.

Pests, diseases, and weeds. Almost all the chickpea cultivars grown are susceptible to pests and diseases. The most important disease is blight (Ascochyta rabiei). The most damaging pests are pod borer (Heliothis armigera), cutworm (Agrotis spp), and seed weevils (Bruchus spp).

Weeds also reduce yields but the high cost of hand-weeding deters farmers from carrying out this task.

Other constraints. These include an inadequate supply of quality seed, inability to plant at the optimum time due to uncertain rains, and such economic factors as low return per unit area, lack of other incentives, and the low purchasing power of most chickpea farmers.

Research Infrastructure for Chickpea and Pigeonpea

Sustained research on the improvement and production of chickpea and other legumes did not begin until 1978-79, when a research unit was set up to work in Sind, NWF, and Baluchistan Provinces. In 1980 the Pakistan Agricultural Research Council established a National Cooperative Research Program. This Program faced a major crisis due to blight damage of the chickpea crop in 3 consecutive years. Growers suffered heavy losses (of the order of

US$ 90 million). In order to avoid the recurrence of such a situation in the future, and to achieve the production targets set for grain legumes in the Sixth 5-Year Plan, research work has been expanded in each province, including the recruitment of more scientists and the procurement of other inputs. Research priorities during the Plan period are given in Table 1.

Table 1. Research priorities for chickpea and pigeonpea, 1983-88.

Priorities	Chickpea	Pigeonpea
Local collection	***	***
Introducton	***	***
Selection	***	***
Breeding	***	-
Water management (inc. irrigation and moisture conservation)	***	*
Fertilizer studies	***	-
Pathology	***	***
Entomology	***	***
Cropping systems	**	***
On-farm trials	***	**

*** = First priority. ** = Important to do. * s Should be done.

Agricultural Extension infrastructure

The extension service relating to chickpea and other major grain legumes is mainly the concern of provincial departments of agriculture (extension wings). Extension work is currently being intensified in every province, and chickpea, groundnuts, mung bean, lentil, and soybean are the principal crops included in promotion programs.

The organization of such work starts at provincial level—the Agricultural Extension Department—and goes down to Union Council level. Extension staff concerned with legumes endeavor to augment the production of these crops, while also promoting the production of cereals and oilseed crops.

In a few selected districts the T&V (training and visit) system of extension has been introduced. Subject-matter specialists have been appointed, and the services of agricultural officers and field assistants are utilized in the time-bound management system that has been created for this intensive extension work.

Training and other Support Requirements

A National Cooperative Research Program was launched in 1980, funded by IDRC, under which six researchers were trained at ICRISAT and ICARDA, and two pathologists participated in an intensive 3-weeks' course on chickpea pathology, sponsored by ICRISAT.

There is a great need for training further chickpea and pigeonpea researchers during the Sixth 5-Year Plan (1983-88) to strengthen the country's research work on grain legumes. It is estimated that at least four persons need to be trained yearly in 6-month training courses, and six need to be released for degree courses.

Associated support is sought additionally for:

a. chickpea and pigeonpea germplasm and breeding materials;
b. the exchange of scientists, and visits by subject-matter specialists;
c. guidance in the development of research programs;
d. the supply of relevant literature; and
e. funds for equipment, training, and research staff.

Footnote on the Prospects of Pigeonpea in Pakistan

Although pigeonpea is currently grown in three provinces of Pakistan chiefly as a border crop around sugarcane and cotton fields, the prospects of this crop are bright, for the following reasons.

a. Growers are acquainted with the crop's production.
b. Pigeonpeas are already known and accepted in the country's markets. Many domestic consumers in Sind and NWFP use split pigeonpeas as dhal.
c. Current marketing rates at Rs.100-150 (US$ 10-15) per 40 kg are quite common.
d. Pigeonpea is well adapted to rainfed farming areas because of its tolerance of drought.
e. Pigeonpea fits well into several crop combinations.
f. New potential production areas are available.

For wider adoption, there is a need to replace the present late-maturing landraces with early-maturing, high-yielding, and better-adapted genotypes.

Groundnut Production in Pakistan

A. Rahman Khan

BARD Project, Pakistan Agricultural Research Council,
P.O. Box 1031, Islamabad, Pakistan

Introduction

Groundnut in Pakistan was first grown in Rawalpindi division in 1949, and is now grown in Punjab (92%), NWFP (7%), and parts of Sind (1%). All nuts produced are marketed as roasted nuts, and none is available for oil extraction. Production data are presented in Table 1.

Table 1. Area and production of groundnut in Pakistan.

Year	Area ('000 ha)	Prodluction ('000 t)	Yield (kg/ha)
1973-74	38.0	54.1	1420
1974-75	40.5	57.1	1411
1975-76	43.6	61.6	1411
1976-77	45.1	64.1	1421
1977-78	50.7	72.4	1428
1978-79	36.5	45.5	1245
1979-80	40.8	50.3	1233
1980-81	46.5	57.4	1220
1981-82	59.7	72.2	1203
1982-83	69.3	84.1	1214

It is considered that the country's hectarage can be substantially increased, making the crop an important contributor to total oilseed production. Also, if significant efforts are made to remove the constraints in the development of the crop, it is believed that the present average yield can be increased to about 1800-2000 kg/ha.

Cultivars

Many cultivars have been imported from different countries, and the following have been released for use by growers.

No.45: a bold-seeded runner. This was the first cultivar released for commercial cultivation, in 1954. It achieves high yields and has attractive pods for table use. The shelling percentage ranges between 50 and 60% (which is low because of the large number of pods it produces). It is not suitable for oil extraction purposes. No.45 matures in about 6 months and its potential yield is about 2000 kg/ha.

No.334. This runner type was released for general cultivation in 1972. It is medium-seeded with well-filled pods, which makes it desirable for table use. Being high in shelling percentage (70-80%), and with good kernel yield, it soon captured popularity from No.45, and is now the widely grown cultivar. Its oil content is as high as 50% with a low free fatty acid value. For this reason, it is favored for oil extraction purposes. It matures in about 6 months and has a yield potential of about 2500-3000 kg/ha.

Banki. This semi-bunch type was approved for commercial production in 1973. It is medium-seeded and high-yielding. It not only possesses all the good qualities of No.334, but is also less laborious and cheaper to harvest. It, too, has gained ground and its seed is in heavy demand. It matures in about 6 months and has a yield potential of about 3000 kg/ha.

Starr and Argentine. These are bunch-type cultivars for late planting in July under rainfed conditions. They mature in about 95-100 days, with an average yield of 1100 kg/ha.

Production Practices

Rotation. Extensive areas of groundnut are planted after harvesting wheat where there is sufficient soil moisture for such rotational cropping. However, best yields are obtained when groundnut follows maize. The crop is also grown after pulses and millets. Spanish types have shown promise in irrigated fields because of their adaptability in such intensive wetland cropping rotations as cotton-groundnut-maize and groundnut-maize-wheat/postrainy-Season oilseeds.

The normal rotation used in the rainfed farming (barani) areas of Punjab, the major groundnut-growing zone, is groundnut-wheat-groundnut. This is a long, uneconomical rotation, and it needs to be replaced, perhaps, with groundnut followed by pulses/millets.

Intercropping. Some experiments have been carried out in which groundnut was planted in wheat fields during March, depending on the availability of moisture. This relay cropping, however, has not been adopted on a commercial scale.

Sowing. The time of planting varies for different areas of the country. In rainfed areas planting starts towards the end of March and continues up to the end of June, depending upon the availability of moisture. The best period is from mid-March to the end of April. Under irrigated conditions planting during the second fortnight of March is recommended. On small farms seeds are dibble-planted, and on larger farms they are planted in furrows through "kera", followed by planking. Recommended spacings, seed rates, and treatments are given in the full paper.

Other Agronomic Recommendations

A fertilizer dose of 3-3.5 bags of DAP is recommended at the time of planting, to provide 68-80 kg/ha of P_2O_5 and 25-29 kg/ha of N. If the soil is sandy and the rainfall is plentiful 1 bag of urea should be applied as a second dose.

Hand-hoeing is required, particularly when the dry period begins in May and when the plants start to peg and to form needles (in July), in order to conserve the maximum amount of moisture.

Irrigated groundnut has been found to be responsive to irrigation at weekly intervals. Also, the provision of adequate moisture at bloom and post-bloom periods is significantly beneficial.

Most of the crop is harvested by hand. This work is expensive, and some pods are left in the ground. For improved harvesting, a tractor-drawn digger has recently been manufactured, and gives excellent performance in digging operations.

Groundnut produce is cured by sun-drying for about 10 days, to maintain the desired flavor and quality. Pod moisture at digging, which is normally about 40-50%, is reduced to 8-10% by this process. At this low level the produce can be stored safely.

Pests and Diseases

Pests. The following insects attack groundnut in Pakistan: jassids, aphids, cutworms, grain caterpillars, hairy caterpillars, armyworms, thrips, termites, and surface grasshoppers. Measures of chemical and cultural control have been investigated, and recommendations have been drawn up and issued. Yields are also reduced by mammalian pests, in particular rats and wild boar. The former may be controlled with poisoned bait, or by fumigating or poisoning the burrows. Boar control, to be effective, requires the organization of large-scale campaigns of eradication.

Diseases. Only scanty information is available on diseases affecting groundnut in Pakistan. However, there is general recognition that "tikka" (<u>Cercosporidium personatum</u>) is a prevalent groundnut disease. Fusarium wilt and root rot diseases have also been reported from different groundnut-growing areas.

Production Constraints

The major constraints in the production of groundnut in Pakistan are the following.

- Lack of short-duration cultivars suitable for intercropping with wheat.
- Nonavailability of certified seed.
- Lack of purchasing power for inputs among farmers.
- High harvesting costs and losses.

- Nonavailability of suitable groundnut diggers.
- Severe damage by rats and wild boars.
- Wide price fluctuation and an inadequate marketing structure.

Research, Training, and Extension

There is an inadequate corps of research staff concerned with groundnut improvement in Pakistan. Training is required for qualified scientists, with particular regard to the disciplines of agronomy, pathology, and engineering. Liaison visits to Pakistan by groundnut agronomists and mechanization engineers are welcomed.

Extension work is the responsibility of the Provincial Extension Departments that are linked with the Provincial Agricultural Research Institutes. Similar arrangements exist for other major crops in the country.

Priorities

Groundnut is one of the important established oilseed crops in Pakistan. Its high-yield potential, as well as the scope that exists for an increase in its cultivation area, have been established. It is therefore now considered a priority oilseed crop in the country. Projects for its maximization and the development of early-maturing and high-yielding cultivars have recently been approved by the Government, and have already been initiated. Consideration is being given at federal level to the installation of a defatting plant, and a special seed production plan has been proposed.

The Philippine Legume Research and Development Program: Status and Direction

Dely P. Gapasin and Bethilda Umali

Crops Research Department, Philippine Council for Agriculture and Resources Research and Development (PCARRD), Los Banos, Laguna, Philippines

Research Thrusts and Priorities

The research thrusts of the national legume research program were formulated to provide solutions to various constraints in the production of legumes. Research activities have therefore been allocated priorities in accordance with the needs and requirements of the industry.

High-priority research projects for major legumes concern the development and screening of cultivars that are stable and high yielders, resistant to insect pests and diseases, tolerant of marginal and adverse conditions, suitable for existing farming systems, have long seed viability, and have high nutritive value. On-farm verification trials to improve available technology have become very important, and work to upgrade village-level technology for processing legumes for food and feed has been undertaken.

For minor (vegetable) legumes, priority activities include germplasm collection and evaluation, on-farm trials, farming systems development, and processing and utilization studies. To improve farmers' practices and provide low-cost technology, further research needs to be conducted on the rate, time, and frequency of irrigation, on fertilizer management, inoculation techniques, and pest control strategies.

The National Legume Research and Development Program

This program is drawn up by PCARRD through its National Legume Commodity Research Team, in consultation with the various agencies involved in legumes research in the National Research Network.

Field legumes such as soybean, groundnut, and mung bean are classified as first-priority crops because they are grown extensively and produced in large volume. But vegetable legumes such as cowpea, beans, peas, pigeonpea, and chickpea are considered minor crops.

PCARRD currently monitors and coordinates the research and development program for legumes in the National Research System. A total of 482 projects and studies have been conducted or are planned during the 4-year period 1982-85. There is increasing national support for this research and development program, and the largest allocation is provided for varietal improvement.

The National Legume Network

The research centers and cooperating stations composing this national network are located strategically throughout the country. The national commodity research center for legumes is at the University of the Philippines at Los Banos (UPLB). It is responsible for carrying out basic and applied research to generate and verify technology and information on groundut, mung bean, soybean, and other legumes. To support its activities 15 regional research centers and cooperating stations have been identified by PCARRD, based on their capability in terms of staff support, infrastructure, equipment, and other resources. They are responsible mainly for conducting applied studies for the regional verification of technologies. They also assist in disseminating the results of research to farmers.

International Links

Collaboration with national and international research agencies involves the exchange of germplasm, provision of funds for research projects, manpower development and training, equipment support, and exchange of new technologies, research findings, and methodologies. International agencies of special relevance in legumes research working with Filipino scientists through PCARRD are: the Asian Vegetable Research and Development Center (AVRDC), International Council for the Development of Underutilized Plants (ICDUP), ICRISAT, the International Soybean Program (INTSOY), NifTAL, and the Peanut CRSP.

Research Status

Cultivars of major and minor legumes. Breeding work at the Bureau of Plant Industry (BPI) and at UPLB has led to the release of five soybean, six groundnut, and eight mung bean cultivars for commercial production by the Philippine Seedboard.

Recommended soybeans include CES 434, Clark 63, L-114, T.K.-5, and UPL-SY-2. Some important cultivars for groundnut are BPI-P9, UPL-Pn2, and UPL-Pn4 and, for mung bean, MG50-10A, Pag-asa 1, Pag-asa 2, and Pag-asa 3. Among the vegetable legumes breeding work first started on string bean and cowpea and, later, on lima bean and pigeonpea. Germplasm (local and foreign) has been collected, screened, and evaluated for its agronomic characteristics and adaptability, and some promising accessions have been used for hybridization.

Cultural management. Recommendations for improved cultivation methods and packages of technology for farmers' use have been developed. Emphases in crop protection studies have been on the chemical control mainly of soybean rust and the cercospora leaf spot disease of groundnut. Studies on multiple cropping with legumes showed that they can be recommended for planting with maize, sugarcane, coconut, and other crops. Only limited studies on the components of production technology for vegetable legumes have been conducted.

Postharvest handling and storage. A soybean drier has been developed at UPLB, and its field-testing is nearing completion. Only a few studies have been done on the effect of packing materials, threshing practices, and pests during storage on the quality of and physico-chemical changes in the seeds. Other research on the handling and storage of legumes has been done, but practical recommendations are limited.

Processing, utilization, economics, and marketing. Problems associated with the processing of soybean are low product acceptability, flatulence effects, the presence of antinutritional and toxic factors, and high processing costs. Studies on aflatoxin in groundnut showed that the situation is aggravated by inappropriate harvesting and postharvest handling practices. Research with field beans showed that there is potential for producing such products as infant feed supplements, snacks, desserts, and flour. Numerous products and by-products from vegetable legumes have also been tried. Studies on the economics of production and market channels for major legumes have been carried out, but there are few production and marketing data for vegetable legumes.

Research Needs and Future Plans

Varietal improvement. Primary legume breeding program objectives are to develop cultivars that are high-yielders: at least 1500 kg/ha for soybean, 1500 kg/ha for mung bean, and 2000 kg/ha for groundnut. Other important breeding features are high nitrogen-fixing capacity, nonphotoperiod sensitivity, and tolerance to marginal and adverse conditions, with highly nutritious qualities and suitability for processing. Long-range breeding objectives include pest resistance, particularly against rust in soybean, and cercospora leaf spot and rust of groundnut.

Cultural management. Research on water management and the physiological factors affecting production needs to be initiated. More research resources will be directed towards the development of an integrated control against pests, particularly soybean rust, and cercospora leaf spot of groundnut. Low-input mung bean technologies will help to improve yields in subsistence farming. Similarly, for vegetable legumes, studies need to be conducted on the distance, rate, time, and depth of planting, on water and fertilizer management, rhizobium inoculation, and pest control.

On-farm trials. Verification trials will be intensified and will include yield trials of promising varieties. Newly developed farm tools, implements, and equipment will also be field-tested. Results of studies on cropping systems involving legumes will undergo verification at different locations to determine their adaptability.

Other pre- and postharvest studies. These will include the improvement of farm tools and equipment, postharvest handling and storage, and research into the processing, utilization, and marketing of legumes.

Research on Winged Bean, Pigeonpea, and Groundnut in the Philippines

Honorato C. Jereza and Jose O. Penuela

Ministry of Agriculture Region no.6 (Western Visayas), Philippines

Introduction

The production of field legumes, such as groundnut, winged bean, soybean, mungo, and pigeonpea, is being intensified through a nutritional food campaign that is aimed at partially meeting the country's nutritional requirements. Part of this campaign is the search for cultivars that are high-yielding and responsive to low-input technology.

This report presents some results of our research on three of the legumes: groundnut, pigeonpea, and winged bean (Psophocarpus tetragonolobus).

Station trials were conducted at the La Granja Experiment Station, La Carlota City, Negros Occidental and Visayas Experiment Station, Iloilo City, Bureau of Plant Industry, Ministry of Agriculture, Philippines. Trials on winged bean and pigeonpea collections/accessions were conducted from 1979 to 1981, while those for groundnut were done during the 1981-82 dry season and 1982 wet season. On-farm trials on groundnut were also conducted in the 1982 wet season.

Data from the trials on winged bean and pigeonpea will form the basis for determining which accessions will be included in the regional trials, which in turn will become the screening trial for selections to be tested in farmers' fields. Thirty-two pigeonpea selections were evaluated at Visayas Experiment Station in a trial planted in July 1983. Twenty-three were from ICRISAT, one was a local cultivar, and eight were from the station itself. Data from the groundnut trials are not considered to be sufficient for drawing up recommendatons at this stage.

Results

Winged bean. Mean yields and agronomic characteristics of 34 entries from five countries were evaluated. Entry P1 7260, from AVRDC, had the longest pods, and Kade from Ghana the shortest. By yield, measured as the weight of dry beans per plant (the total yield of five primings), P1 7267, from AVRDC, had 103.5 g and outyielded all other entries.

Pigeonpea. All the collections evaluated were seasonal and flowered in November, 220-240 days after planting. Indices of maturity were based on the initial harvest taken at 317-335 days after planting. The average of three primings indicating the dry bean yield showed that, among the 12 collections, Pigeonpea No. 4 achieved 390 g and outyielded the others, and that Pigeonpea Nos. 11 and 12 were the lowest yielders.

Groundnut. Nine cultivars were tested in a regional yield trial conducted during the 1981-82 dry season and the 1982 rainy season. The highest-yielding entry was CES 2-25, with a mean yield of 1910 kg/ha. Entries UPL Pn4 (the check), CES 2-26, and CES 2-33 achieved 1560, 1480, and 1480 kg/ha, respectively. The lowest yielders were CES 1-9 and CES 5-105, at 1020 and 1090 kg/ha. Results during the 1982 wet season showed no significant difference among entries. However, CES 2-33 (2110 kg/ha) outyielded the two check varieties BP1 Pn9 and UPL Pn4 (at 1990 and 1980 kg/ha).

In an on-farm trial with seven established varieties and selections, selection CES 2-25, given the Recommended Input and Management Practices (RIMP) treatment, achieved a significantly higher yield (1250 kg/ha) than any variety or practice except in comparison with Established Variety Pn9 (at 1210 kg/ha with RIMP).

The yields of CES 2-25, when grown at 50% below RIMP and at 50% above RIMP, were closely comparable at 1080 and 950 kg/ha. This shows that CES 2-25, even with few inputs, could give optimum yields. Low yields were observed for BP1 and Pn9 at 50% below RIMP, and on Farmers's Choice Variety (UPL Pn9), grown with farmers' management practices and input levels.

Selection CES 2-25 at RIMP gave the highest net return of P3133/ha, but at 50% above RIMP it generated a low net return of P789/ha. This low return was due to a high level of inputs and management practices, suggesting that, for better profit, CES 2-25 need be grown only at RIMP. The lowest net return was observed on BP1 P9 at 50% above RIMP.

Pigeonpea observation nursery, 1983. All entries were well established during their early growth stages. However, the early-maturing selections were affected by continuous rain and typhoons during flowering and pod formation. This favored the infection of some susceptible selections with *Sclerotium rolfsii*, resulting in quite a number of missing hills. Observations, including yield assessment, were still in progress at the time of writing.

Research Plan

The Regional Integrated Agricultural Research System (RIARS) of the Ministry of Agriculture is in the 1st year of implementation of its integrated farming systems trials in marginal hilly and rainfed areas. The target clientele/cooperators are small farmers with an average landholding of 1.74 ha.

In the case of Region 6 (Western Visayas), trials are being conducted in different sites in the provinces of Iloilo, Negros Occidental, Capiz, Antique, Aklan, and Guimaras. After at least two seasons of trial the technologies will be further tested over a wider scale and piloted before their dissemination to farmers.

The three crops under study will be tested in RIARS sites throughout the country. Short and early-maturing pigeonpeas from IRRI are already being tested and evaluated in RIARS sites, and it is hoped they can be distributed to farmers in 1984.

(Acknowledgment is gratefully made to Mr. Isidro S. Domingo, Superintendent of the La Granja Experiment Station, for providing related information on the crops studied, and to researchers Nestor J. Almodiente, Eduardo B. Arro, and Corazon A. Arroyo for contributing data on regional trials on groundnut and winged bean and pigeonpea evaluation trials, and the on-farm groundnut trial, respectively.)

Groundnut Production, Research, and Development in Thailand

Vichitr Benjasil

Field Crops Research Center, Khon Kaen, Thailand

Introduction

Groundnut ranks 10th among crops of economic importance in Thailand. Among grain legumes it shares second place in importance with soybean, while mung bean is the most important legume crop in hectarage and production. It is one of the most versatile crops that can be grown in any part of the country, but the major growing areas are in the North, Northeast, and Central regions. Planted area, production, and yield have been relatively stable over the last 10 years. The planted area has varied from 100,000 to 130,000 ha, annual production from 106,000 to 160,000 tonnes, and yield from 1000 to 1288 kg/ha. In its Fifth National Economic Development Plan, the Thai Government has set the target for increasing the groundnut-growing area by 1.6%, production by 4.0%, and yield per hectare by 2.4% annually by the end of the Fifth Plan in 1986.

Production Practices

Three cultivars have been released to farmers. Lampang has a white seed coat and SK 38 a red one. Both cultivars are of the Valencia type and are selections from local sources that require 100-110 days to mature. The third, Tainan 9, a recently released introduction from Taiwan, is of the Virginia Bunch type with a white seed coat and bold seed. This cultivar has been readily accepted by farmers for its higher yield and high shelling percentage. It matures within 110-120 days.

Rainfed groundnut can grow well in the rainy season (6 wet months, each with more than 100 mm of rainfall), and also in the dry season with supplementary irrigation (annual rainfall being 1000-1400 mm).

There are three groundnut cropping seasons in Thailand. The early crop is planted in April-May and harvested in July-August, and the late crop grows from July-August to November. Both early and late crops are planted in the rainy season under rainfed upland conditions. The dry-season (or paddy groundnut) crop is planted in November-December in paddy fields after the rice harvest, with irrigation, and is harvested in April-May.

Almost all production in Thailand is by sole-cropping in rotation with rice in the dry season, and with other field crops such as maize, sorghum, cotton, mung bean, and black gram, in the rainy season. Intercropping is not acceptable to farmers at present because of shading effects and the poor competitive ability of the groundnut plant which results in a drastic reduction in yield both of groundnut and the main crops.

Weeding by hand labor is practiced once (or seldom twice) after thinning. Little chemical fertilizer is applied and, in most cases, the crop obtains residual nutrients left over from the previous crop. Plant protection from disease and insects is rare, because of the high price of pesticides, except when heavy infestations occur.

Harvesting is done by hand, with some help from hand tools if the soil is hard and dry at harvest time. Pod-picking is also done by hand. The nuts are marketed as fresh groundnut, picked green, or as dry groundnut in whole pods or shelled.

Groundnut oil is produced for human consumption at an output of 10,000-14,000 tonnes annually. Groundnut meal (about 13,000-18,000 t/yr) is used as an animal feed protein source equivalent in quality to soybean meal but lower in price.

Economics and Marketing

The cost of production of groundnut is relatively high in comparison with other field crops and legumes. Labor costs for planting and harvesting account for 64.82%. Almost 20% of production cost is for seed alone, while only 4% is for other inputs.

About 30% of the country's production goes to the edible oil industry. Some 15,000-20,000 tonnes of shelled groundnut is exported annually, while the rest of production is consumed domestically as human food. Groundnut meal is in great demand as a low-cost protein source in feed rations, competing with fish meal and soybean meal.

Constraints to Production

The following are the production problems that limit the growth in the total cultivated area and the yield potential.

1. Unavailability of good quality seed of good and recommended cultivars.

2. Seed cost per unit planted area is very high when compared with other crops (20% of total production cost).

3. Diseases and insects that diminish yields during both the rainy and dry seasons. Yields are drastically reduced if pesticides and good pest management techniques are not used.

4. The manual labor involved in harvesting, picking, and drying takes up much time.

5. The low marketing price of groundnut and the low profit per unit area compare unfavorably with other crops, especially as groundnut is a labor-intensive crop.

Status of Groundnut Research

Groundnut research is undertaken by the Department of Agriculture. Development and extension are the responsibility of the Department of Agricultural Extension. Some additional research and development are also voluntarily undertaken by university research staff in appropriate areas of their expertise.

Breeding. Although three cultivars have been released and generally accepted by farmers, they are slow-yielding. Breeding objectives aim at achieving high yields, with emphasis on tolerance of environmental stress, resistance to rust and cercospora leaf spot, resistance to some insect pests and to Aspergillus sp (that produces aflatoxin). Earliness and large seed size are also considered important in cropping systems research work, and to make groundnut more attractive to consumers.

Crop management. Groundnut is subject to intensive experimentation regarding cropping systems in various patterns, by rotation before or after rice or field crops, and by intercropping or relay cropping with such crops as kenaf, cassava, etc. Results in the sequential cropping of groundnut with other short-duration field crops are very promising. Groundnut grown before and after rice under rainfed conditions often suffers from either waterlogging in wet years or moisture stress in dry years. But cropping after rice under lowland conditions is very promising.

Fertilizers and rhizobium. A low rate of nitrogen fertilizer is applied to stimulate early growth (20 kg/ha). In general, $N:P_2 0_5:K_2 0$ at 20:40:0 or 20:60:40 kg/ha is recommended. Lime and calcium sulphate are essential for improving pod-filling and increasing yield, especially in acid or slightly acid soils. Rhizobium strains for groundnut are being studied and improved yield has been observed in some cases. No inoculation is practiced by farmers, but natural rhizobium is abundant in soils growing groundnut.

Diseases

Rust (Puccinia arachidis) and leaf spot (Cercospora arachidicola and Cercosporidium personatum) are the most important diseases of groundnut in Thailand. Other diseases such as crown rot (Aspergillus niger) and stem rot (Sclerotium rolfsii) are often observed in some areas. The recommended control is by improved cultural practices. Fungicides are available, but costly. Breeding programs for resistance to diseases, involving screening and the transfer of resistant characters to standard varieties, are under way. Breeding for resistance to Aspergillus flavus has also been started recently, to protect groundnut products from aflatoxin contamination.

Insect Pests

Three major insects regularly damage the groundnut crop. They are the leaf miner (Biloba subsecivella), the leaf hopper (Empoasca sp) and thrips. Other minor insects are the American bollworm (Heliothis sp), aphid (Aphis sp), cutworm (Spodoptera litura), semi-looper (Phytometra sp), coreid (Anoprocnemes phasiana), leaf roller (Lamprosema indicata), and the subterranean ant (Dorylus orientalis). Insect control measures are available for farmers' use in most cases. Mechanical and integrated control are often too slow to prevent crop damage. Chemical control is effective but costly, and it causes pollution.

Presentations by International Organizations

Involvement of the Australian Centre for International Agricultural Research (ACIAR) in Grain Legume Research in Southeast Asia

G.J. Persley

ACIAR, P.O. Box 1571, Canberra City 2601, Australia

E.S. Wallis

Department of Agriculture, University of Queensland, St. Lucia, Brisbane, Queensland 4067, Australia

Introduction

The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982, to fund collaborative research between Australian scientists and those in developing countries. Australia has ecological similarities with many countries in the tropics and subtropics: a mainly semi-arid environment, generally infertile soils, and large areas of land geographically within the tropics. The main focus for the Centre's research activities is Australia's near neighbors in Southeast Asia, especially the ASEAN countries, the South Pacific, and Papua New Guinea.

Plant Improvement Program

Australia's need to rely heavily on introduced plants has meant that its scientists have had to develop the skills necessary to adapt such species to new and often hostile environments. This in turn has led to emphasis on plant breeding aimed at adaptation to stresses such as temperature, nutrition, drought, pests, and diseases. Plant improvement research in Australia therefore covers the full spectrum from basic genetic engineering to applied agronomic research for a wide variety of crop, pasture, and tree species.

The need for plant improvement is similarly important in developing countries. Many new high-yielding crop cultivars are capable of yield increases. But there is a large gap between crop yields obtained by scientists on research stations and those obtained on farmers' fields.

The objective of ACIAR's plant improvement program is to reduce this gap. It plans to do so through research aimed at understanding the biological, agronomic, and socioeconomic constraints involved, and exploring how they can be overcome.

Grain Legume Program

Tropical grain legumes are not only important crops in developing countries, but also an area of Australian research extertise and genetic resources, as are temperate legumes and the nitrogen-fixing Rhizobium species associated with both.

ACIAR is currently developing a series of projects concerned with the plant improvement, plant protection, mineral nutrition, and bacteriology of these legumes. Three ACIAR-supported projects are already in operation, as described below. Under discussion are other projects on grain legumes in Southeast Asia, particularly on soybean and mung bean in Thailand, and groundnut in Indonesia. Additionally, the ACIAR and the Thai Department of Agriculture sponsored a- planning meeting on the improvement of grain legumes in Thailand from 10 to 12 October 1983 in which an overview of grain legumes R&D work in Thailand was presented.

Plant Virus Identification Project

Viruses have been found to be major causes of crop losses but they are difficult to identify. The Virus Ecology Unit of the Research School of Biological Sciences, Australian National University, has assembled a data base on viruses infecting legumes to test the use of a computer-based system to assist in plant virus identification. The object of the project is to evaluate the system by providing ready access to identification keys and biological and physical properties of viruses. The project will concentrate initially on viruses infecting legumes and its staff will work closely with members of the International Working Group on Legume Viruses. The first publication from the project, a book entitled Legume Viruses 1984, will be available early in 1984.

Project on the Development of Legumes for Farming Systems in Northeast Thailand

Research on legumes, particularly cowpeas and fodder legumes, for northeast Thailand is to be conducted jointly by the University of Queensland and the University of Khon Kaen. The project has arisen from a long-term association between these institutions in a project supported by the Australian Development Assistance Bureau (ADAB). The purpose of the project is to identify suitable varieties of crop and pasture legumes for use in various farming systems in northeast Thailand, which is an area of poor soils and erratic rainfall. The project is a broad-based one, covering work on plant improvement, plant protection, plant nutrition, and legume bacteriology.

The ACIAR/University of Queensland Pigeonpea Project

The primary objective of the initial phase of this research has been to identify genetic material with high seed yield potential which, under appropriate agronomic practices, will ensure that pods are borne at the top of the canopy, and that flowering and pod development are synchronized. As a result, control of insect pests can, where necessary, be easily achieved by a small number of applications of insecticide over a few weeks. Other objectives have been:

a. to exploit photoperiod-responsive genotypes in order to control the length of the preflowering phase and plant height, and to condition the synchrony of flowering; and

b. to exploit the perennial nature of the crop, to permit ratoon cropping in certain situations, and to provide a homeostatic mechanism to stabilize yield where environmental or biotic factors impose stresses (e.g., drought, insects) at particular phenological stages.

This research program has identified and tested appropriate germplasm and production systems that are capable of extremely high seed yields. (Mean yields from a plant crop in excess of 8000 kg/ha under favorable conditions have been obtained.)

Several organizations have supported this research at the University of Queensland. These include two Australian organizations and ICRISAT, which supported the work from 1978 to 1982. The ACIAR pigeonpea improvement project was established in December 1982, at the University of Queensland. Its primary objective is to continue research into pigeonpea improvement with particular attention to short-season production systems. For this it is necessary to develop an improved scientific understanding of the basis for high seed yield potential of short-season systems, and to explore the potential of these and other pigeonpea production systems in environments in Australia and overseas. This will involve integrated research with plant introduction, genetics and breeding, aspects of crop and plant physiology, and agronomy. Close collaboration already exists with ICRISAT, the Thai Department of Agriculture, and the Fiji Ministry of Agriculture and Fisheries. Initial contacts have been made in Indonesia and will be sought with national programs in other countries.

The project is based on a core program in Australia and a collaborative outreach program in a number of countries (initially Thailand, Fiji, and Indonesia). The outreach program is focused initially on the evaluation of production systems and genetic material. Collaborators overseas are contributing substantially in the planning and execution of the research, and an extensive two-way interaction between core and outreach programs is in progress.

The experiments involved in testing the potential of particular production systems need to be precise and not limited by edaphic, nutritional, pest, weed, disease, and moisture conditions. A number of areas for study have been developed by joint meetings in participating countries, and discussions with collaborators. In Thailand and Fiji work initiated in 1983 concerns germplasm introduction from a number of sources, and setting up seed production systems for the maintenance of germplasm. Serial sowing trials and genotype x density x sowing date studies have also been established, supported by genotypic evaluation of a wide range of material from diverse sources, and research into constraints to pigeonpea improvement in particular locations (e.g., acid soils in Fiji). The program has sufficient flexibility to permit the redefinition of objectives at all stages of development, and to build on experience gained as the collaborative research progresses.

Conclusion

Grain legumes are high priority crops for ACIAR, both because of their current and growing importance in Southeast Asia and because of Australia's experience in the production of some legumes, particularly soybean and groundnut in tropical and subtropical environments. ACIAR has consulted with other national and international agencies in the preparation of the projects described, and is willing to collaborate with others interested in the improvement of grain legumes in Southeast Asia.

The Asian Development Bank's Inputs to Agricultural Research in the Asian Region

A.K. Auckland

Asian Development Bank, P.O. Box 789, Manila, Philippines

The Bank's Approach to Research

The Bank has limited resources for (grant-financed) technical assistance operations; but it has recognized the importance of agricultural research and has funded it on a selective basis at the project, national, regional, and international levels. In so doing, the Bank follows a three-point policy.

1. It supports only such research as would be of high priority and application in the Asian region.

2. It does not make general budget-support grants.

3. It supports specific, measurable, and time-bound research projects that are pertinent to the Bank's operations in the agricultural sector.

Project-related Research

In its efforts to promote agricultural research that is of direct benefit to small farmers, considerable emphasis has been placed on production-oriented adaptive research efforts by building such components into many Bank-loan projects, the overall objective being to promote new technology for expanding farm output. In this context, the Bank is particularly keen that findings emanating from the international agricultural research institutes get to the farmers.

Agricultural Research at the National Level

This has received attention in Bangladesh (a 1974 loan) where the Bank strengthened the overall research capability in jute, developed a new central research farm and two seed production farms, and installed seed-processing facilities. These latter facilities were included to ensure maximum utilization of the research efforts and the new cultivars being produced. A gene bank for storing jute germplasm was also installed. More recently, the Bank included a research component, (new research farms, fiber laboratory, consultants, etc.) in its 1982 loan for the Cotton Development Project in the Philippines. During 1983 the Bank's loan to the Solomon Islands for an agricultural development project included substantial support to agricultural research. Four new research substations are to be established in differing agroclimatic environments (in order that adaptive research can be carried out on the major food crops [taro, sweet potatoes, and yam] and cash crops [coconut and cocoa]), and consultancy services and overseas fellowships are to be provided. All three projects are linked to extension programs for crop maximization.

Support to International Agricultural Research Institutes and Regional Programs

In July 1971 the Bank became a member of the Consultative Group on International Agricultural Research (CGIAR). With due regard to the Bank's resource constraints, it has supported the international agricultural research network only in respect of institutes located in its own region of operation, and such support has been made available on a project basis rather than as direct budgetary support. In 1983 the Bank was one of the founder donors of AVRDC, and has recently contributed to the capital cost for the establishment of the International Irrigation Management Institute (IIMI). Table 1 identifies the Bank's total assistance to international research institutes and their programs within the region to date. A proposal for Technical Assistance for a Regional Training Program in Vegetable Production and Research, based at Kasetsart University, Thailand, in collaboration with AVRDC, is being considered. An objective is to give far wider regional dissemination of the technological advances made at AVRDC than is achieved at present.

Table 1. ADB assistance to international research institutes.

THE INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)	($•000)
Equipment for Training Center (1975)	300
Equipment for Rice Genetic Resources Laboratory (1977)	500
Intensification of Rice Research for Disadvantaged Areas (1979)	700
Demonstration-cum-Training Center on Rice Production, Postharvest Technology, and Biomass Utilization (1983)	400
Subtotal	1,900
THE INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS (ICRISAT)	
Research on Animal-drawn Equipment and Allied Implements (1976)	325
Establishment of a Genetic Resources Laboratory (1981)	450
Chickpea Research in Pakistan (1983)	300
Subtotal	1,075
THE ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER (AVRDC)	
Capital Cost for Center Establishment (1969)	300
Outreach Programs in Vegetable Research in the Republic of Korea, the Philippines, and Thailand (1975)	390
Strengthening Vegetable Research in Indonesia and Malaysia (1983)	475
Subtotal	1,165
THE INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE (HMD	
Capital Cost for Institute Establishment (1983)	500
THE INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE (IFPRI)	
Study of Food Demand and Supply and Related Strategy for the Bank's Developing Member Countries (1983)	248
Total	4,888

The Bank's Present Inputs to Grain Legume Research

The only direct input to grain legumes research per se is the outreach program to strengthen chickpea research in Pakistan, with ICRISAT as the collaborating agency. Technical assistance to AVRDC programs, however, involve mung bean and soybean research. The technical assistance to chickpea research, it will be noted, is "of high priority and application in the Asian region" and is a "specific, measurable, and time-bound research project". Future requests to the Bank for technical assistance for similar grain legumes projects would be viewed favorably by the Management of the Bank if they fulfilled the criteria noted in the three-point policy above.

(Editorial note: Not summarized. This is the complete paper, as presented.)

Work Program of ESCAP CGPRT Centre and Possible Field of Cooperation with Asian Regional Research on Grain Legumes

Shiro Okabe

ESCAP CGPRT Centre, Jalan Merdeka 99, Bogor, Indonesia

The ESCAP CGPRT Centre

The Regional Co-ordination Centre for Research and Development of Coarse Grains, Pulses, Roots, and Tuber (CGPRT) Crops in the Humid Tropics of Asia and the Pacific, is a subsidiary body of the Economic and Social Commission for Asia and the Pacific (ESCAP) of the United Nations.

Reasons for establishment of the Centre. Coarse grains, pulses, roots and tuber (CGPRT) crops are very important to most of the developing countries of Asia and the Pacific. They are food staples and a source of dietary protien; they are also used as feed for livestock and as raw materials in several agroindustries. These crops are cultivated mostly at subsistence level by small-scale and marginal farmers, usually under rainfed conditions. Despite the research and development efforts of some countries in the region, however, the average productivity and profitability of these important crops remain low. More dynamic research and developmental programs therefore need to be undertaken.

The activities considered to be required within such programs are the following.

- The establishment of a regional network to enhance research cooperation.

- Comprehensive socioeconomic research on such factors as marketing, trade, utilization, pricing policies, nutrition, and food and rural employment preferences that have a bearing on the transfer of improved technology,

- The development of manpower for technical and socioeconomic research on CGPRT crops at the levels appropriate to support the work that needs to be carried out to improve productivity.

The ESCAP CGPRT Centre has recently been established in the light of these considerations, and in response to a strong request for assistance expressed by countries of the region.

The Centre's membership, objective, and structure. Membership is open to all members and associate members of ESCAP.

The Centre's objective is to provide members and associate members of ESCAP with expert technical services and facilities required for the development of production, utilization, and trade of CGPRT crops by strengthening research and development activities as a means of solving food problems, increasing employment opportunities, achieving better income distribution and a balanced diet, as well as accelerating close linkages with livestock and other related industries.

Although the work of the Centre is primarily oriented towards the humid tropics of Asia and the Pacific, the Centre also takes into consideration the problems of the semi-arid and other zones related to its economic and social areas of responsibility.

Accordingly, the Centre has the following functions. (a) Provision of assistance for the development of a cooperative agricultural research network. (b) Preparation of agroeeonomic studies, including social aspects. (c) Training of national research and extension workers. And (d) the collection, processing, and dissemination of information on CGPRT crops.

The Centre has a Governing Board, currently with representation from 10 countries, and a Technical Advisory Committee. The Centre has a small core staff consisting of the Director and a few professionals, including agricultrual economists and an agronomist.

Program Activities

Plan of activities. In Phase 1, the work program has been focused on two activities, limited to a few crops and a few countries, (a) Socioeconomic studies on production constraints and the potential impact of expanded production of CGPRT crops on income, price, marketing, and employment. And (b), agroeconomic studies on CGPRT cops and related farming systems. The following crops have been selected for priority attention: soybean, maize, and cassava in Southeast Asia, and selected pulses in South Asia. In both subregions the priority to be given to mung bean and black gram are under discussion with government officials and experts. This initial work will be considerably expanded during Phase 2 to cover more crops and more countries.

The 1983-84 program, A workshop on methodology and planning of socioeconomic research on selected CGPRT crops in the humid tropics of Asia will be held in Bogor, Indonesia, in mid-1984, A workshop on the future potential of cassava in Asia and related research development needs will be held in Bangkok, Thailand, in early June 1984. A study of the soybean commodity system in Indonesia has been initiated and, for comparison, a similar study will be undertaken in Thailand in 1984. In addition, financial assistance was provided for the participation of two key scientists from Indonesia and Thailand in the First International Symposium on Soybean in the Tropical and Subtropical Cropping Systems which was held in Japan in September/October 1983.

Collaboration with National and International Research Institutions and FAO

Fields of research and development regarding CGPRT crops that are appropriate for national and international cooperation have been identified by the Centre. Contacts have been established with relevant national focal points as well as with such international research institutes and agencies as CIAT, IFPRI, ICRISAT, IADS, SEARCA, and FAO. Cooperative programs have already been initiated with the CRIFC in Indonesia for the soybean study and with CIAT for the cassava workshop; and the 1984 workshop on socioeconomic research is expected to strengthen cooperative networking relationships. Regarding cooperation with FAO, a UNDP-funded regional project related to grain legumes and coarse grains in the tropics and subtropics of Asia is presently under preparation for implementation. Further efforts by the Centre, in seeking the cooperation of concerned institutions in promoting network activities, are considered to be needed.

Cooperation between ICRISAT and CGPRT Centre

In recent discussions between ICRISAT and the CGPRT Centre, it was agreed in principle that the two institutions would cooperate and assist each other in the following ways.

First, ICRISAT will be able to provide research scientists from Southeast and South Asian countries with training on socioeconomic research related to ICRISAT's mandate crops, with emphasis on its methodological components.

Secondly, the Centre will cooperate with ICRISAT in a joint or collaborative research project, with particular regard to Southeast Asia, to study the demand for and utilization of commodities from ICRISAT's mandate crops, and to study the socioeconomic constraints to their expanded production. Research development needs will receive priority attention in formulating this project.

Lastly, ICRISAT and the CGPRT Centre will encourage their staffs to participate in workshops and other meetings of common interest, to the extent possible; and both organizations will strengthen the related research network by mutual assistance and cooperation.

Possible Collaboration with Asian Regional Research on Groundnut, Chickpea, and Pigeonpea

It is intended in the Centre's work program related to grain legumes that the first priority of its efforts at the initial stage will be placed on soybean in Southeast Asia, and on selected oilseed crops and pulses in South Asia. Selection of the crops to be studied by the Centre in the latter area will be finalized through discussions with the government officials and experts concerned as well as with ICRISAT. Mung bean and black gram will be considered as priority crops to the extent possible, if the governments of cooperating countries have particular interest in socioeconomic aspects in their development plans for these crops.

It may be tentatively concluded that, in the Centre's present program, grain legumes such as groundnut, chickpea, and pigeonpea would be included in a first-priority group for South Asia, but not for Southeast Asia. It is fully recognized that groundnut is widely grown in Southeast Asia and that various problems need to be solved in exploring the crop's potential in the region. It is given less than first-priority rating at present only because of the Centre's limited resources and capability.

Pigeonpea and chickpea have so far received very limited attention in formulating the work program for Southeast Asia due to the small area presently planted to these crops. However, taking into account their potential of adaptability to certain environmental conditions in Southeast Asia, as well as the importance of diversification of cropping patterns in that region, the Centre may need to pay more attention to these two crops in preparing its program of work for the next phase.

Trends and Prospects of Grain Legume Production in Asia and the Pacific

R.B. Singh

FAO Regional Office for Asia and the Pacific, Maliwan Mansion, Phra Atit Road, Bangkok 10200, Thailand

Pulses Production in the Region

Between 1971 and 1981 Asia and the Pacific Region accounted for almost half of the world's production of pulses. During this period pulses production declined marginally each year by 0.1% whereas, in the rest of the world, it decreased at an annual rate of 0.9%. Over the 10-year period, therefore, per capita availability of pulses decreased by about 2% per year.

Average yields of pulses in Asia and the Pacific over the same period dropped from the already low level of 611 kg/ha to 602 kg/ha, an annual decrease of about 0.1%, whereas for the rest of the world average productivity dropped from 744 kg/ha to 688 kg/ha, an annual negative growth rate of 0.8%. By contrast, the area under pulses in the Region increased marginally by 163,000 ha (a growth rate of 0.05% per year). Nevertheless, the region accounts for about 53% of the world's cultivated area of these crops.

From observed trends in production, yield, and cultivation area data for pulses during the period 1971-81, it is evident that they have been neglected as food crops, and have even been pushed into marginal growing areas. Further, there have been no breakthroughs in increasing their productivity.

Groundnut Production in the Region

For the period 1971-81 there was an annual production of 10.7 million tonnes of groundnut in the Region, comprising 58.4% of the world's production of groundnut. Production in the Region increased by 1.3% per year, whereas in the rest of the world it decreased by 1.1% yearly. Yield and area also increased yearly, by 0.8% and 0.5%, respectively, whereas in the rest of the world the cultivated area decreased by 1.2%/yr, and the yield increased yearly only 0.2%.

Medium-term Prospects of Grain Legume Production and Future Tasks

The potential for increasing production of grain legumes in Asia and the Pacific Region primarily depends on the prospects of increasing the area under these crops and their yield levels. Increased production can come about in two ways: by an increase in the net cropped area and an increase in cropping intensity.

The prospects of increasing the net area in the Region are rather bleak. Approximately 80% of the potential agricultural land is already in use. Cropping intensity varies considerably. For instance, in China, with about 100 million ha of arable area, the total cropped area is estimated at about 145 million ha, representing a cropping intensity of 145%. In India the intensity is about 120%, Such data depend considerably on such factors as the extent of the cropping area under irrigation, cultivar-maturity period, the crops grown, and agroclimatic conditions. Over the 1961-81 period, however, there were overall increases in cropping intensities. In "rice zone" countries, for instance, they rose by 1.85% per year, in the wheat zone (Pakistan) by 2.46%, and in the mixed zones (where both rice and wheat are major crops) of India and China by 1.92 and 3.1%.

The analysis presented to the Meeting in the full paper indicated that the total area under pulses, groundnut, and soybean in the Region remained almost static; it increased from 53.0 million ha in 1971 to only 54.1 million ha in 1981. During the same period the area under rice and wheat increased by more than 21 million ha. During this period arable land increased by about 12 million ha, and the irrigated land area increased by 20.4 million ha. Almost all of these increases were diverted to the production of high-yielding cultivars of wheat and rice. These increases have slackened in recent years, however, perhaps because most readily available land has already been occupied and brought under irrigation, and the growing of improved cultivars on marginal lands is not as remunarative. Further, most of the developing countries in the Region have attained, or will soon attain, cereal self-sufficiency, and rice and wheat prices have not been all that attractive.

In order to increase rice paddy production, lands unsuitable for rice cultivation were planted to rice. It is now increasingly realized that such lands should be diverted to other suitable crops. In fact, China has reduced its rice-growing area in recent years. But its rice paddy production has increased because of intensification of production in the most suitable agroecological areas, and by increasing productivity per unit area. This strategy should be adopted by other countries in the Region. In this way, additional areas could be brought under grain legumes in several countries.

To accelerate and stabilize crop production most of the countries in the Region have been expanding their irrigated areas. Grain legumes, by the virtue of their wide adaptability, nitrogen economy, and soil-improving properties, must find increasing representation in multiple cropping under irrigation. So it is expected that, with increasing irrigation, the area under irrigated pulses will also expand. Under limited-irrigated conditions, as for instance in northern India where available water in the postrainy (rabi) season is sufficient for one irrigation only, chickpea will be more remunerative after rice than wheat. Also with the current low levels of fertilizer application, intensive rotations, namely rice-rice or rice-wheat or rice-rice-rice, may not be practicable. Under such situations grain legumes are the best crops to follow the major cereal crop.

Additionally, even if the current rate of expansion of irrigation is maintained, about 60% of the arable land in the Region will still be rain-dependent by the year 2000. Therefore, because legumes are the preferred crops for rainfed areas, the total area under grain legumes should be increased by growing them as intercrops, by growing them in the off-season and in nontraditional systems, and in marginal areas where other crops fail to grow satisfactorily. And, because there is considerable variation in the amount of fertilizer used in traditional farming, there are advantages to be gained from fitting legumes into existing cropping patterns and exploiting their Rhizobium-based nitrogen-fixing ability. This will call for special extension efforts, involving the production and distribution of effective and efficient inoculums.

Data in the full paper show that mung bean, soybean, groundnut, and dry bean are the most popular legumes in the Region, although, among pulses, chickpea has the highest hectarage because of its high concentration in India. Pigeonpea is primarily concentrated in India, but is also grown in Burma and Sri Lanka.

Groundnut must assume greater importance in India, Burma, China, Indonesia, Laos, Malaysia, Pakistan, the Philippines, Thailand, and Vietnam. In India there are good prospects of intensifying its production. There is scope for expanding its area, as well as the crop's productivity, under varying cropping patterns in both South and Southeast Asian countries.

Chickpea is an important pulse crop in South and West Asia, but systematic research on this crop began only recently. Its area, yield, and production have remained stagnant or even slightly declined over the past decade or so. This was attributed partly to chickpea-growing areas being diverted to semi-dwarf wheat production. Recently, however, because of its favorable price and its relatively low demand for inputs, chickpea has gained popularity in rainfed or partially irrigated areas. This trend needs to be consolidated through the development and large-scale adoption of high-yielding, wilt-, blight-, and pest-resistant cultivars, and location-specific agronomic management practices. There is potential for chickpea to move eastward to Bangladesh, Burma, Thailand, Laos, Vietnam, Kampuchea, and even to the Philippines and Indonesia.

Pigeonpea is predominantly a crop of South Asia. Preliminary trials have shown that it could become a viable crop in the rainfed semi-arid areas of Burma, Thailand, the Indochinese countries, and even Indonesia. Carefully chosen cultivars of different maturity groups and plant types should therefore be tested under different cropping patterns in rainfed semi-arid areas of Southeast Asia.

In conclusion, and with reference to the full paper, I recommend that soybean and groundnut deserve priority attention, and that mung bean and cowpea should receive increasing attention in order to exploit the technology already available. Pigeonpea and chickpea could become important crops in rainfed and semi-arid tracts of several of the South and Southeast Asian countries, other than India, for which an improved governmental policy and a production strategy are required.

EEC Assistance to Agricultural Research in South and Southeast Asia

M. Marieu

EEC Regional Office, Commission of the European Communities, Taj Palace Hotel, Sadar Patel Road, New Delhi 110 021, India

Introduction

With the exception of food aid programs, which have been in operation for many years, development cooperation between the European Economic Community (EEC) and Asia has become significant only over the last few years. Individually, however, some EEC members states have had a long tradition of bilateral cooperation with South and Southeast Asian countries.

This cooperation started in 1976 with the creation, within the EEC budget, of a specific program of technical and financial assistance—in grant form—to developing countries outside the ACP* area, in the sector of rural development, with special emphasis on agricultural production development.

This program, which benefits mainly Asian countries, and Latin American countries to a smaller extent, has been launched with very modest resources, but has grown rapidly to a significant size during the last 4 years.

Since no special budgetary resources have yet been devoted to agricultural research within the EEC development budget, and priority has been given to projects benefiting small farmers and the rural poor directly and rapidly, the funds committed in favor of agricultural research programs have remained comparatively limited.

*The "ACP Group" comprises several African, Caribbean, and Pacific countries,, associated with the EEC through the "Lome Convention[11], that benefit from the resources of the European Develo]pment Fund.

However, regular support has been provided to international agricultural research and, to a smaller extent, production-oriented and adaptative research projects in Asia have benefited from EEC contributions.

EEC Support to International Research Institutes

Since 1976 the EEC has contributed every year towards the core research budget of ICRISAT, and supported as well some other international agricultural research centers within the CGIAR system, in particular IRRI.

Over the period 1976-82, CGIAR Centers have received a total contribution from the EEC amounting to 26.4 million ECU**, out of which more than 8 million ECU have been allocated to ICRISAT.

EEC Support to National Agricultural Research Activities

Two small applied research projects concerning pulse crops have been funded by the EEC under the 1979 program, both located in Thailand.

A total of 600,000 ECU has been committed to the Winged Bean Crop Development Project, which aims at developing the winged bean as a possible alternative to cassava production in the northeast region of Thailand, Project activity includes seed-multiplication and variety trials, industrial acceptability trials and market research, as well as investigations into possible farming systems and the potential economic impact of this crop.

In addition, 2.6 million ECU have been allocated to an applied crop research project on the Preliminary Crop Development for the Northeast Region. The project involves the provision of technical assistance and research support for applied crop research and field trials related to the cultural introduction of certain new crops, in particular groundnut, in northeastern Thailand.

Some other projects supported by the EEC in southeast Asia (Burma, Indonesia, Thailand) include a research component that focuses mainly on the oilseeds sector.

Recent statements made by the European Commissioner for Development, Mr. Pisani, stressed the key role played by agricultural research in increasing food self-sufficiency in developing countries. The Commission's services are therefore considering, with an active interest, the possibility of intensifying EEC assistance to agricultural research activities at national level in the coming years, while maintaining its previous financial support for research work at international level.

**1ECU (1 European Currency Unit.)- US$ 0.9 at the December 1983 rate.

However, discussions on this matter are still at a preliminary stage. The first step will be to identify in various developing countries priorities for the most suitable research programs and the institutions that merit encouragement.

In this context, the present Meeting offers an invaluable opportunity for improving our understanding of the requirements for agricultural research in Asia, both at national and regional level.

(Editorial note: Not summarized. This is the complete paper, as presented.)

International Development Research Centre (IDRC) Support for Grain Legume Research in Asia

K.W. Riley

IDRC, P.O. Box 8500, Ottawa, Canada K1G 3H9

Introduction

Over the past decade, support for grain legume research has been an increasingly important area of activity for the International Development Research Centre (IDRC). This support has been given both to national programs as well as to international agricultural research centers. In several cases, support for a number of similar projects in a region has led to links among the national programs as well as with an international center. For example, in the Middle East, IDRC supports projects in national programs in Egypt, Sudan, Turkey, Algeria, and Jordan the staff of which are carrying out research to increase the production of faba beans, lentils, and chickpeas. The presence of ICARDA in the region provides a strong base for training, distribution of germplasm, technical information, and visits to the national programs.

Grain Legume Research Support in Asia

IDRC is supporting three types of projects aimed at increasing grain legume production and utilization. These are (1) grain legume breeding and improvement projects; (2) cropping systems projects within the Asian Farming Systems Network (AFSN), participants in which are testing grain legumes to fit into cropping patterns; and (3) projects aimed at better preservation and utilization of grain legumes.

Grain Legume Breeding and Improvement Projects

The IDRC involvement with grain legume research in Asia started in 1973 with support given to the Pulses Improvement Program at ICRISAT. Since then, support has been channeled increasingly to national programs in Asia, There are grain legume improvement programs in six countries currently receiving support from IDRC.

Pakistan, Since 1980, IDRC has provided support to the Pakistan Agricultural Research Centre to develop higher-yielding and more disease-resistant lines of grain legumes; to carry out economic studies, and to strengthen the national program with training of both technical and scientific staff. The crops involved in the project are the winter pulse crops—chickpea and lentil—and the summer pulses—green gram and black gram. Chickpea is the most important pulse crop in Pakistan, accounting for 75% of the total production. However, ascochyta blight has been extremely serious in recent years, making the quest for improved disease-resistant lines more urgent. This project has links both with ICRISAT and ICARDA.

Bangladesh. The Food Legume Improvement Project, which started in 1977, provides support to the Bangladesh Agricultural Research Institute for the improvement of lathyrus, chickpea, and lentil, as well as black gram and pigeonpea. Objectives are to develop higher-yielding and more disease-resistant lines; to improve the nitrogen-fixing capability of these crops, and to provide training for national scientists in legume improvement. Again, there are links with ICRISAT which assisted in defining the project and providing technical support.

Sri Lanka. Since 1976, support has been given to the Department of Agriculture, based at Peradeniya, for a Food Grain Improvement Project that includes three legume crops—green gram, cowpea, and pigeonpea. Groundnut improvement is part of an oilcrops project based in the south of Sri Lanka. Although these projects were not initially linked with farming systems activities, they have integrated well, and they now feed the cropping systems project with material for cropping pattern testing on farmers' fields.

Indonesia. The grain legume project was started in 1982, with the Central Research Institute for Food Crops based at Bogor. This project is aimed at developing improved legume cultivars for two specific situations: for planting after the harvesting of lowland rice, and for planting in upland areas with acid soils. The main legume crops presently grown are soybean, groundnut, mung bean, and cowpea. This project substantially increases the availability of operating funds, and encourages more research in the less populated islands,

Thailand. Groundnut is an important crop in Thailand, both as a source of oil and as a grain legume. Production is mainly in the northern, eastern, and central areas of the country, both as a rainfed crop and following rice under irrigation. The Groundnut Improvement Project gives support to the universities of Khon Kaen and Kasetsart, in cooperation with the Field Crops Institute of the Ministry of Agriculture, to develop groundnut cultivars suitable for cropping systems in different regions of Thailand, and to develop more efficient production practices.

The Philippines. The grain legume project is being carried out jointly by the Institute of Plant Breeding (IPB) and the University of the Philippines at Los Banos (UPLB). The project is administered through IRRI. There are strong legume research groups both at IPB and UPLB. This project is aimed at producing improved grain legume cultivars not only within the Philippines, but also as a resource and training base for other projects in Asia. Mung bean, soybean, groundnut, and cowpea are the main legume crops grown in the Philippines.

Evaluation of Grain Legumes in the Asian Farming Systems Network

The Asian Farming Systems Network (AFSN) is a voluntary association of scientists from 13 countries in Asia. At the hub of this network is the cropping systems program at IRRI. IDRC supports five national cropping systems projects, as well as providing support to the cropping systems program at IRRI.

One of the activities of the AFSN is to circulate useful material among the countries in the network, for testing in specific cropping patterns. Grain legumes form a component of many of the cropping patterns being tested. Thus, support for legume improvement programs, which are integrated into the AFSN, allows improved material to be developed, then circulated around the network for testing.

Preservation and Utilization Projects

Improvements in postharvest handling and processing are an integral part of improving the availability of grain legumes. A project on grain legume dehullers in the Philippines complements the breeding project at UPLB. In Indonesia, a food processing study is under way to produce the fermented foods called tofu and tempeh from legumes other than soybean. Simple groundnut threshers have been developed and tested at Khon Kaen University in Thailand, while a project in Bangladesh is assessing postharvest losses and developing better drying, storage and distribution systems for the pulses.

The Nature of IDRC Support

The following features are characteristic of IDRC projects, particularly those in the Agriculture, Food and Nutritional Sciences Division.

1. Projects are fairly small, and have a specific focus. Emphasis is placed on building national research capability.

2. Projects that have a similar focus or deal with similar crops in a region are very often linked together in a network,

3. The form and the level of interaction in a network can vary greatly, but all networks aim to improve the effectiveness of the research being carried out by their members. The common features of such networks are:

   - their effectiveness depends on the activities of a coordinator;
   - they facilitate exchanges of germplasm and information;
   - they facilitate the training of scientific and technical staff, and exchange visits of scientists; and
   - they promote the organization of workshops where research findings and methodology are discussed.

4. It is important that all members of the network have independent funding. This encourages them to interact as equals in the network, and promotes more effective feedback to the related international agricultural research center,

5. An effective network influences research policy and planning in relevant international centers.

Conclusion

IDRC has given considerable emphasis to supporting grain legume research in Asia, and it is expected that this support will continue. The support that ICRISAT has to offer from its Pulses Improvement, Farming Systems Research, and Economics Programs is considered to be of immense benefit in grain legume research and development in Asia.

Grain Legumes in Rice-based Cropping Systems

R.K. Pandey

International Rice Research Institute (IRRI),
P.O. Box 933, Manila, Philippines

Introduction

Rice dominates the agricultural economies of the South and Southeast Asian countries where rice fields cover 81 million ha of the landscape, usually occupying the most fertile and level land. But only a small proportion of the rice area is irrigated (30%) and only a fraction of that receives water year-round.

Grain legumes, namely cowpea, soybean, mung bean, and groundnut, are of primary importance in rice-based cropping, Pigeonpea and chickpea have been added to this list. They not only provide a good-quality protein food source to rice farmers but also enrich the rice land.

The Paddy Environment

A dryland crop following paddy rice encounters some formidable difficulties. The most critical of these are adverse soil physical conditions, tillage constraints, a high probability of waterlogging during early growth, and the near certainty of drought during the reproductive period.

Cropping Patterns involving Legumes

Rice-legume rotation. More than half of the rice in Asia is grown in paddies whose source of water is primarily rainfall. In these areas there is usually enough rainfall for only one crop of rice per year. Thus, other crops that require less water are usually grown in rotation with rice.

In legume-before-rice rotations the rice is transplanted at the peak rainfall month so that there are about 2-3 months available in which another crop can be grown before rice. For a crop to fit this period it must mature early, preferably in less than 70 days, and it must be able to tolerate heavy rains at the later growth stages. Only mung bean and cowpea satisfy the early-maturity requirement.

In legumes-after-rice rotations the legume must be able to tolerate drought in its later growth stages. Popular crops for growing in rice paddies during the dry months are cowpea, mung bean, soybean, groundnut, pigeonpea, and chickpea. The performances of these legumes, however, differ greatly due to adverse growing conditions.

Intercropping legumes with other crops such as maize, cassava, and sugarcane is attractive because the legumes have short stature and ability to fix nitrogen, there is little yield reduction in the nonlegume crop, and yield from the legume intercrop can be regarded as an additional product with a useful economic return.

Problems and Potentials of Selected Legumes

Cropping systems research results at IRRI show great potential for cowpea, mung bean, soybean, groundnut, and pigeonpea cultivation after rice.

Cowpea showed most versatility of the legumes studied because of the possibility to market green beans. The crop establishes itself readily after lowland rice and tolerates low-tillage management methods.

Soybean could be grown either before or after rice. The crop is well suited to seeding after paddy rice where the dry season coincides with longer daylength, as in Indonesia and Malaysia. However, soybean cultivars are being developed with less sensitivity to photoperiod and more resistance to diseases. In many areas of the tropics soybean is becoming an important grain legume.

Mung bean can best be cultivated towards the end of the rains. Yields after rice varied from 300 to 1200 kg/ha in recent studies in farmers[1] fields. Major problems encountered were crop establishment, early damage due to empoasca leaf hopper and flea beetles, and powdery mildew.

Groundnut showed drought tolerance similar to that of cowpea. The crop is well suited to the post-paddy environment, performs better on the upland rice soils with low clay contents, and requires good tilth. Yields obtained on farmers' fields after rice in upland conditions varied from 600 to 1600 kg/ha. Groundnut has been profitably intercropped with maize and cassava.

Pigeonpea, being drought-resistant, has great potential in rainfed areas as human food, animal feed/fodder, and green manure. Early-maturing cultivars have produced 2000-3000 kg/ha grain yield, when planted after paddy. The crop's ratooning ability offers attractive alternative land use in the dry season when it is difficult to plant new crops. With occasional rain, it can produce a decent yield (700-1000 kg/ha). Except for <u>Heliothis armigera</u> (pod borer) there are no major insects and diseases. But some management studies, for instance on crop establishment and ratooning, need attention in rice-based systems.

Chickpea appears to have limited adaptability in the tropics. The grain yield ranges from 200 to 600 kg/ha. However in hilly areas, when the temperature is cool for a few months, it could be grown successfully. A tropically adapted cultivar may prove useful in the future.

Grain Legumes Technology for Rice-based Systems

Varietal development. For rice-based cropping systems grain legume cultivars must be early-maturing, multiple disease and insect resistant, and tolerant of excessive moisture and drought. Three international centers—IITA (cowpea and soybean), ICRISAT (pigeonpea, chickpea, and groundnut), AVRDC (mung bean and soybean)—are involved in the development of cultivars suitable for different environments. IRRI, in collaboration with these centers and with national programs, identifies cultivars of grain legumes suitable in rice-based cropping systems for Asia.

Tillage. Experimental evidence suggests that zero tillage may provide yields comparable with conventional tillage.

Inoculation and fertilizer application. Rhizobium inoculation, following a lowland rice crop, often improved the yield of grain legumes, particularly soybean. The addition of 30-50 kg/ha P_2O_5 has been shown to increase the yield of grain legumes on soils low in available phosphorus.

Plant density and seeding method. To obtain optimum plant density of grain legumes following rice is often a problem. Under limited soil moisture conditions, low density may be beneficial but, where adequate moisture is available during the growing season, slightly higher density may improve grain yield. The seeding methods used by farmers also affect the plant stand.

Plant protection. Yield losses caused by insects at each crop growth stage have been quantified by IRRI's Cropping Systems Program and suitable insect control measures are being developed. The occurrence and succession of important weed species in grain legume crops have been recorded and suitable cultural practices are also being developed.

The Present Grain Legumes Research at IRRI

The Cropping Systems Program is involved in the improvement of cowpea, soybean, and mung bean production in pre- and post-rice environments and in groundnut, pigeonpea, and chickpea in the post-rice environment. The major research on grain legumes involves identification of short-duration and high-yielding cultivars with multiple disease and insect resistance and tolerance of adverse environmental stresses. We also develop suitable production technology for major production complexes and identify the most productive and economically feasible cropping patterns. Within this framework, we collaborate with other international centers, the Institute of Plant Breeding (IPB), University of the Philippines, and national programs.

The most promising entries from international centers, the IPS, and national breeding programs are collected and evaluated at IRRI and the Asian Cropping Systems Network, These promising cultivars are also tested in intensive cropping pattern trials.

Conclusions

The development of rice/grain legumes cropping patterns is a response to the need to intensify land use in the densely populated Asian rice-growing areas. The increasing cost of nitrogenous fertilizers further justifies this approach. The availability of short-duration and high-yielding rices, coupled with development of early-maturing grain legumes, has made it possible to increase the cropping intensity. Greater efforts are needed to improve grain legume technology for the post-rice environment, the most critical areas being crop-establishment practices and varietal adaptation. Although rice/grain legumes is a common cropping pattern, its potential includes expansion of many millions of hectares in Asia.

NifTAL Biological Nitrogen Fixation Resource Center for South and Southeast Asia

Douglas Beck and Jake Halliday

BNF Resource Center, Rhizobium Building, Soil Science Division, Department of Agriculture, Bangkok 10900, Thailand

Introduction

At NifTAL, in Hawaii, we have for several years offered services, training, and resource support for in-country research on and adaptation of Biological Nitrogen Fixation (BNF) technology. With the rapid growth of interest in BNF, and the difficulties imposed by long-distance communication, we recognized the need to regionalize our activities, and have instituted regional BNF Resource Centers both in Africa (Zambia) and Asia (Thailand). In seeking to support the development of BNF technology for the tropics, three main areas of need have been identified.

Improvement of the Database

Basic economic information on the benefits of BNF are scarce and, until these benefits are translated into economic data, policy-makers at the national level will be unable to offer the necessary support. We still cannot consistently predict the economic return of inoculation in the farmer's field. This is why the INLIT (International Network of Legume Inoculation Trials) was devised and still has limited success. Yield data from which to obtain the economic return still need to be generated.

Technical and Information Services

The services necessary for a viable research program include both:

a. research tools such as Rhizobium strains, companion antiserum, and seed of improved cultivars; and

b. information in the form of journal articles, current publications, and regional news.

Document-provision services, information on availability of funding, and information on current regional research may provide a core of collaboration essential to solving the tremendous task of exploiting BNF fully.

Multilevel Training

In the past NifTAL has had considerable interest in training personnel in BNF technology, with emphasis at the laboratory level but stressing the importance of accompanying field research. Our training emphasis will shift now to courses in inoculum production on a scale-neutral basis (ranging from laboratory-size production units up to commercial plant production), and to training at the extension level. Effective transfer of new technology to the farm level is the basic goal of agricultural research, but can be accomplished only if collaboration between research, extension, and production management is properly developed and maintained.

Providing these various means of support will fall increasingly under the auspices of the NifTAL Regional Resource Centers. A pressing need is for orientation to each region's particular requirements, in terms of research, information, and training.

The structure for continuing the work of the Resource Center in Thailand will be composed around three professional Rhizobium specialists, one of whom will be stationed full-time in Bangkok, and who will be available upon request for consultation within the region.

Biological nitrogen fixation research and promotion are rapidly gaining momentum as policy-makers recognize the importance of this technology in their agricultural development programs. This fact increases the need for cooperation between institutions, in order to prevent overlap of effort and to accumulate the information necessary for full utilization of the technology.

Resource Center Activities (NifTAL-Thailand) for 1984

These activities center upon three identified areas of need.

Improvement of the database.

a. Initiation of a regionally focused research program from the Center, with research focused initially on the following topics:

1. N-fixation measurement and N-cycling.
2. Competition and persistence of Rhizobium.
3. Effect f soil/environmental stress on Rhizobium/legume symbiosis.
4. Rhizobium/legume/mycorrhizae interactions.

This research will be conducted collaboratively with scientists in countries of the region after consultation with the various organizations and scientists conducting BNF research. This will be initiated as soon as possible.

b. An internship exchange program will be initiated. Participating scientists will visit the Resource Center to exchange information and use the Center's excellent research facilities. These internships will have a probable duration of 2-3 months, consisting of programs tailored to individual needs.

c. Continued interaction with INLIT cooperators in the region, with increased communication through direct support from the Resource Center.

Technical and Information Services.

a. Priorities initially lie with the Rhizobium/legume and Azolla/Anabaena symbioses, and support will consist of making available Rhizobium germplasm, companion immuno-diffusion and fluorescent antiserum, Azolla germplasm, seeds of difficult-to-obtain cultivars, and perhaps specialized analysis, such as N-.15 determinations or strain serotyping. Germplasm storage may be in the form of an information bank, rather than actual storage, through which information on strains and seed of underexploited legumes or unavailable cultivars is made available on request. Networking such support with an institution strong in the particular field may be the most feasible approach. Inoculants for research purposes will also be available upon request.

b. Response to consultation requests, with priority determined by need, and the delegation of consultants from NifTAL staff according to their specialities. Again, networking with other agencies to help provide consultative services would be most efficient.

c. Distribution of information materials, including a document-provision service, with a regional BNF newsletter forming the core vehicle of information distribution. This newsletter, circulated quarterly, will contain:

- titles and abstracts of selected articles on BNF subjects focused especially on regional aspects;
- regional news of BNF activities and new methodologies;
- activities of regional agricultural Centers;
- information on funding agencies and grant availability;
- calendar of regional events (training courses, symposia, workshops, etc.);
- research contacts in the form of a world register.

d. (Perhaps the most important in this group): Collaboration with other agencies in the activities listed above. There are many opportunities to cooperate and, through a special focus on BNF, we hope to explore the possibility of a networking role, facilitating information exchange between scientists, institutions, and agencies for development. This will include promotion of conferences and workshops in the region, for example a Southeast Asian Rhizobium Conference to be held in 1985.

Training.

Listed below are training courses planned for coordination by the NifTAL-Thailand Resource Center. In addition to these, requested cooperation on courses in related subjects will be considered.

a. Ten-day Azolla workshop, attended by two delegates of each country of the region, at the Resource Center in January 1984.

b. Ten-day extension workshop on Rhizobium/legume inoculation, in Bangladesh in March 1984, for approximately 30 persons.

c. Possible extension-type training course for regional FAO staff prior to increased FAO involvement in BNF in the region. The venue will probably be the NifTAL-Thailand Resource Center in August 1984.

d. Inoculum Production Course (scale-neutral) to be held at NifTAL-Hawaii in November 1984. This 3-week course will be attended by 8-12 persons from the tropics, and is the prototype of similar courses to be held subsequently at the Resource Center in Thailand.

e. Graduate assistantships will be offered for Ph.D. work at any US institution. Funding for each person will be $7000/yr for 3 years, plus air fare.

f. Distribution of training materials, including an Inoculation Pocket Book (a joint FAO/NifTAL publication), an Inoculum Production Manual (by Dr J, Burton), the NifTAL Training Manual, and extension materials in the form of manuals and audiovisual aids.

The Peanut Collaborative Research Support Program

D.G. Cummins

University of Georgia, Georgia Experiment Station, Experiment, Georgia 30212, USA

Goal

The Peanut Collaborative Research Support Program (CRSP) brings together the resources of developing country and US research institutions into a long-term collaborative research program aimed at increasing the production and utilization of groundnut in developing countries. The program is funded through Title XII—"Famine Prevention and Freedom from Hunger"—of the United States Congress. The Peanut CRSP was implemented on 1 July 1982.

Objectives

The Program has several basic objectives. These are: to conduct research to relieve constraints to groundnut production and utilization; to provide short-term and degree-training programs for host-country staff at US institutions; to provide on-site consultation in host countries by US scientists; and to give program support for equipment, supplies, travel, and personnel. Secondarily, US groundnut research programs are enhanced through the exchange of germplasm and knowledge of production and utilization, and program support.

Constraints

The research objectives of the projects that comprise the Peanut CRSP have been developed around constraints with allocated priorities. These are: low yields because of unadapted varieties and lack of varietal resistance to diseases, insects, and drought; health hazards and economic losses due to mycotoxin contamination; yield losses due to infestations of weeds, insects, and nematodes, and disease infections; inadequate food supplies where groundnut is not generally considered a primary food source; economic and sociological problems preventing efficient production and utilization; and physiological and soil microbiological barriers resulting in low yields.

Program Strategy

Individual Peanut CRSP projects are designed with careful consideration being given to host-country needs, but at the same time focusing on regional research and development problems. Information derived from project findings will be shared on a regional basis by means of reports, publications, and appropriate meetings or workshops.

Program Participants

The US institutions involved in the Program are Alabama A&M University, University of Georgia, North Carolina State University, and Texas A&M University. Eleven projects in collaboration with nine host countries are distributed among these organizations.

The University of Georgia was selected to manage the Program and received the prime grant from USAID. Under subgrants, each university leads its respective project and develops collaborative activities in the host country, and participating staff in that country receive financial and technical support.

Host-country participating organizations are selected on the basis of interest, need, identifiable constraints to production and utilization, and the presence of an existing research program with which to develop suitable collaboration. In Southeast Asia the countries involved are: Thailand and the Philippines; in Africa: Senegal, Mali, Upper Volta, Niger, Nigeria, and Sudan; and in the Caribbean: Trinidad.

The collaborating institutions in Thailand are the Department of Agriculture, Kasetsart University, and Khon Kaen University. In the Philippines collaboration is with the University of the Philippines at Los Bafios and the Institute of Plant Breeding, through the Philippines Council for Agriculture and Resources Research and Development.

Research Projects

Four research projects are currently under way in the Philippines and Thailand. Each project involves work in both countries.

1. "Peanut Varietal Improvement for Thailand and the Philippines." Johny C. Wynne, Principal Investigator, North Carolina State University. The objectives are to develop cultivars with desirable agronomic traits of high yield, early maturity, drought tolerance, and resistance to rust, leaf spots, and Aspergillus flavus. Cooperative efforts with the two following projects will develop cultivars resistant to insects and high in nitrogen-fixation capacity.

2. "Management of Arthropods on Peanuts in Southeast Asia." W.V. Campbell, Principal Investigator, North Carolina State University. The objectives are to evaluate groundnut germplasm for insect resistance, determine the damage potential and population dynamics of important insects, determine the effect of cultural practices on insect populations, establish insect damage thresholds, and develop a pilot pest management system.

3. "Rhizobia and Mycorrhizae Influence on Nitrogen Fixation and Growth of Peanut in Thailand and the Philippines."

   A. Rhizobia Considerations. G.H. Elkan, Principal Investigator, North Carolina State University. The objectives are to identify rhizobial strains effective in symbiosis with local groundnut cultivars, study the effect of flooding on the survival of rhizobia, determine the effect of soil stresses (acidity, high Al and low P) on nitrogen fixation, and select germplasm/rhizobia tolerant of these conditions, and determine the efficacy of inoculants prepared using strains identified as being effective with local cultivars.

   B. Mycorrhizae Considerations. Ruth Ann Taber, Principal Investigator, Texas A&M University. The objectives are to maximize groundnut production through manipulation of the microbial inhabitants of the roots; survey endomycorrhizal fungi in the rhizosphere of groundnut; collect, develop inoculation techniques, and test fungal isolates; evaluate the effectiveness of selected mycorrhizal fungi for alleviating salinity, drought, and flooding stresses and for improved phosphorus uptake; and determine if mycorrhizal fungi can give groundnut protection against soil-borne diseases.

4. "Appropriate Technology for Storage/Utilization of Peanut." Tommy Nakayama, Principal Investigator, University of Georgia. The objectives are to survey the food consumption patterns of groundnut, devise appropriate technology for groundnut storage, and enhance utilization by the introduction/development of new food forms of the crop.

Summary

The Peanut CRSP is based on four premises.

1. Collaboration: a partnership beneficial to the host countries and the USA.

2. Research: to provide solutions to production and utilization constraints.

3. Support: to provide technical advice, training, and funding.

4. Program: to coordinate the constituent projects within the overall Program.

Participants

Mr, Noor Rawi Abu Bakar, Research Officer, Malaysian Agricultural Research and Development Institute, MARDI Research Station, P.O. Box 3, Kuala Trengganu, Malaysia (West)

Mr. Joji Arihara, Tropical Agriculture Research Center, Ministry of Agriculture, Forestry and Fisheries, Yatabe, Tsukuba, Ibarki, 305 Japan (ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India)

Dr. A.K. Auckland, Senior Agronomist, Agricultural Services Division, Asian Development Bank, P.O. Box 789, Manila, Philippines

Dr. Gordon R. Banta, Program Officer, IDRC, Tanglin, P.O. Box 101, Singapore 912X

Dr. Douglas Beck, Director, BNF Resource Center, Rhizobium Building, Soil Science Division, Department of Agriculture, Bangkok 10900, Thailand

Dr. Vichitr Benjasil, Director (Peanut Coordinator), Khon Kaen Field Crops Research Center, Khon Kaen, Thailand

Mr. Achyut Nath Bhattarai, Chief Agronomist, Department of Agriculture, Agronomy Division, Khumaltar, Kathmandu, Nepal

Dr. Satish Chandra, Project Director (Pulses), IARI Regional Station, Kanpur, Uttar Pradesh 208 024, India

Dr. Rajman Chaudhary, Leader, Grain Legume Improvement Program (GLIP), Agronomy Division, Khumaltar, Kathmandu, Nepal

Dr. David G. Cummins, Program Director, Peanut CRSP, University of Georgia, Georgia Experimental Station, Experiment, Georgia 30212, USA

Dr. (Ms.) Dely P. Gapasin, Director, Crops Research Department, Philippine Council for Agriculture & Resources Research & Development, Los Bafios, Laguna, Philippines

Mr. Azmi Ibrahim, Research Officer, Malaysian Agricultural Research and Development Institute, MARDI Research Station, P.O. Box 3, Kuala Trengganu, Malaysia

Dr. Abdul Rahman Khan, Project Director, BARD, Pakistan Agricultural Research Council, P.O. Box 1031, Islamabad, Pakistan

Professor K. Kumazawa, Faculty of Agriculture, University of Tokyo, Bunkyo-ku, Tokyo, Japan

Dr. Bashir Ahmed Malik, Coordinator, Food Legumes, National Agricultural Research Centre, Pakistan Agricultural Research Council, National Park Road, P.O. National Institute of Health Labs, Islamabad, Pakistan

Mr. Michel Marieu, First Secretary (Development Advisor), Delegation of the Commission of the European Communities for S. Asia, Taj Palace Hotel, Sardar Patel Road, New Delhi 110 021, India

Dr. Shiro Okabe, Director, ESCAP CGPRT Centre, Jalan Merdeka 99, Bogor, Indonesia. (ESCAP Regional Coordination Centre for Research and Development of Coase Grains, Pulses, Roots and Tuber (CGPRT) Crops in the Humid Tropics of Asia and Pacific)

Dr. R.K. Pandey, Agronomist/Breeder, IRRI-IITA Project, International Rice Research Institute, P.O. Box 933, Manila, Philippines

Dr. (Ms.) Gabrielle J. Persley, Research Coordinator, Australian Centre for International Agricultural Research (ACIAR), P.O. Box 1571, Canberra City 2601, Australia

Dr. P.S. Reddy, Project Coordinator (Groundnut), All India Coordinated Research Project on Oilseeds, Punjabrao Krishi Vidyapeeth, Akola, Maharashtra 444 104, India

Dr. K.W. Riley, Oilcrops Technical Adviser, Institute of Agricultural Research, Holetta Station, P.O. Box 2003, Addis Ababa, Ethiopia (IDRC, P.O. Box 8500, Ottawa, Canada, K1G 3H9)

Dr. R.B. Singh, Regional Plant Production & Protection Officer, FAO Regional Office for Asia and the Pacific, Maliwan Mansion, Phra Atlt Road, Bangkok 10200, Thailand

Mr. Sadakin Somaatmadja, Legume Breeder, Central Research Institute for Food Crops, Jalan Merdeka 99, Bogor, Indonesia

Mr. Preecha Suriyapani, Acting Director, Ubon Field Crops Research Center, P.O. Box 69, Ubon Ratchathani, Thailand

Mr. E.S. Wallis, Research Officer, Department of Agriculture, University of Queensland, St. Lucia, Brisbane, Queensland 4067, Australia

Participants from ICRISAT

Dr. S.P.S. Beniwal, Sr. Plant Pathologist (Pulses)

Dr. J.R. Burford, Principal Soil Chemist

Dr. D.G. Faris, Principal Pigeonpea Breeder

Dr. B.C.G. Gunasekera, Principal Soil & Water Scientist, International Cooperation

Dr. C.R. Jackson, Director for Interational Cooperation

Dr. J.S. Kanwar, Director of Research

Dr. L.J.G. van der Maesen, Principal Germplasm Botanist

Dr. D. McDonald, Principal Groundnut Pathologist & Leader, Groundnut Improvement Program

Dr. M.H. Mengesha, Principal Germplasm Botanist & Leader, Genetic Resources Unit

Dr. A.S. Murthy, Sr. Training Officer

Dr. Y.L. Nene, Principal Pulse Pathologist & Leader, Pulses Improvement Program

Dr. D.L. Oswalt, Principal Training Officer

Dr. W. Reed, Principal Entomologist (Pulses)

Dr. V.W. Saka, Visiting Scientist, Pulse Pathology

Dr. A.R. Sheldrake, Consultant, Pulse Physiology

Dr. J.B. Smithson, Principal Chickpea Breeder

Dr. L.D. Swindale, Director General

Dr. T. Takenaga, Principal Agricultural Engineer

Mr. B.K. Varma, Plant Quarantine Officer

Dr. S.M. Virmani, Principal Agroclimatologist & Leader, Farming Systems Research Program

Dr. M. von Oppen, Principal Economist & Leader, Economics Program

Dr. T.S. Walker, Principal Economist

Dr. R.W. Willey, Principal Agronomist

Dr. J.H. Williams, Principal Groundnut Physiologist

Mr. J.B. Wills, Research Editor

Participants: Consultative Group Meeting for Asian Regional Research on Grain Legumes, ICRISAT Center, 1983

RA-0072

ICRISAT

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