CLAN

Cereals and Legumes

An Asian Perspective

International Crops Research Institute for the Semi-Arid Tropics

Abstract

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This publication is a report of the first Country Coordinators' meeting of the Cereals and Legumes Asia Network (CLAN). Network activities during 1991-93 are reviewed; collaborative research projects in the member countries are described, and future priorities suggested. The role of ICRISAT's research and research-support programs in the network is discussed. Papers from three international research institutes and a major funding agency are also included, outlining their possible contributions to future CLAN activities.

Recommendations are made for future research activities aimed at alleviating the major constraints to the production of CLAN priority crops: sorghum, millets, chickpea, pigeonpea, and groundnut.

Résumé

Céréales et légumineuses: une perspective asiatique. Comptes rendus de la Réunion consultative des coordonnateurs des pays membres du CLAN. Cette publication est un rapport de la première réunion des coordonnateurs des pays membres du Réseau asiatique sur les céréales et les légumineuses (CLAN). Les activités du réseau pendant la période 1991–93 sont passées en revue; les projets de recherche collaborative dans les pays membres sont décrits, suivi d'un bref exposé des priorités futures. Le rôle des programmes ICRISAT de recherche ainsi que des programmes soutenant cette recherche au sein du réseau y est discuté. Sont également incluses des communications de trois instituts internationaux de recherche et d'un important bailleur de fonds, esquissant leurs contributions éventuelles aux activités du CLAN dans le futur.

Diverses recommandations sont faites pour les activités de recherche futures, visant à alléger les contraintes majeures à la production des cultures prioritaires du CLAN, notamment le sorgho, les mils, le pois chiche, le pois d'Angole et l'arachide.

Cereals and Legumes: An Asian Perspective

Summary Proceedings of the CLAN Country Coordinators' Consultative Meeting

29 Sep to 1 Oct 1993
ICRISAT Center

Edited by

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and
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International Crops Research Institute for the Semi-Arid Tropics
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1993

Objectives of the Meeting

To review the research activities within each country and the region, on sorghum, millets, chickpea, pigeonpea, groundnut, and related resource management, and indicate future collaborative activities under CLAN;

To review and suggest improvements for the exchange of materials, information, and technology; and for enhanced human resource development in the region;

To review interactions and linkages with other regional and international institutions and nongovernment organizations involved in research and development on mandate crops/areas;

To provide guidelines for network activities that will have greater impact on the production of CLAN priority crops in the region.

Contents

Introduction

Overview of the Meeting

Y.L Nene[1]

On behalf of the Organizing Committee, I extend to all of you a very hearty welcome to this first Cereals and Legumes Asia Network (CLAN) Country Coordinators' Consultative Meeting, being held almost immediately after the Asian Sorghum Researchers' Consultative Meeting, also conducted under the auspices of CLAN.

At ICRISAT we have a mandate to work on six crops: three cereals (sorghum, pearl millet, and finger millet), and three legumes (groundnut, pigeonpea, and chickpea). All six crops contribute substantially to the diets of the people of the semi-arid tropics of Asia, Africa, and Latin America.

Let me briefly trace the history of this interesting and easy-to-remember acronym, CLAN. In December 1983, almost 10 years ago, we had organized a consultative group meeting of legume scientists from Asia. Two years later (1985) we hosted a review and planning meeting. In response to the recommendations made at these two meetings, the Asian Grain Legumes Network (AGLN) was established under the leadership of Dr D.G. Faris, who has now retired.

In December 1988 we held the first Regional Legumes Network Coordinators' Meeting, followed by another meeting in December 1990. Another network, called the Cooperative Cereals Research Network (CCRN), was established in 1988 and operated globally to serve the needs of sorghum and millet scientists. At a consultative meeting in 1991, it was resolved to establish a Sorghum Research and Development Network for Asia, and ICRISAT was asked to initiate and coordinate the activities of this network.

By now I suspect you must be somewhat confused by this proliferation of networks. No wonder, therefore, Asian scientists and administrators preferred to have a single network covering both cereals and legumes. AGLN and CCRN were therefore merged in 1992 to form the Cereals and Legumes Asia Network—CLAN—and Dr C.L.L. Gowda was appointed its Coordinator. In all these 10 years, ICRISAT has acted as a catalyst in bringing about research collaboration in the areas of crop improvement, crop management, crop geography including agroclimatology, and crop protection. ICRISAT has also played a significant role in enhancing the skills of collaborators in many different areas. The exchange of information has been substantial.

Most of the support for these activities has come from network members, who use existing facilities and resources in their countries to carry out collaborative research. ICRISAT provides support to the Coordination Unit, partly funds travel by the Institute's scientists, and trains scientists from the national agricultural research systems (NARS). Additional external funding has been graciously provided by donors

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such as the Asian Development Bank (ADB), Australian Centre for International Agricultural Research (ACIAR), United Nations Development Programme (UNDP), Food and Agriculture Organization of the United Nations (FAO), International Development Research Centre (IDRC), and Peanut-Collaborative Research Support Program (CRSP) of the United States. We have cooperated with institutions such as the Regional Coordination Centre for Research and Development of Coarse Grains, Pulses, Roots, and Tuber Crops of the Economic and Social Commission for Asia and the Pacific (ESCAP CGPRT), Asian Vegetable Research and Development Center (AVRDC), International Center for Agricultural Research in the Dry Areas (ICARDA), Centro internacional de agricultura tropical (CIAT), International Rice Research Institute (IRRI), and Centro internacional de mejoramiento de maiz y trigo (CIMMYT) for joint projects in Asia.

The objectives of this meeting are to:

- Review the research activities within each country, and the region, on sorghum, millets, chickpea, pigeonpea, and groundnut, and related resource management, and indicate future collaborative activities under CLAN;
- Review and suggest improvements for the exchange of materials, information, and technology; and for enhanced human resource development in the region;
- Review interactions and linkages with other regional and international institutions and nongovernment organizations involved in research and development on mandate crops/areas;
- Provide guidelines for network activities that will have a greater impact on the production of CLAN priority crops.

The schedule of the meeting provides adequate time to exchange information, hold discussions, and plan activities for the future. It would also be appropriate to discuss in what form and in which ways CLAN should function.

It is gratifying to see that 12 of the 13 invited country coordinators are present. Representatives of regional and international institutions, including a major donor agency, are also here. This clearly shows a positive interest in CLAN by all the concerned NARS and other institutions in Asia.

Ladies and gentlemen, let me welcome you once again. We sincerely hope you enjoy your stay here and find the meeting professionally satisfying.

Overview of ICRISAT's Research Strategy

James G. Ryan[1]

Introduction

The acronym CLAN is appropriate for the new combined Cereals and Legumes Asia Network, as it signifies a like-minded group with common concerns and backgrounds. In this case the backgrounds are cereals and legumes; and we have a common purpose, as a clan does.

I would like to provide an overview of our perceptions of where ICRISAT is planning to go in the years ahead, against the background of the challenges we face. I particularly want to emphasize the challenge, because of the nature of the environments in which we and our partner countries work. The semi-arid tropics (SAT), where one-sixth of the world's people live, are harsh for both scientists and farmers, with a combination of poverty, unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate

The ICRISAT mandate is five-fold.

- To improve grain yield and quality of sorghum, pearl and finger millets, pigeonpea, chickpea, and groundnut. To date, 166 improved cultivars developed jointly by ICRISAT and our partners have been released in 48 countries;
- To serve as the world repository for the germplasm of our mandate crops. The collections are duplicated wherever possible, and are always freely available to researchers worldwide. ICRISAT has distributed over 577 000 accessions to date, some 276 000 outside India.
- To develop improved farming systems that compare favorably with traditional management practices in terms of yield, stability, and sustainability.
- To identify and help alleviate socioeconomic and production constraints (drought, diseases, pests, soil and water management problems, etc.). For example, the broad-bed and furrow system is effective against flooding and erosion in heavy black soils;
- To assist national programs in technology development and exchange. This includes information exchange through publications crop- or area-specific networks, Working Groups, etc., and training programs for students, scientists, and technicians from the national agricultural research systems (NARS).

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Medium-Term Plan for ICRISAT

There are many successes that ICRISAT has achieved in collaboration with its national program partners. However, much remains to be done, and we need to increase our research efforts if we are to do our part to feed the 90 million additional people that are born each year in the developing world. It is against this background that ICRISAT began a major exercise in 1992, following the development of our strategic plan, to put together a Medium-Term Plan (MTP) for the period 1994-98.

The MTP that ICRISAT has developed is analytically rigorous; aimed at being transparent in the process and the criteria that we have used to make the choices; drew on an extensive agroclimatic, biological, and socioeconomic database; and involved all ICRISAT scientists and major NARS. The process drew out both the objective knowledge and the subjective scientific intuition of scientists concerning the various biotic, abiotic, and socioeconomic constraints to agricultural production in the SAT, and importantly the extent to which research can help alleviate those constraints.

Identification of research themes

Based on a detailed analysis of the economic consequences of the various constraints to crop production in the SAT, and following considerable internal discussion, 110 potential research themes were identified. In identifying those research themes, we analyzed in detail what we termed 'research domains' in which our mandate crops grow across the SAT and beyond.

Research domains. We defined a research domain as a somewhat homogenous ecoregion throughout which strategic research results of a particular nature, or in a particular area/discipline, could be applied. It was found necessary to define different domains for different crops and for resource management. The crop improvement programs found zones of adaptation a very convenient way to identify potential research domains; the Resource Management Program found soil and water environments more convenient.

Subsequent to the compilation of the MTP and the delineation of appropriate research domains for its implementation, we are well on the way to identifying a number of production systems, as we are terming them, which will form the basis of the development of a coherent series of themes and projects on which we will work in the next 5 years.

The 110 themes in our MTP were ranked using four criteria:

- Efficiency
- Equity
- Internationality
- Sustainability

Efficiency was measured by the net benefit-cost ratio, which was derived from an estimated economic value of success in the conduct of research on that particular constraint, the likelihood of success, the potential for economic, scientific, or agroecological spillovers, research and adoption lags, and the influence of markets. We benefitted greatly in this exercise from interaction with our national program partners, whose perceptions of the severity of the various constraints helped us to arrive at final estimates of the potential economic value of success in overcoming them.

Equity was measured by two variables—the number of absolutely poor people in the research domains where the particular constraints were judged to be serious, and the number of female illiterates residing in each domain.

Internationality. A measure of internationality was calculated using Simpson's index. Being an international center, it was appropriate for ICRISAT to ensure that we were focusing on problems which were important in many countries or over large areas, and conducting research in a complementary way to national programs.

Sustainability was measured by the likely contribution of the particular theme to the conservation and enhancement of the natural resource base.

Each of the four criteria was given an equal weight to compute a composite index for each theme. Of the 110 themes we determined that 18 were suitable for complementary funding. The relative priorities of the remaining 92 research themes were determined by their composite indices, and the cumulative annual cost was calculated. This enabled us to determine cut-off points based on likely levels of funding for implementation of the plan.

Costing of research themes

The total cost of the 92 themes (together regarded as the core portfolio) was around US $30 million a year. Because of the analytical approach that was used, we could clearly identify which themes would be lost (from the bottom of the prioritized list) if funding was insufficient, and the benefit stream which would be lost in such an event. The MTP envisages an increased emphasis on groundnut and resource management research. There would also be a slight increase in the share of chickpea in the total research budget, perhaps at the expense of sorghum and millets. Funding for these two cereals, however, would remain at current levels in absolute terms.

Other features of the plan

Other features that we have included in the MTP are as follows: The data we have used in the construction of the research themes would be regarded as milestones for the purpose of future monitoring and evaluation of research.

To more effectively implement the plan, we will be putting to our Governing Board a proposal for a change in the organization and management of ICRISAT which emphasizes project-based management, facilitated by a matrix organization. This change would allow a flexible response to current and potential challenges, and enhance research productivity and potential impact.

There would be a greater emphasis on natural resources management research, particularly on the enhancement of social science research capabilities. We have done considerable multidisciplinary work on Vertisols. This research will continue, and be extended to Alfisols, to understand the basic mechanisms that regulate production. Alfisols currently represent one-third of the land area in the SAT, and in many ways are probably more fragile and support more poor people than do Vertisols.

We are also considering ecoregional initiatives such as:

- Studies on desertification, focused on the desert margins of the Sahelian zone in Africa;
- Ecoregional initiatives in the eastern African highlands in collaboration with other international institutions;
- Cooperation with the International Rice Research Institute (IRRI) in the important agroecologies in Asia. Two meetings have been held with IRRI representatives, and more will follow.

Strategic research on crop improvement both in cereals and legumes will be built on our work on biotechnology, which is now being considerably strengthened, particularly by collaboration with mentor institutions.

ICRISAT will intensify specialist scientific human resource development activities, including short courses and arrangements for visiting scientists. Production training activities would be scaled down to accommodate increased activities in scientific training, and gradually be devolved to the national programs.

Our reliance on networks will continue and grow. Networks not only help to cement partnerships between ICRISAT and the various national programs, but also improve the chances of research successes by ensuring continuous, joint review.

We will have a proactive gender analysis and gender employment program during the coming years. The former will have its focal point in the Economics Group, but we will ensure that scientists explicitly factor an appropriate gender perspective into their research.

Of the 92 priority themes that we had identified, 80% directly relate to the priorities determined in Agenda 21 of the United Nations Conference on Environment and Development (UNCED). We firmly believe that our projected research portfolio, besides being clearly focused on the mandate of the Consultative Group on International Agricultural Research (CGIAR) system, addresses the contemporary concerns of the international community about the environment and the sustainability of growth.

The future

All of us have funding constraints, and this is something we scientists must recognize and take responsibility for rectifying. Let me give my perception of the role of agricultural research in the contemporary concerns of the international community.

The five related problems of food production, malnutrition, poverty, population growth, and environment are more acute now than they were some 20 years ago when ICRISAT began its activities. Today, concern about the environment has so preoccupied the world community that it seems to have forgotten about the other four elements. There is a nexus among these five conundrums of development. Poverty limits opportunities for protecting and enhancing the environment because poor people have few options but to exploit the natural resource base for food security, and sometimes even for survival. Poverty also hinders efforts to manage population growth, because children represent additional sources of income for poor people. The way forward is through agricultural and economic development and broad-based poverty alleviation programs.

The linkages between higher agricultural productivity and general economic growth are direct and very real. Farmers who are more productive earn higher incomes; a demand is thus created for goods and services outside the agricultural sector. More productive agriculture also means more food at lower prices. These lower prices facilitate the complex interactions that promote economic growth. Real incomes increase, especially where food accounts for a large part of household budgets (as it does in the developing world). A portion of this additional income is spent on non-food products, thus stimulating further rounds of demand and growth. Some of this extra income is also saved and reinvested. Productivity gains in agriculture will reduce the need to farm fragile lands and forest and desert margins, and thus reduce pressure on natural resources. Institutions such as ICRISAT and the national programs thus contribute both directly and indirectly to reducing poverty, protecting the environment, and slowing population growth.

The complexities of agriculture require greater resources for research to meet the demands of the developing world. The commitment of governments and scientists in NARS is pivotal. The relationship between ICRISAT and its Asian partners has been a valuable collaborative effort, and we trust that this relationship will be maintained for a long time to come, and that we will jointly continue our commitment to the people of Asia.

CLAN Reports

CLAN Coordinator's Report

C.L.L Gowda[1]

Introduction

The Cereals and Legumes Asia Network (CLAN) was formed by merging the erstwhile Asian Grain Legumes Network (AGLN) and the Asian component of the Cooperative Cereals Research Network (CCRN). AGLN was established in 1986 to facilitate technology exchange in chickpea, pigeonpea, and groundnut in Asia, while CCRN was instituted in 1988 and operated globally, for the exchange of genetic material and information. However, scientists and research administrators in the member countries expressed their preference for a single network for technology exchange activities for both cereals (sorghum and millets) and legumes (chickpea, pigeonpea, and groundnut). To meet this demand CLAN was formally launched in April 1992.

Networks

Before going into the past and future activities of CLAN, I would like to briefly touch upon a few network concepts as a background to our deliberations. An agricultural research network is a group of individuals or institutions linked together by their commitment to collaborate in solving problems of mutual concern, and to use existing resources more effectively. The essence of such networks, therefore, is collaborative research; members share scarce resources, staff, and facilities in order to find solutions to problems of common concern. The network belongs to, and is driven by, the members. The members (institutions or individuals) form the body of the network, and contribute staff, facilities, and resources. However, additional external funding is usually required for research coordination and communication. ICRISAT has provided the Coordination Unit and operational funds to facilitate, coordinate, and harmonize the collaborative research, and provide the necessary logistic support. Since the Coordination Unit is located at ICRISAT Center, the network benefits from the scientific and technical backstopping available at the Institute for CLAN priority crops and resource management research.

Each partner has an important role in determining network priorities and providing guidelines for various activities. As the Country Coordinators of CLAN, and representatives of regional and international institutions, I solicit your comments and suggestions to make CLAN more viable and effective.

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Activities During 1991-93

This report presents highlights of CLAN activities from Jan 1991 to Sep 1993. Details are given in Appendices 2-13.

Exchange of germplasm and breeding material

The Genetic Resources Program (GRP) at ICRISAT has provided strong support to CLAN activities in germplasm exchange. Over 34 500 germplasm lines of ICRISAT mandate crops were supplied to national program scientists in Asia (Appendix 2). The national programs have reciprocated, contributing 1 887 samples of new germplasm lines to the GRP gene bank.

The crop improvement programs at ICRISAT have supplied large quantities of early and advanced generation breeding material, and varieties/hybrids for local testing and selection (Appendices 3 to 7). A summary is given below.

		Number of samples			
Crop	Trials (no. of sets)	Varieties/ Breeders' seed	Advanced lines	Segregating populations	Others
Groundnut	162	345	1467	804	99
Chickpea	194	228	625	1909	150
Pigeonpea	284	413	1207	145	268
Total	640	986	3299	2858	517
Sorghum	322	55	12034		-
Pearl millet	227	1431	7710		
Total	549	1486	19744		-

During the period 1991-93, the national programs have released 4 chickpea, 5 pigeonpea, 8 groundnut, 1 sorghum, and 5 pearl millet varieties based on material supplied by ICRISAT. A few of these releases have been grown extensively in some countries, while in others they are finding acceptance. ICRISAT is planning a joint evaluation of varietal adoption in selected countries. A full list of released/promising legume varieties is given in Appendix 8.

Workshops, meetings, and tours

The CLAN Coordination Unit organized or helped to organize a number of workshops, meetings, and monitoring tours. A full list of workshops and meetings held to date is given in Appendix 9. Many of these were specially designed for Asian countries because of the regional importance of a problem, or an identified need for such meetings. These meetings have greatly enhanced interaction between scientists, and helped to plan collaborative research (as in the case of Working Group meetings). In-country monitoring tours involving NARS and ICRISAT staff were organized to visit the experiments, provide technical assistance, and for information exchange.

The Review and Planning Meetings held in each member country have led to the development of collaborative work plans for each country. These work plans are reviewed or updated every 1 or 2 years.

Four hundred and eleven scientists from Asia spent 2 111 mandays at ICRISAT Center or ICRISAT-supported workshops and meetings during 1991-93. Among these were *66* NARS staff who visited other NARS programs or participated in meetings in Asian countries. ICRISAT scientists spent 1 607 mandays, spread over 168 visits, interacting with national program scientists and providing scientific backstopping (Appendix 10). These visits helped scientists from ICRISAT and the national programs exchange information and plan collaborative research.

Human resource development

During 1991-93, 154 scientists and technicians from Asia participated in human resource development (HRD) programs. These included 6-month in-service production training courses (36 participants), short-term special training (38 participants), and research fellows (46) (Appendix 11). It is evident from these figures that there has been a shift in HRD emphasis from regular production-type courses for technicians to more specialized technical and skill-development training for mid- and senior-level scientists. A special course on quality aspects of food legumes and coarse grains was conducted in 1992 in collaboration with the National Institute of Nutrition, Hyderabad, India, with financial support from the FAO RAS/89/040 project. In-country training courses on the identification of seedborne groundnut viruses were organized in China (1990) and India (1992). A list of special courses conducted is given in Appendix 12.

Working Groups

Working Groups (WGs), which are set up to address high priority regional problems, have been effective in enhancing collaboration between scientists. A separate report on the WGs is presented later. Currently four WGs are operating: Asia-Pacific

Groundnut Viruses, Bacterial Wilt of Groundnut, Integrated Pest Management and Insecticide Resistance Management, and Botrytis Gray Mold of Chickpea.

A WG on acid soil tolerance was formally launched in Sep 1993 at a meeting in Australia; and a WG on biological nitrogen fixation in legumes will be initiated at a meeting in Dec 1993 at ICRISAT Center.

On-farm adaptive research

In view of the importance of making improved varieties and management practices available to Asian farmers, the network has collaborated with NARS in Indonesia, Nepal, Sri Lanka, and Vietnam on the Asian Grain Legumes On-farm Research (AGLOR) project. A detailed report on AGLOR is presented later. A workshop on on-farm adaptive research was organized (in collaboration with the FAO RAS/89/040 project and ESCAP CGPRT) in Vietnam during 18-20 Feb 1993 to allow the four AGLOR project countries to share their experiences with the other 14 member countries of the FAO RAS/89/040 project.

Special projects

CLAN provided logistic support to the ADB-Sri Lanka-ICRISAT Pigeonpea Production Project. This special project was initiated to popularize pigeonpea cultivation in Sri Lanka as a substitute to imported lentil. Earlier varietal trials had indicated that the new short-duration varieties introduced from ICRISAT could be profitably grown in Sri Lanka. The project concentrated on on-farm trials, with a few demonstrations to convince farmers of the potential of pigeonpea and familiarize them with the necessary management practices. Large-scale commercial cultivation (around 150 ha) was undertaken during the 1992/93 season. Although a few farmers have harvested >2 t ha^{*1}, average yields (with both main + ratoon crops) have been around 1 t ha^{-1}. Farmers have been able to process pigeonpea seed into *dhal* using either locally available mills or the dehulling machines provided by the project. Some commercial firms have purchased pigeonpea seed from farmers, processed it into *dhal,* and sold it in the markets. However, *dhal* processing and pest management are still major problems. A second phase of the project was approved by the Asian Development Bank (ADB) in Aug 1993 to carry forward the work of the first phase.

Future Plans: Ongoing Activities

This is the first consultative meeting of the Country Coordinators after the formation of CLAN, and as Country Coordinators and representatives of other institutions, you have to provide guidelines for future network activities. I would like to briefly discuss the ongoing activities and also the new possibilities suggested during recent discussions with NARS scientists and administrators. We are also submitting a proposal to the ADB for funding network activities. We need your approval and support to strengthen this proposal.

Working Groups

Working Groups will identify 'lead centers' in member countries where major research on a topic can be done, depending on the comparative advantage (in terms of facilities and expertise) of a research institution. Similarly, other centers will be identified as 'satellite centers' where some components of research will be conducted. By involving NARS institutions in Working Group research, we propose to gradually transfer the research and coordination of WGs to national programs. The network Coordination Unit will continue to provide logistic support to the Working Groups.

On-farm adaptive research

Many national programs have shown an interest in on-farm adaptive research (OFAR), but lack the resources and/or trained personnel to undertake such projects. Depending on the funds available from donors, and the need and interest of NARS, the network may help to initiate or expand OFAR in CLAN countries.

Evaluation of the suitability of various technologies for adoption by farmers, and assessment of their impact (e.g., the number of farmers adopting the technology; the extent of yield gains, etc.) is an essential component of OFAR. The network proposes to undertake some of these studies jointly with selected countries.

Information exchange

Currently, information flows largely from ICRISAT to other network members. However, a few national programs do generate technology and information that will be useful to other CLAN members, including ICRISAT. There is a clear need, therefore, to encourage bilateral or multilateral information exchange among members, particularly because access to global sources of information is a bottleneck in many NARS. CLAN organized a travelling seminar in Sri Lanka during Sep 1993 to train NARS scientists and library staff on the use of electronic/computer-based systems to access global literature databases. We would like to conduct such workshops in other countries also, to help develop networks for literature exchange. Efforts will also be made to co-publish important technical publications in local languages, depending on NARS needs and interests.

Human resource development

This will continue to be a major activity, with a shift in emphasis from production training towards courses for the development of specialized skills. The former, in line with current CGIAR policy, will be devolved to the NARS. The network will help the HRDP at ICRISAT to identify NARS which can shoulder this responsibility. CLAN will also organize in-country training courses with major inputs (in terms of resources and teaching faculty) from national programs.

Linkage activities

The following linkage activities are essential for efficient functioning of the network:

- Review and planning meetings in each member country to review past research results and prepare future plans for collaborative research;
- Monitoring tours (in-country or regional) to observe *field* experiments, identify constraints, evaluate research progress, and identify technology or material potentially valuable to other members;
- Exchange of visits by scientists to exchange information and research results, and participate in collaborative research;
- Surveys to assess the extent and seventy of damage due to stress factors, and provide feedback for research planning;
- Workshops and meetings to share information and research results, and formulate regional work plans for collaborative research.

Coordination

ICRISAT has *provided* the support (staff, resources, funds) for the Coordination Unit. Such a contribution was considered essential to build and sustain the network. We now need to examine whether, and over what time frame, responsibilities for coordination should be devolved to the NARS. There is a suggestion to involve NARS staff in network coordination as Visiting Scientists, and we would like to have your opinion.

Future Plans: New Initiatives

Steering Committee

CLAN Country Coordinators' Meetings are held only once in 2-3 years; annual meetings are not possible due to a shortage of funds. A smaller Steering Committee, which can meet more frequently, could oversee network coordination, and ensure that activities do not suffer from the infrequency of Coordinators' Meetings.

Currently, all country coordinators together form the Steering Committee for CLAN. The issue was discussed at earlier AGLN Country Coordinators' Meetings, but no consensus developed on forming a small Steering Committee. This meeting could consider the formation of a Steering Committee consisting of 4-5 representative Country Coordinators from member countries, who would serve in rotation. The Chair, selection of members, and tenures need to be discussed.

Visiting Scientists

We propose to offer Visiting Scientist positions to senior national scientists/administrators to work in the Coordination Unit on a short-term basis. In addition to working on research projects at ICRISAT, the Visiting Scientist will also be able to gain experience in network coordination.

Collaborative breeding endeavors

Many national programs in Asia have good crop improvement programs, while a few others are beginning to establish these. Therefore, there appears to be a greater need for early generation segregating materials, and unfinished products such as breeding lines and populations. The network, with support from ICRISAT Center programs, will supply these intermediate and unfinished products to national programs as and when required. Several possibilities exist for collaborative breeding programs:

Cooperative breeding. Crosses will be made at ICRISAT Center and the F_3/F_4 populations supplied to NARS for screening and selection.

Population improvement. Populations with the desired character combinations will be developed (or selected from existing populations) and sent to NARS for local adaptability selection.

Polygon breeding. This will involve three or more country programs. After the initial crosses are made at any one of the programs, the F_2 and further generations will be exchanged among cooperating programs after each cycle of selection. Final selections for adaptation will be made at each location and then exchanged for testing for *wide* adaptation (including *resistance* to *stress* factors).

Newsletters

Communication plays a major role in any network. Currently, CLAN does not publish a separate newsletter, but relies on several other newsletters (including three published by ICRISAT and one each by the Working Groups on Drought Research in

Grain Legumes, and Biological Nitrogen Fixation in Legumes) to provide information to members. With all these newsletters, is there a need for an exclusive CLAN Newsletter or Bulletin containing news items and research reports?

Video films and slide sets

There have been several suggestions to produce video films and slide sets for training and extension work. We have supplied a few slide sets to interested scientists on request. A video film on pigeonpea production technology in Sri Lanka was produced with financial support from ADB, and has been well received. We are also planning to make a video film on AGLOR, which should be ready early next year. Video films are generally considered to be good extension tools. However, no definitive data is available on their impact on farmers; and they are time-consuming and expensive to make. We need your guidance on how to proceed on this.

Conclusions

I have discussed the past activities of AGLN and CCRN, the formation of CLAN, and my perceptions about the course the network may take in the next 2-3 years. Future activities will be guided by the recommendations made at this meeting. Technology exchange is a dynamic activity, and will need to be flexible to meet the changing needs of CLAN members. However, because of resource limitations, all demands cannot possibly be met by the network. The NARS should consider—and clearly enunciate—what their priorities are, and to what extent these can be addressed with NARS resources (with only limited support from the network). Programs that are important to many member countries will necessarily have high priority. Issues vital to an individual country can be addressed through special or bilateral projects. In any case you should discuss these issues and come up with clear-cut recommendations that will chart a future course for CLAN.

CLAN in Bangladesh

M.A. Malek[1]

Introduction

Bangladesh has a total cultivated area of about 25 million ha. The main crops are rice, jute, sugarcane, tea, vegetables (especially root and tuber crops), and horticultural crops. Pulses cover only 0.74 million ha, with a total production of 0.52 million t.

Among the CLAN priority crops, chickpea, groundnut, and pigeonpea are important. Sorghum is grown on a limited scale, and proso and foxtail millets are cultivated in some areas.

Chickpea

Chickpea ranks third in both area and production among the legume crops in Bangladesh, and accounts for about 20% of the total production of pulses. About 85% of the country's chickpea-growing areas lie in the five erstwhile districts of Faridpur, Jessore, Kushtia, Rajshahi, and Pabna. Potential yields of more than 4 t ha^{-1} have been recorded at the Ishurdi Research Station. Recent findings have shown that chickpea has a tremendous potential in the dry Barind area (Rajshahi, Nawabgonj, and Naogaon districts), where about 1 million ha of land remain fallow in winter after the rice harvest.

Pigeonpea

Pigeonpea is a minor pulse crop in Bangladesh, grown on about 6000 ha, producing 4200 t of grain, which constitute only 0.81% of the total pulses production. Tall long-duration (300 days) varieties are grown along roadsides and in backyards. It is grown as a mixed crop with upland rice, finger millet, etc. in small pockets of Meherpur, Kushtia, Jessore, Pabna, Rajshahi, and Jamalpur districts as a fuel crop (not primarily for grain), and to a limited extent on field boundaries.

Groundnut

Groundnut is grown on about 17 500 ha; average yields are 1.2 t ha^{-1}. It ranks third in importance as an oil crop after rape seed and mustard. It is expanding fast as a winter crop in *char* (riverbed) areas in recent years.

1. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur 1701, Bangladesh.

Sorghum

Sorghum is not grown as a grain crop in Bangladesh, but rather as a fodder crop in very limited areas.

Pearl millet

This crop is not grown in Bangladesh. Proso and foxtail millets are grown in *char* areas or on marginal lands in the northern districts.

Collaborative research

Research linkages with ICRISAT were established in 1978, primarily for chickpea improvement. In 1985 a BARI/ICRISAT joint mission collected 200 Bangladeshi germplasm lines of chickpea, which are being maintained at the ICRISAT gene bank. With the establishment of AGLN in 1986 the linkage has been strengthened further. Large quantities of germplasm, advanced lines, yield and disease nurseries, and trials received from ICRISAT were evaluated and tested under local conditions. With the advancement of the breeding programs, breeding strategies have changed. Accordingly, the materials we now request from ICRISAT (wilt and root rot nurseries, *Helicoverpa* resistance nursery, advanced breeding lines, F_2 materials, etc.) are only those relevant to specific problems in the country.

The first Botrytis Gray Mold (BGM) of Chickpea Working Group meeting was held in Bangladesh in 1991 to formulate a work plan. Bangladesh is one of the lead centers for research on BGM of chickpea. The Crop Diversification Program (CDP) and the Bangladesh Agricultural Research Institute (BARI), in collaboration with ICRISAT, have established an effective BGM nursery at Ishurdi, equipped with a mist irrigation system to maintain humidity for disease development. BARI will now be able to assist other CLAN countries to screen their materials for BGM resistance.

Short-duration pigeonpea lines from ICRISAT and USDA were introduced and tested. Short- and medium-duration, high-yielding, and pest-resistant lines are now being tested for mixed cropping, bund-cropping, and for sowing in hill-tops and valleys in Chittagong district. Two lines, 76012 and ICPL 151, have shown promise.

Groundnut germplasm and advanced lines have been introduced from ICRISAT since 1982. Various international trials, elite trials, disease nurseries, and drought-resistance trials received from ICRISAT have been evaluated.

Collaborative research successes

Chickpea. During 1982-92, 540 germplasm lines and several sets of three trials (ICCT-DS, ICSN-DS, and ICSN-DM) received from ICRISAT were tested. One line (ICCL 81248) received in 1982 had large seeds and 14% higher yield than the local control, and was released as 'Nabin' in 1987. It performed well for 2-3 years and is still popular in some areas. However, this variety is susceptible to fusarium wilt and needs immediate replacement. In 1984/85 seven chickpea lines (ICCLs 83103, 83105, 83003, 93007, 83008, and 83228, and ICC 11320) were identified as wilt-resistant. ICCL 83228 and ICCL 83105 have been evaluated and recommended by the technical committee of the National Seed Board (NSB) for release as commercial varieties BARI-Chhola 2 and BARI-Chhola 3. A few wilt-resistant and BGM-tolerant lines will be evaluated by NSB in the 1993/94 crop season. These include ICCLs 83149, 83103, 85222, and 86237, and RBH 228.

Pigeonpea. A short-duration line, 76012, has shown a yield potential of 2.5 t ha^{-1}. This line, along with another promising new line, ICPL151, can be relay-cropped with blackgram.

Groundnut. During the period 1982-1992, 250 groundnut lines were evaluated and tested. Two lines, ICGS(E)-11 and ICGS(E)-55, have been found to be superior in yield (16-18% higher) and earliness (by 7 days) compared to the local control DA-1. These will be submitted to NSB for field evaluation in 1994. One line, ICGS 87242, selected from international foliar disease resistance trials, has been found to be resistant to early leaf spot and rust, and moderately resistant to late leaf spot; yields are higher than with DA-1. This line is undergoing further evaluation.

Future research priorities

The possibility of growing grain sorghum and pearl millet can be explored. Germplasm testing on a limited scale for suitability to Bangladeshi climate can be initiated. Future priorities for the three legumes are as follows:

Chickpea

- Identification of cultivars with multiple disease resistance;
- Germplasm screening against collar rot and dry root rot to identify resistance sources;
- Identification of cultivars suitable for late sowing in rice-based cropping systems;
- Identification of cultivars which can emerge in low-moisture conditions and ensure good plant stand (especially for the Barind region);
- Identification of slow-growing cultivars for light-soils. Large areas in Rangpur district now lie fallow during the chickpea season because of low pH, boron deficiencies, and light-textured soils (in which rapid, luxuriant growth causes severe reductions in flowering and podding);
- Identification of cultivars that respond to high inputs (irrigation and fertilizer);
- Identification of kabuli types (which are otherwise suitable) with resistance to pod borer.

Pigeonpea

- Introduction of short-duration varieties resistant/tolerant to *Helicoverpa* pod borer and sterility mosaic, with high yield potential;
- Bund cropping to be promoted in Barind and other highland areas.

Groundnut

- High-yielding, short-duration (<130 days) varieties resistant to leaf spots and rust. Early maturity is required in *char* areas, which are likely to be flooded early.
- Varieties with seed dormancy of 20-30 days with long viability (> 4 months) under ordinary storage conditions.

Information and technology exchange

The value of services provided by ICRISAT's Information Management and Exchange Program is tremendous. The bulletins, proceedings, research publications, and recent books on various aspects of pulses have been of great value to Bangladeshi scientists. ICRISAT/CLAN should supply the national program with relevant publications on a regular basis.

The exchange of visits by scientists is useful in developing linkages and interactions. Such visits, as also workshops, Working Group meetings, and group visits by scientists, should be made regular and more frequent.

Human resource development

Very little was done in this respect in the past, due to Bangladesh government restrictions on travelling abroad for training. We are now making efforts to send junior scientists/technicians for short-term (7-8 weeks) training in breeding, crop production, farm management, and pest and disease management.

Support to the National Program

Scientists from ICRISAT attend BARI's annual internal review programs on CLAN priority crops, and have made valuable contributions to the research planning process. These visits should be continued on a regular basis. It should also be ensured that the visiting ICRISAT staff participate for the entire duration of the review meeting.

BGM is a very serious problem in Bangladesh; rains during the chickpea flowering period can lead to almost zero yields. Research support in this area (as has been effectively provided by the BGM Working Group) should be given top priority. Research infrastructure should also be built up in Bangladesh by providing equipment and possibly setting up small research/observation stations at BGM hot-spots.

Improving linkages and participation

The Memorandum of Understanding between ICRISAT and Bangladesh is valid up to Nov 1993. This should be extended for a further period of 5 years, as discussed earlier between ICRISAT and BARI representatives, to allow Bangladeshi scientists to participate more fully in CLAN activities.

Slight modifications are required in some of the existing procedures. A consolidated list of all available nurseries, segregating materials, and advanced lines should be sent to the Country Coordinator. Materials should be sent together, ideally in a single container, to avoid bureaucratic and procedural delays in the receiving country. In addition, to improve logistics and communication, all seed material should be sent to the Country Coordinator, not directly to institutions.

The Country Coordinators should visit the different CLAN countries in a group during the crop season. Such visits would improve the review of CLAN activities, and also strengthen the national programs. Visits by ICRISAT scientists to CLAN countries should be continued. ICRISAT should assist CLAN members in developing linkages with other international research institutions such as ICARDA and IITA. ICRISAT scientists should be sent to CLAN countries on request for short periods, to train national scientists on specific technologies.

CLAN should allow national scientists to work at ICRISAT on sabbatical leave or as post-doctoral fellows with attractive fellowships paid, as in other international institutes like IRRI, ICARDA, and IITA.

CLAN in India

O.P. Makhija[1]

Introduction

All the CLAN priority crops (sorghum, pearl millet, chickpea, pigeonpea, and groundnut) are important in India. Groundnut is the most important of the nine oilseed crops, and accounts for 45% of the area and 55% of the production of oilseeds in the country. Chickpea is the most important pulse crop, and accounts for 30% of the area and production of pulses. Pigeonpea occupies 15% of the area and constitutes 17% of the production of pulses. Sorghum, which is used for both grain and fodder, accounts for 12% of the area and 7.5% of the cereals production. The area and production figures are shown in Table 1.

Table 1. Area and production in India of CLAN priority crops, 1990/91.

Crop	Area (10^6ha)	Production (10^6t)	Funds/scientific manpower allocation
Groundnut	8.3	7.6	25% of funds, 20% of manpower[1]
Chickpea	7.0	5.0	23% of funds and manpower[2]
Pigeonpea	3.6	2.4	19% of funds and manpower[2]
Sorghum	15.0	11.9	16% of funds, 11 % of manpower[3]
Pearl millet	11.0	7.0	9% of funds, 8% of manpower[3]

1. Out of total for oilseed crops.
2. Out of total for pulses.
3. Out of total for cereals.

The Indian national program has collaborated closely with ICRISAT for many years, especially because India is the host country for the Institute. Collaboration with CLAN/ICRISAT extends to a number of areas: exchange of germplasm and breeding materials, training, information exchange, participation in common research forums, workshops, etc.

1. Indian Council of Agriculture Research, Krishi Bhavan, Dr Rajendra Prasad Road, New Delhi 110 001, India.

Germplasm and breeding material exchange

Groundnut. To date, ICRISAT has supplied 4 500 germplasm accessions (including wild species) and 76 advanced fixed lines to the Indian Council of Agriculture Research (ICAR). The advanced lines were used by ICAR to develop a number of improved varieties, e.g., ICGVs 87285, 87310, and 89401 (resistant to rust); ICGV 88438 (confectionery type), ICGVs 88382, 88389, 88403, 88408, and 88429 (high yield). The germplasm lines were used mainly as source material for resistance to foliar diseases. The cultivar Girnar-1, which is becoming increasingly popular in western and southern India, incorporates resistance from ICRISAT germplasm lines. The other varieties developed from segregating material received from ICRISAT are SG 84, Tirupati 3, and RG 141.

Chickpea. One thousand five hundred ICRISAT germplasm lines were received by the Project Directorate of Pulses Research. These, along with 400 other lines, are being evaluated for responsiveness to high-input conditions. Segregating materials comprising 25 desi and 28 kabuli types are under evaluation. ICC 4958 was used as a source for drought tolerance, ICC 1069 for botrytis gray mold resistance, and ICCV 10 for high yield.

Pigeonpea. During 1989 and 1990,1 550 germplasm lines were received for evaluation. ICPLs 83024, 84023, and 87119, and ICP 8860 were used as sources of resistance to wilt and sterility mosaic. Three pigeonpea hybrid trials were conducted by ICRISAT. Four varieties developed by ICRISAT are noteworthy: ICPL 151 is suitable for the northwestern zone, ICPL 87 for the southern zone, and ICPH 8 and ICPL 87119 for the central zone.

Sorghum. During last 3 years about 14 300 seed samples were supplied by ICRISAT to the Indian NARS. ICRISAT is also supplying international diseases and pests nurseries for evaluation. Several varieties, e.g., SSV 84, SPV 913, and PVK 400, have been developed from materials supplied by ICRISAT. New sources of resistance to diseases (grain mold, rust, and downy mildew) and pests (stem borer, midge, and head bug) have been identified from the ICRISAT material, and are being utilized in the ICAR breeding program. SPV 351, SPV 475, SAR 1, and SPH 221 developed by ICRISAT performed well in all-India trials, and have been released.

Pearl millet. A large number of germplasm lines and breeding materials have been supplied to several collaborating institutions, which have benefitted considerably. Male-sterile lines 81A, 841A, 842A, 843A, 863A, and 84004A have been used for hybrid development. A number of germplasm lines were also used in breeding programs, e.g., 700651, P-7, and P-310 for downy mildew resistance. Through ICAR/ICRISAT collaborative efforts, four varieties (ICTP 8203, ICMV 155, ICMH 179, and ICMH 356) have been developed for cultivation.

Training programs

ICRISAT has trained 18 national scientists and 12 research fellows in sorghum. A groundnut virologist and three technicians from the Indian NARS were trained at ICRISAT in the ELISA technique for the detection of peanut stripe virus, which has recently become important in India. The training was found to be useful.

CLAN/ICRISAT should strengthen the training programs in pathology, entomology, and biotechnology in respect of groundnut, chickpea, pigeonpea, and pearl millet. Short-term (1 to 3 months) and long-term (1 year) training courses should be organized on screening methods for biotic and abiotic stresses, analytical chemical procedures, genetic engineering including RFLP, and crop modeling. These would be particularly useful to project staff in the national program.

Information exchange

Different ICAR institutes, agricultural universities, and libraries receive Annual Reports, Newsletters, and some of the other important ICRISAT publications. These have proved very useful, and should continue to be sent.

ICRISAT is supporting the participation of a few scientists in international workshops and symposia. Financial support for this purpose should be increased if possible, particularly for chickpea researchers.

Field visits have allowed national program scientists to observe new techniques and select breeding material and resistance sources. However, these visits last only for a day. Their duration should be extended to a full working week to make field visits meaningful. The frequency of field visits should also be increased, to allow scientists to select breeding materials at different stages of growth.

Equipment and infrastructure

CLAN/ICRISAT has contributed substantially to the infrastructure at several groundnut research stations. Seven centers, including the National Research Center for Groundnut at Junagadh, have been provided with three rainout shelters each, for a study of water use efficiency. In addition, drip irrigation systems have been provided at six locations.

Network coordination and Working Groups

The Working Group on botrytis gray mold of chickpea has been effective and should be continued. Several priority areas remain, where the national program would benefit from increased collaboration with CLAN/ICRISAT, possibly through Working Groups. These areas include development of male-sterile lines resistant to major insects and diseases (grain molds), diversification of cytoplasmic sources, and use of a molecular/genetic approach to crop improvement.

Future research priorities

Groundnut

- Exploitation of germplasm for breeding for resistance to diseases, pests, and drought; incorporation of desirable attributes from wild species;
- Integrated management of peanut stripe virus;
- Resistance to fungal infection and aflatoxin development.

Chickpea

- Resistance to aschochyta blight, fusarium wilt, and botrytis gray mold, and to pod borer;
- Development of varieties responsive to irrigation and other inputs.

Pigeonpea

- Resistance to diseases, pests, and drought;
- Intensified research on hybrid development;
- Integrated pest management;
- Biotechnology for the management of pests and diseases.

Sorghum

- Use of biotechnology for diversification of cytoplasmic male sterility and exploitation of apomixis;
- Development of dual-purpose varieties/hybrids for the postrainy season;
- Development of multicut forage hybrids.

Pearl millet

- Development of varieties/hybrids with resistance to downy mildew and drought;
- Population improvement through diversification of male-sterility sources.

CLAN in Myanmar

Thu Kha[1]

Introduction

The Union of Myanmar is an agricultural country. Of the total cropped area of 8-9 million ha, 70-80% (most of the lowland areas) is under rice. Sorghum is the most important cereal crop after rice. The area under sorghum was 190 000 ha in 1992, with an average yield of 0.67 t ha^{-1}. It is used for animal feed and as a food supplement in rice-deficient areas. Pearl millet is an economically minor crop. CLAN priority crops are usually grown in upland areas. One exception is chickpea, which is grown on both upland and lowland areas, the latter as a second crop after rice.

Owing to the variability in agroclimatic conditions, a number of legumes are grown. The most important of these is groundnut, which covers an area of 600 000 ha, with an average yield of 1 t ha^{-1}. It is used mainly for oil extraction. The pigeonpea area in 1992 was estimated at 116 000 ha, with an average yield of 0.6 t ha^{1}. This comparatively low yield is attributed to the use of low-input technology by local farmers and to intercropping with other crops such as groundnut, sesame, and cotton. Two potentially productive landraces have been identified, but both are of long duration. Most farmers prefer pigeonpea to other pulses because of its hardiness and ability to provide stable yields. The Myanma Agriculture Service (MAS) is trying to boost pigeonpea productivity and production, and upgrade the quality of the crop to earn more foreign exchange. Of the 70 000 t of pigeonpea produced in 1992, over 10 000 t were exported.

The chickpea area in 1992 was estimated at 200 000 ha, and production at 200 000 t. The crop is grown mainly as a relay or sequential crop with rice, and also following sesame, maize, or sorghum; it is sometimes grown as a sole crop. Chickpea has recently been mix-cropped with sunflower and wheat (where these two are major crops) due to increasing demand.

Production constraints

ICRISAT scientists working on groundnut, chickpea, pigeonpea, and sorghum have visited the Central Agriculture Research Institute to study the field problems of these crops.

Groundnut. Moisture stress is the single major yield-reducing factor. *Over* 40% of the groundnut in Myanmar is grown as a rainy-season crop in the dry region, where

1. Central Agricultural Research Institute, Yezin, Pyinmana, Myanmar.

the average rainfall is around 600 mm during the growing season. The crop generally suffers from long spells of drought lasting 3-4 weeks at a stretch, and from unreliable rainfall distribution.

Many diseases caused by fungi and viruses have been noticed. Of these, early and late leaf spots are the most important, and cause up to 60% yield loss. All Spanish type varieties cultivated in Myanmar are susceptible (to varying degrees) to leaf spot diseases. Among the insect pests, the leaf miner is very common in all groundnut-growing areas, and results in very low yield in some years. White grubs are a major pest, causing severe crop damage especially in Magway Division. Jassids have recently become a major pest, attacking all rainy-season groundnut. Yield losses due to jassids have not yet been estimated.

Pigeonpea. Short- and medium-duration lines have been introduced in Myanmar. The short-duration varieties distributed to farmers, however, are extremely susceptible to the *Maruca* pod borer, which is a serious production constraint. Local varieties, well adapted to Myanma conditions, on the other hand are of long duration.

Chickpea. Wilt disease reduces plant stand and yield. Among the insect pests the *Helicoverpa* pod borer is the most serious production constraint; it reduces yield and causes seed quality to deteriorate.

Sorghum. About 75% of the total sorghum area is sown to landraces which are relatively tall, long-duration (160-180 days), and highly photoperiod-sensitive, with a low harvest index. Slow adoption of high-yielding introduced varieties is a major constraint to production. Most sorghum growers are reluctant to accept exotic high-yielding varieties because of their low fodder yield, poor fodder storage quality, and vulnerability to bird damage.

Current research thrusts

Following a Myanmar-CLAN/ICRISAT Review and Planning Meeting in January 1992, a research work plan was developed for all CLAN priority crops, taking into consideration the major production constraints for each crop.

Research work is confined mainly to screening for desirable characteristics, followed by breeding work. Future research will continue along the same lines. The research thrust for each mandate crop is as follows:

Groundnut

- Short-duration material with limited seed dormancy (especially for the monsoon period in lower Myanmar);
- Drought-resistant material (120 days duration with limited seed dormancy);
- Lines suitable for acidic soils (in hilly and delta regions);
- Insect management, including resistance to leaf miner, jassids, thrips, and white grubs;

- Resistance to late leaf spot;
- Effective seed storage methods for humid areas.

Chickpea

- Short-duration desi and kabuli types resistant to wilt and root rot;
- *Helicoverpa* pod borer resistance;
- Management of irrigation and nutrients in heavy soils;
- Short-duration types with tolerance to acid soils and high temperatures.

Pigeonpea

- High-yielding short-, medium-, and long-duration varieties for different climatic zones;
- Large-seeded, high-yielding varieties for mixed-, inter-, and normal cropping systems;
- Insect pest management, including resistance to *Helicoverpa, Maruca,* and podfly;
- Resistance to wilt, sterility mosaic, and phytophthora blight.

Sorghum

- Dual-purpose varieties with medium maturity (100-110 days) and good fodder storage quality;
- Varieties suitable for intercropping with pigeonpea and groundnut;
- Varieties resistant to *Striga* and shoot fly.

Pearl millet

- Varieties with higher fodder yield, ratoonability, and better fodder quality;
- Varieties suitable for intercropping, with tolerance to lodging.

Impact of network activities

Germplasm and breeding materials. Large quantities of germplasm, including advanced lines and international trials, have been tested in Myanmar since 1975, mainly in collaboration with AGLN/CLAN. About 1 000 groundnut lines, 250 of pigeonpea, and over 500 chickpea lines have been tested. International trials of ICRISAT-supplied groundnut, pigeonpea, chickpea, and sorghum lines are conducted every year.

Scientists from ICRISAT's Genetic Resources Program, together with MAS staff, have collected germplasm of groundnut, chickpea, sorghum, pigeonpea, and pearl millet. A joint characterization and evaluation of 500 groundnut germplasm lines was undertaken in Myanmar in 1992, and led to the identification of a large number of high-yielding lines.

A number of ICRISAT lines of several crops have been released in Myanmar, or are at advanced stages of testing. ICRISAT groundnut lines JL 24 and Robut 33-1 were released as Sinpadetha 2 and Sinpadetha 3, respectively. Two new groundnut lines, ICGV 87160 and ICGS 76, are about to be released. Two foliar disease resistant lines, ICGV 86612 and ICGV 86699, are being used in the breeding program.

Two ICRISAT pigeonpea lines, ICPL 87 and ICPL151, are being grown by farmers on a limited scale, but have not yet been formally released due to their small seed size and susceptibility to diseases and pests. Two other pigeonpea varieties, ICP 7035 and ICPL 83024, were identified as being promising, and will be released soon.

Four chickpea varieties, ICCV 2, ICCV 5, ICCC 37, and ICCC 42, are being multiplied for release in the near future.

Three sorghum varieties (ICSVs 735, 758, and 804) are promising, and are likely to be released soon.

Human resource development. Limited access to ICRISAT training programs is a problem which needs attention. The number of 'slots' is inadequate; only six Myanma researchers have undergone training at ICRISAT Center (two each year during 1991-93). The age limit for trainees, presently 40 years, should be increased to 45 years so as to allow our more experienced technicians to benefit. Specific areas where training is needed are crop improvement, breeding, and resource management, including production agronomy.

Future plans

The exchange of visits by scientists should be increased in order to improve network coordination. CLAN should also invite policy makers from member countries to visit ICRISAT. This would help to improve coordination and governmental-level cooperation.

Annual review and planning meetings should be held in different member countries. Monitoring tours of the host country in conjunction with these meetings will allow the participants to view CLAN activities at first hand, and contribute more effectively to research planning.

Crop-wise demonstrations and experiments should be conducted as before. In addition, pilot production programs should be carried out for each newly-introduced promising variety, covering not less than 8 ha at each location.

The co-publication program should be extended to all CLAN priority crops. Literature updates for CLAN crops should be provided regularly.

In Myanmar, funding for CLAN activities is more effective when provided in kind rather than in cash. However, the expenditure incurred on on-farm demonstrations, experiments, and pilot production programs can be met by the host country.

Equipment/infrastructure. The Myanma national program would benefit greatly from a strengthening of infrastructure with CLAN/ICRISAT support. A larger proportion of the existing CLAN budget for each country should be used to procure equipment.

CLAN in Nepal

Dhruba N. Manandhar[1]

Introduction

The total cultivated area in Nepal is approximately 2.7 million ha. Rice, maize, and wheat, in that order, occupy the largest areas, followed by grain legumes which occupy 9.8% of the total cultivated area (1991/92 census). Because of the growing demand for vegetable ghee and roasted nuts, the area under groundnut cultivation is increasing. Sorghum is grown for fodder and grain in small pockets in the *terai* and foothills. Pearl millet production is not significant, but finger millet is grown widely in the hills.

Grain legumes play a significant role in Nepalese agriculture, both for their food value and for their ability to restore soil fertility. The rapid depletion of soil fertility due to increased cereal-based cropping has been a matter of great concern to scientists for the last several years. In this context winter legumes in particular (which share almost 77% of the area and account for 79% of the production of grain legumes) are becoming an essential component of the cropping system. Yields and cropped area of pulses have fallen marginally or remained static for the past five years. This trend clearly indicates the need to strengthen research activities to increase productivity.

Of the eight mandate crops of the Grain Legumes Research Program in Nepal, chickpea and pigeonpea are the most important. Chickpea research work was initiated in 1973, and pigeonpea research in 1977. Several international agencies such as the International Development Research Center (IDRC) and USAID have been supporting the program since 1985/1986. AGLN/ICRISAT support began in 1987, mainly for strengthening on-station and on-farm research, and seed production.

Current research thrusts

Among the CLAN priority crops, sufficient emphasis is given to research activities on chickpea, pigeonpea, and groundnut. Sorghum and pearl millet are not important in terms of research activities.

Chickpea. Research on varietal improvement has resulted in the recommendation of two local cultivars as Dhanush and Trishul in 1980. In 1987, two more varieties, Sita (ICCC 4) and Radha (*JG* 74), were released. Two other cultivars, Kalika (ICCL 82108) and Koseli (ICCC 32, kabuli type), were released in 1990. The selections of a

1. Nepal Agricultural Research Council (NARC), Khumaltar, P.O. Box 5459, Kathmandu, Nepal.

cross between Dhanush and K 850 (ICCXs 840508-36, 840508-38, 840508-40, and 840508-41) have performed well in all test locations and have shown tolerance to botrytis gray mold (BGM). They are likely to be released soon. Current research efforts are mainly focused on:

- Development of bold seed and kabuli types with good adaptability;
- Identification of high-yielding varieties resistant or tolerant to BGM, fusarium wilt, and pod borer;
- Selection of varieties suitable for relay planting, late planting, and inter- or mixed cropping conditions.

Pigeonpea. Varietal improvement work has led to the releases of two local cultivars in 1991: Bageshwari (PR 5147), a long-duration variety, and Rampur Rahar 1, a short- to medium-duration variety. Several promising short-duration lines (e.g., ICPL 146, ICPL 151, UPAS 120) have been selected and are in the process of release for general cultivation. Some genotypes such as ICPL 84072 and ICPL 87133 are resistant to wilt and sterility mosaic, and produced higher yields in farmers' fields than did local varieties. Current research efforts are mainly focused on:

- Development of high-yielding varieties with large seed size and different maturity periods (extra short-, short-, medium-, and long-duration);
- Identification of high-yielding varieties resistant or tolerant to sterility mosaic and pod borer;
- Selection of varieties suitable for both rainy and postrainy season planting.

Groundnut. Two varieties (B 4 and Janak) were released in 1980 and 1989, respectively. Some promising lines (e.g., ICCV 86010, ICGS 37, and Robut 33-1 for early maturity; AH 144 and ICGV 86546 for normal maturity) have been identified and are in advanced yield trials. Current research efforts (future work will continue along the same lines) are mainly focused on:

- Development of high-yielding varieties with large *seed* size;
- Identification of high-yielding varieties resistant or tolerant to bud necrosis disease and early leaf spot;
- Control of termites.

Sorghum. Research activities were initiated in 1990/91, and materials have been received from ICRISAT. The elite lines selected for advanced yield trials are ICSHs 88065, 89051, and 90002, SPH 468, and ICSV 112.

Exchange of germplasm and breeding materials

The exchange of genetic material through CLAN has been very useful in selecting and developing genotypes suitable for specific environments. Most breeding materials received from ICRISAT have performed well under Nepalese conditions, and the chickpea and pigeonpea varieties released are mostly the genotypes/lines received from ICRISAT. This collaboration has greatly strengthened the crop improvement activities of related commodity programs.

Information and technology exchange

This activity has been helpful in terms of sharing field problems and experiences. CLAN/ICRISAT provided support for the publication of Nepalese translations of Field Diagnosis of Pigeonpea and Chickpea Insects (ICRISAT Information Bulletin no. 26) and Field Diagnosis of Chickpea Diseases (ICRISAT Information Bulletin no. 28). Above all, the exchange of visits by scientists has been highly beneficial in improving the quality of Nepalese research programs; the frequency of such visits should be increased.

Human resource development

The training organized by CLAN at ICRISAT Center or in-country was found quite helpful to field-level research and extension workers. Such practical training courses should be continued. In addition, short-term refresher courses should be arranged in order to keep NARS scientists up-to-date in research techniques. ICRISAT should also consider initiating training programs leading to a formal degree, to help strengthen commodity research programs in the NARS.

Support to the National Program

The review and planning meetings, Working Group meetings, and workshops have been instrumental in identifying major research areas, developing or improving appropriate research methodologies, and establishing research priorities. The network should adequately address diagnostic services support.

Coordination of regional research

The current trend of increased levels of funding is clear evidence of the Nepal government's commitment to improving agriculture research management. The Nepal Agricultural Research Council (NARC), which was granted autonomy in May 1991, consists of 12 disciplinary divisions, 14 commodity programs, 4 regional stations, and 16 research stations. All research programs are managed by NARC. NARC, however, will develop and strengthen an operational relationship with the Department of Agriculture Development for on-farm research activities. Thus, coordination with NARC is sufficient for instituting any collaborative research programs in Nepal.

Future collaborative activities

- Identification of high-yielding varieties resistant or tolerant to major insect pests and diseases; development of an Integrated Pest Management (IPM) model;
- Development of appropriate low-cost technology to increase production; publication of a monograph in Nepali on Technology for Higher Production for distribution to extension workers and farmers;
- Exchange of germplasm and breeding materials; collection and evaluation of local germplasm;
- Collaborative breeding activities; development of high-yielding varieties suitable for the main cropping systems;
- Exchange of research scientists;
- Working Group and review and planning meetings;
- Training for research and extension workers;
- Field tours or visits to India by Nepalese scientists;
- A degree program for scientists working on specific problems;
- Improvement of diagnostic services facilities;
- Workshops to strengthen linkages between researchers and extension workers.

CLAN in Sri Lanka

N. Vignarajah[1]

Introduction

It is estimated that out of the approximately 6.4 million ha of land area of Sri Lanka, 3 million ha are devoted to agriculture. A significant and challenging feature is that this includes 1.1 million ha of rainfed alfisols in the dry zone. Of the CLAN priority crops, only groundnut can be considered a major crop in the country (10 500 ha out of 0.98 million ha under food crops). Sorghum, pigeonpea, and chickpea cultivation is negligible, and pearl millet is not cultivated in Sri Lanka.

Collaboration between Sri Lanka and ICRISAT through AGLN activities commenced in 1987. Activities under the Pigeonpea Production Phase I Project supported by the Asian Development Bank (ADB) commenced in 1990 and terminated in end 1992. Phase II of this project will commence towards the end of 1993. Collaborative work under the Asian Grain Legume On-farm Research (AGLOR) Project started in 1991.

Pigeonpea

The Department of Agriculture (DOA) Work Plan for 1993-97 places pigeonpea high on its prioritized list of research and development objectives. Research thrusts will be on crop improvement, agronomy, entomology, microbiology, and postharvest technologies.

Pigeonpea is among the crops best suited to the 1.1 million ha of rainfed alfisols in the dry zone. Efforts to introduce its cultivation in the 1930s and 1970s failed due to the lack of appropriate varieties, heavy pod borer damage, lack of processing equipment, and insufficient knowledge of *dhal* processing. Lentils (*Lens culinaris)* constitute the major *dhal* component in the Sri Lankan diet. The entire requirement is imported (55 000 t in 1991 at a cost of US$ 28 million). Recognizing that pigeonpea is the most acceptable substitute for lentils, Phase I of the ADB-ICRISAT-Sri Lanka Pigeonpea Production Project was initiated. Under this Project, varieties and advanced generation segregating populations, 697 in all, were introduced from ICRISAT and the Indian national program. After intensive screening and adaptability studies, three varieties, ICPLs 2, 87, 84045, were identified for their high yield

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potential, wide adaptability, and good ratoonability. These varieties are now being cultivated by farmers. The importance of pigeonpea as a lentil substitute is now recognized in government policy, which is to progressively reduce imports of lentils.

The emphasis in entomology research is on population dynamics of the pod borer complex (particularly *Maruca testulalis),* integrated pest management, screening of lines for pod borer tolerance, pest dynamics in intercropping systems, and chemical control of insect pests.

Two types of *dhal* processing units were fabricated after modifications in designs of units used in India. A cast iron processor, similar to the Indian *chakki,* with a capacity of 15 kg hr^{-1} and costing US$ 35, was developed for domestic use. Medium scale processors (designed by the Central Food Technology Research Institute) of capacity 80 kg hr^{1} (motor or two wheel power-tiller driven) were also developed. These cost US$ 805 and 540, respectively. Modified designs are being developed for these units based on field testing. Some locally available rice and mungbean *dhal* milling units are being modified to process pigeonpea *dhal.*

Studies are in progress on the economics of pigeonpea cultivation in comparison with other crops, and on farmer acceptability and marketing.

The net impact at the farmer level was that approximately 150 ha were cultivated in 1991, and 265 ha in 1992. It is anticipated that over 400 ha will be cultivated in 1993.

Groundnut

The total area under groundnut has stabilized at around 10 000 ha (mostly rainfed) and the annual production at around 10 000 t, during the last 10 years. Groundnut is consumed as a roasted snack rather than being processed for oil, which now comes mainly from coconut. However, with the area under coconut dwindling sharply (since coconut plantations are being converted to housing), groundnut is likely to play a positive role as an oilseed crop. Accordingly, it now receives more priority than earlier, in the DOA Research Division Work Plan.

On-farm trials include testing of varieties from ICRISAT, and studies on seed treatment, control of foliar diseases, optimum seed rates, fertilizer dosages, and soil management. The most significant outcome of these investigations is that the varieties ICGS 11 and HYQ (CG) 49 (confectionery type)—both from ICRISAT—and 1080/2 (mutant)—developed in Sri Lanka—have performed extraordinarily well. These are now being extensively tested, and may be released officially as recommended varieties.

Impact of network activities

The germplasm provided has had the greatest impact, as is evident in the pigeonpea and groundnut programs.

DOA officers have been participating mainly in the 6-month in-service programs. These have been useful. It is suggested that ICRISAT develop more post-graduate programs leading to an MSc/PhD, in collaboration with the local university and funding agencies. The monitoring tours by ICRISAT scientists to Sri Lanka have been useful. However, it is suggested that different scientists visit Sri Lanka with regard to a particular commodity or discipline, so that local scientists can interact with scientists with different philosophies and in different disciplines.

ICRISAT publications have been well received by DOA and other institutions. The co-publication of the Pigeonpea and Chickpea Insect Identification Handbook (Information Bulletin no. 26) in local languages (Sinhala and Tamil) is a commendable venture.

CLAN in the People's Republic of China

Hu Jiapeng[1]

Introduction

More than 400 crops are grown in the People's Republic of China, over a total area of about 100 million ha. Rice, wheat, and maize account for most of this area, but other crops, including some within the CLAN mandate, are also important.

Sorghum. China is a major producer. By the end of the 1970s, the area under sorghum reached 3 million ha; annual production was over 7.5 million t, with yields of 2.4 t ha^{-1}. Between 1985 and 1989, the cropped area fell by 35%, to 1.7 million ha. This was compensated to some extent by increased productivity (3.5 t ha^{-1}), but average production declined to 5.4 million t per year. Current area and production have yet to regain their earlier high levels.

Sorghum production is affected by market factors, the varieties and management practices in use, and by export policy. Production is expected to increase due to the new open market policies now in operation. However, improved varieties and management/research methods are required, and we hope to benefit from collaborative research with CLAN.

Pearl millet. Since the 1960s, the Chinese Academy of Agricultural Sciences (CAAS) has introduced some varieties from India and a few African countries. Some of these varieties are cultivated on a small scale in parts of Henan and Shanxi provinces.

Groundnut. This crop is grown throughout the country, but three regions (northern, central, and southern China) account for 95% of the production. The northern region comprising Shandong, Henan, Hebei, Liaoning, Jiangsu, and Anhui provinces is the most important, and includes 60% of the country's total groundnut area. The southern region includes Guangdong, Guangxi, and Fujian provinces, and accounts for 21% of the groundnut area. The central region, which includes Sichuan, Hubei, Hunan, Jiangxi, and Zhejiang provinces, accounts for 12% of the total groundnut area.

There have been substantial increases in area, yield, and production from the 1980s onwards. Between 1980 and 1984, the area under groundnut averaged 2.37 million ha, and annual production 4.02 million t, with yields of 1.7 t ha^{-1}. These represented increases of 30% in area, 39% in yield, and 81% in production over 1970s levels. These

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increases continued between 1985 and 1989: area increased by 31% to 3.1 million ha, production by 48% to 5.95 million t, and yields by 13% to 1.9 t ha^{-1}.

Chickpea. Chickpea is grown on about 50 000 ha; about 75 000 t are produced each year. On-farm yields are 1.5-2 t ha^{-1}, but substantially higher yields have been achieved on experimental plots. A desi type local variety in Qinghai yielded 4.785 t ha^{-1} of dry seed, and a kabuli variety from ICARDA yielded over 4.5 t ha^{-1} of seed in a large area in Gansu province.

Pigeonpea. Pigeonpea is a minor legume in China. We estimate that it covers about 1 200 ha (total production about 1 500 t). The yields, which range from 1.1 to 2.3 t ha^{-1}, compare favorably with the world average.

Research thrusts

Sorghum. Substantial work has been done on genetic resources. So far more than 16 000 accessions have been collected, of which more than 10 000 have been characterized, and are being maintained at low temperature for long-term storage. Protein quality has been analyzed for over 8 000 accessions. Seed protein content averaged 11.26%; 64 accessions had protein content >15%.

Considerable work has been done on the identification of tolerance/resistance to various stress factors, e.g., drought, low temperature, salinity, and poor soil. Some accessions have been found to be promising against major diseases and pests. Three new lines with multiple disease resistance, high yield, and acceptable quality have been bred.

Pearl millet. Relatively little research is being done on this crop. One hundred and three accessions from ICRISAT, USA, Yemen, and several African countries have been characterized, and are being maintained at low temperature for long-term storage.

More than 1 000 accessions were received from ICRISAT, but most of these were found unsuitable for the major pearl millet-growing areas in China. Jufeng, a local variety of unknown origin, has shown yields of over 7.5 t ha^{-1}, and is being studied in greater detail.

Groundnut. Research on this crop has resulted in the development of several varieties, with help from ICRISAT. Over 4 350 accessions have been collected, most of which are being maintained at low temperature for long-term storage. About 4 000 accessions have been evaluated for resistance to early and late leaf spots, rrst, and nematode diseases. Some accessions were found to be highly resistant. However, none of 1 000 accessions tested showed resistance to peanut stripe virus (PStV), although some showed low virus seed transmission.

More than 100 accessions of 24 wild *Arachis* species were introduced from USA, Argentina, and ICRISAT in the 1980s (China has no native wild species), and are maintained in nurseries at Wuhan and Nanning. These have been studied for resistance to leaf spots, rust, PStV, and bacterial wilt; research on interspecific hybrids is now in progress.

A number of research centers in China, including the Oil Crops Research Institute, CAAS, and others in several provinces, have established breeding programs. As a result, over 30 improved varieties have been released so far. Breeding efforts were made on many parameters, including earliness, yield, seed size, and resistance to rust and bacterial wilt. There has also been some progress in research on the inheritance of these two major diseases.

Chickpea. Four hundred and five accessions, almost all of them indigenous, have been collected. There is also some research on adaptation. Selections made on the basis of trials have yielded two good varieties (FLIP 81-71C and FLIP 81-40W) which are now being promoted, especially for cultivation in northern China.

Pigeonpea. Research is limited, being concentrated on germplasm collection. Breeding programs have been instituted in order to develop suitable varieties for release; some trials and adaptation studies are in progress.

Network activities

Collaboration between CAAS and ICRISAT was formalized with the signing of a Memorandum of Understanding in May 1988. Collaborative research began after the first work plan was signed in Sep 1989. The collaborative research activities in the past 5 years include training, visits by scientists, workshops, germplasm and breeding material exchange, participation of Chinese scientists in Working Groups, and information exchange.

Groundnut virus research. The major effort has been on PStV. Of the 447 genotypes which were screened during 1991-93, two showed seed transmission levels of <1%. Wild groundnut species showed promise. Six accessions of five *Arachis* species—*Arachis duranensis* (468319 and 30073), *A. paraguanensis* (31187),A. *glabrata* (PI 262801), *Arachis* sp 38900, and *Arachis* sp 9835—appeared resistant, and two others showed PStV incidence of <10%.

Studies were also conducted on aphid resistance as a means of PStV control. Plastic film mulch, particularly when used early in the growing season, was successful as an aphid repellent during field trials in 1991/92.

Groundnut bacterial wilt. Multilocational evaluation to identify sources of resistance to this important disease is continuing. Preliminary selections have been made on the basis of tests of over 500 lines at three locations. We are also studying the mechanisms and genetics of inheritance, seed transmission, and various other aspects of the disease.

Chickpea research. Four varieties of Asian origin have been introduced, and are being tested at experimental stations as a preliminary to release. These are expected to be suitable for spring sowing in northwestern China. Adaptation trials have shown that large-seeded kabuli varieties yield less than local (desi) varieties do, particularly in rainfed conditions. Kabuli types with medium-sized seeds performed as well or better than local controls; improvement of drought resistance in these genotypes would be greatly beneficial.

The cultivation of two proven varieties, FLIP 81-71C and FLIP 81-40W, is being extended to parts of Gansu, Shanxi, and Qinghai provinces. The chickpea trials have been enlarged, with material (for both breeding work and crop physiology studies) provided by ICRISAT and ICARDA. Two hundred and thirty three lines were recently received from ICRISAT.

Pigeonpea research. Collection expeditions, with CLAN/ICRISAT help, were continued. Twenty-one local varieties were collected in 1991, and this work is continuing. Six varieties from ICRISAT are being tested this season.

Publications. Three ICRISAT information bulletins: Pigeonpea and Chickpea Insect Identification Handbook (IB 26), Field Diagnosis of Chickpea Diseases and Their Control (IB 28), and Field Diagnosis of Groundnut Diseases (IB 36) have been translated into Chinese and co-published jointly by ICRISAT and the Chinese national program. Other relevant titles (e.g., Peanut Stripe Virus, IB 38) could also be considered for such co-publication.

Future collaborative research

Future collaborative research will be on similar lines as existing programs. Help from ICRISAT/CLAN is needed particularly in the dissemination of new technologies in key areas. These include:

- Groundnut viruses (breeding for resistance, virus control by synthetic means, disease mechanisms);
- Groundnut bacterial wilt (germplasm screening, breeding for resistance, seed transmission studies, genetics of resistance);
- Chickpea trials to select suitable varieties; it is important to increase the scope of varietal testing, particularly by using local varieties from northwestern China, and eventually substantially increase the area under chickpea.

Adaptive research and information exchange (training, scientists' visits, co-publications, and Chinese participation in Working Groups) should increase. We also hope that CLAN will develop strong research linkages on cereals, particularly sorghum and pearl millet. Additional funding support is required for specific research topics, e.g., root-knot nematode studies in groundnut.

CLAN in Indonesia

Sumarno[1]

Introduction

The major crops in Indonesia are rice, maize, and soybean. Accordingly, research on the four CLAN priority crops grown in Indonesia (sorghum, groundnut, pearl millet, and pigeonpea) *is* considered to be less of a priority.

Although groundnut is a cash crop, the cultivated area has been stagnant at around 500 000 ha, scattered over all the islands. Productivity on farmers' fields is low, varying from 0.5 to 1.2 t ha^{-1} of dry pods.

The Javanese are believed to have subsisted on millets until the fourteenth century, but later rice, maize, and root crops replaced millets as staple foods. Sorghum was a traditional food until the early 1960s, but was then replaced by rice. It is now grown on less than 20 000 ha, mainly in drought-prone areas during the dry season. Sorghum is used as a food grain (through less widely than before), and on a very limited scale in animal feeds. Pigeonpea is a minor crop, planted in a mixture with other annual crops in drylands. No data on harvested area is available, partly because there are no areas devoted exclusively to pigeonpea.

The present government policy is to diversify crop production, increase farmers' incomes, become self-sufficient in food production, and improve nutrition. The production of groundnut will be increased to reduce imports (currently 100 000 t per year). Sorghum production is also being increased, to provide material for feed industries. As for pearl millet and pigeonpea, no significant change in policy is expected. Research emphasis, therefore, will be primarily on groundnut and sorghum.

Research activities

Groundnut. Breeding and crop improvement for groundnut is aimed at developing confectionery types suitable for roasting or frying whole seed. High yield (over 2 t ha^{-1} dry pod), early maturity (around 90 days), tolerance to leaf diseases, and resistance to bacterial wilt are also required. Breeding for virus resistance was found to be difficult, due to the unavailability of sources of resistance.

High-yielding improved varieties (up to 2.5 t ha^{-1}) are available, but are not generally accepted because they are unsuitable (in terms of seed size and seed quality) for confectionery processing.

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Crop production research is aimed at finding suitable production techniques for drylands, irrigated areas, and acid soil areas. Research on disease control is mainly targeted at rust and leaf spots. Future research will focus on identifying production techniques suitable for specific locations, and will consider both agroclimatic and socioeconomic factors.

Sorghum. The objectives of sorghum research are to develop high-yielding, short-duration (90 days) varieties with drought tolerance, low tannin content, and white grain color. Breeding work on forage and sweet stalk varieties is also carried out, but with less intensity. Agronomy research includes the development of cultural practices for drought-prone areas, using optimum dosages of fertilizers.

Pigeonpea and pearl millet. Research on these crops is limited mainly to production techniques for dry-season intercropping. In addition, varietal testing and pest management trials on pigeonpea are being conducted at research stations. We are also studying the possibility of introducing pigeonpea as a component of dryland cropping systems.

Impact of network activities

Network activities should be intensified towards a more active and free exchange of information, germplasm, and breeding material. The NARS should not function as testing sites for international agricultural research centers (IARCs), for the purpose of accomplishing IARC objectives; IARCs should, on the contrary, provide NARS with genotypes likely to be suitable for specific regions. Varieties from national programs should be included in international trials.

Exchange of germplasm and breeding materials. Germplasm from various countries should be collected by ICRISAT, in cooperation with the NARS, screened, and distributed to the countries which require such material. These lines/varieties should be evaluated by NARS scientists, who could then select promising lines for inclusion in yield trials. Germplasm exchange among NARS (coordinated by ICRISAT) should be intensified, especially of materials containing 'economic genes' (genes for resistance to diseases, pests, etc.).

Information and technology exchange. ICRISAT publications are extremely useful to national researchers. This activity should be intensified; we are particularly interested in receiving current literature and technology updates on pest forecasting and epidemiology, water management for drought-prone areas, and soil nutrient management. Workshops and Working Group meetings on specific research topics should be held more frequently. International workshops should be organized by CLAN/ICRISAT, and conducted alternately at ICRISAT Center and at a NARS location.

Human resource development. Training programs at ICRISAT have allowed national program scientists to broaden their knowledge and acquire specialized new skills. However, language remains a problem. Most participants in such programs have only a limited knowledge of English and would therefore prefer to be trained in groups (even though this would permit less individual contact between trainee and supervisor/advisor), with a combination of lectures, handouts, and field work.

More short training courses (lasting 2 weeks to 3 months) are required in some specific areas (breeding for resistance to specific pests and diseases, insect population forecasting, etc). In-country training courses could be held for problems or constraints that are limited to one country.

Support to the National Program

The review meetings where ICRISAT scientists interact with those from the Indonesian national program should encourage the latter to put forward their views and findings more effectively and cogently. Research objectives and methodologies should be formulated on the basis of farmers' needs and the likely constraints to technology adoption. The model developed by ICRISAT has proved effective in this respect, and should continue to be used.

The on-farm adaptive research project (AGLOR) has been found to be effective in identifying suitable production techniques for groundnut. In 1993, the program was intensified, with larger technology-evaluation plots (about 25 ha at two sites for each package of technologies). This has indicated the possibility of improving groundnut yields in farmers' fields from around 1 t ha^{-1} at present to 1.8 t ha^{*1} of dry pods.

NARS would benefit greatly if research equipment not available in the respective countries is provided by CLAN/ICRISAT, particularly equipment which has been developed by ICRISAT.

'Research models' for each major research area should be formulated by ICRISAT and introduced to the NARS.

Coordination of regional research

Working Groups are most effective when all group members are interested in a subject. Since this does not usually happen, complementary (bilateral) research work among members should be encouraged. For research on some constraints, the network should consider forming Working Groups consisting of ICRISAT scientist(s) plus several NARS scientists from one country only.

Future network activities

Future collaborative activities of the network should include research on the following:

- Factors limiting groundnut productivity;
- Aflatoxin prevention;
- Techniques to produce virus-free groundnut seed.

CLAN in the Philippines

Ester L. Lopez[1]

Introduction

Cereals and legumes are important crops in the Philippines. The main cereal crops are rice and maize, which are the staple foods of Filipinos. Sorghum is considered a minor crop. Among the leguminous crops grown in the country, groundnut, mungbean, and soybean are important. Pigeonpea and chickpea cultivation is minimal.

The resources allocated by the national program to these crops reflect their relative importance. In terms of commodity budget allocation in 1991, rice research and development (R and D) accounted for 18% of the total, followed by coconut (14%), and legumes (13%). Of the total budget for legumes, groundnut R and D cornered more than 25%, amounting to about 4 million pesos (US$ 160 000).

Groundnut is the most important among the CLAN priority crops in the Philippines, for the following reasons: it has varied uses and could provide valuable raw material for many processes that could be a basis for small-scale manufacturing enterprises; it is an excellent cash crop that fits well in rice- and maize-based farming systems; and it is a good source of vegetable protein.

Other CLAN crops such as pigeonpea and sorghum are currently restricted to specific areas. The potential for expanding their uses and thereby increasing demand (and production) remains untapped.

Current research thrusts

The defined national objective for legumes, particularly for groundnut, as articulated in the National Action Program for legumes (1993-2000) is to attain self-sufficiency—groundnut imports have increased steadily during the past 5 years. The specific objective is to improve yields from a national average of 0.85 t ha^{-1} to 1.5 t ha^{-1} by the year 2000, through the development and/or adoption of high-yielding, drought- and pest-resistant varieties, and improved production technologies. Postharvest facilities and operations will also be given attention. Another strategy is to expand into non-conventional production areas, e.g., slightly rolling upland areas, or between widely-spaced, fully-grown coconut trees. To effectively utilize these areas, appropriate varieties with special characteristics (shade tolerance, acid tolerance) will

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have to be identified or developed. Another thrust is to diversify product utilization in order to create higher demand and enhance product value. R and D activities to support this objective are focused on the development and improvement of groundnut products and by-products.

For sorghum and pigeonpea, a deeper study of the production, marketing, and utilization practices will be conducted in areas where these crops are currently grown or utilized. This will give us an idea of the possible interventions that can be made to fully exploit their potential and expand their uses.

Impact of network activities

Collaboration between ICRISAT and the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) dates back to 1975, but it was only after the establishment of AGLN in 1986 that collaborative research activities between the Philippines and ICRISAT were initiated. These activities were intensified from 1990, after the signing of a work plan. Since then, the following activities have contributed significantly to the Philippine Legumes R and D program:

Exchange of gertnplasm and breeding materials. A total of 120 groundnut accessions, 31 pigeonpea varieties/lines, and 30 chickpea varieties/lines were received from ICRISAT/CLAN. These breeding materials were instrumental in developing cultivars for specific cropping systems and seasons. The groundnut materials were used to breed high-yielding varieties resistant to rust, leaf spots, *Sclerotium* wilt, *Aspergillus* sp, and peanut stripe virus; and tolerant to drought, shade, and acid soils. A significant benefit from network collaboration is the Indian groundnut variety JL 24, which performed well during cooperative trials in the Philippines. JL 24 is high-yielding, large-seeded, resistant to leafhopper, highly resistant to defoliators, and moderately resistant to *A. flavus* invasion. Now a Philippine Seed Board variety, it is being seed-produced in preparation for the launching of a pilot production project in Isabela province in Oct 1993.

Pigeonpea materials sourced through CLAN were used to breed early-maturing, pod borer resistant varieties at the Institute of Plant Breeding. In addition, chickpea and pigeonpea germplasm are evaluated at several locations in the Southern Tagalog, Ilocos Norte, and Cagayan regions.

A new sorghum variety (IES Sur 4) was approved by the Philippine Seed Board in Aug 1993. This variety was selected from sorghum populations provided by ICRISAT.

PCARRD has encountered some problems with the air-shipment of seeds from ICRISAT to the Philippines. Extensive formalities need to be completed, and the process is both expensive and time consuming. The mailing system has considerably improved, and though it takes longer, is now preferred. The materials can be sent directly to the institution concerned, but PCARRD should be informed of all such exchanges in order to effectively monitor the utilization of these materials.

Information and technology exchange. PCARRD regularly receives information/publications on technologies developed by ICRISAT. These are passed on to the members of the National Agriculture Resources Research and Development Network (NARRDN). The trainings/workshops/monitoring tours organized and sponsored by CLAN/ICRISAT enable our researchers to obtain new ideas and to exchange information of mutual interest with their counterparts. However, Filipino participation in meetings and workshops is hampered by budgetary constraints on travel expenditure.

Human resource development. For the past several years, ICRISAT/CLAN has trained many Filipino scientists in the areas of breeding and crop production. Four researchers were trained on groundnut breeding and agronomy, and two in the agronomy of pigeonpea. A shift in emphasis to training on crop utilization and processing will help Filipino scientists push the program on CLAN priority crops.

Research infrastructure

One of the basic problems of doing research in the Philippines is the lack of agroclimatic data. Not all experimental stations are capable of providing data on rainfall, temperature, and solar radiation, and consequently, analyses of experimental results are often incomplete or insufficiently rigorous. Perhaps CLAN could contribute to the acquisition or upgrading of equipment at stations where CLAN projects are being undertaken.

Network coordination

The existing system of coordination between ICRISAT/CLAN and PCARRD is widely appreciated. Both institutions have a well-developed network of research stations which facilitate collaborative activities. The various Working Groups formed by CLAN are very effective in sharing research responsibilities and addressing regional problems.

The Philippines would like to continue its involvement in these Working Groups, and also participate in other areas (aflatoxin, leaf spot and rust, seed production, and low pH studies).

Future collaborative activities

CLAN is considered a major partner in the development of R and D programs for groundnut, pigeonpea, chickpea, and sorghum in the Philippines. During 1991/92, CLAN provided support to seven projects/studies on groundnut modeling, on-farm trials of improved groundnut, chickpea, and pigeonpea varieties, and pest management trials on leaf spot and rust. Some of these studies are continuing. During

1993/94, CLAN support will extend to five development projects focused on groundnut modeling, on-farm trials and pilot testing. The Philippines, in collaboration with CLAN/ICRISAT, will also explore the possibilities of developing or improving products and by-products from CLAN priority crops. We would expect CLAN to continue supporting the research network in several ways:

- As a source of germplasm and improved varieties (with high yields and tolerance to pests, diseases, drought, shade, and acid soils);
- As an organizer and supporter of training courses on CLAN priority crops (particularly on biotechnology, seed technology, food processing, and postharvest operations);
- As a source of information and technologies to enhance research;
- As a contributor to the upgrading of facilities and equipment (soil and weather instruments, and laboratory facilities for biotechnology) at national agricultural research stations.

CLAN in Thailand

Sophon Sinthuprama[1]

Introduction

Rice, maize, and cassava together occupy much of the cultivated area in Thailand. However, groundnut, sorghum, pearl millet, and pigeonpea are also considered to be important. Groundnut is important as a food legume and as an oil crop, and provides both cash income and dietary protein to rural populations throughout the country. The current annual production is about 130 000 t from an area of about 125 000 ha. The average yield is low (1.2 t ha^{-1}) due to weeds, diseases, insects, drought, and improper management. In general, groundnut is grown on upland areas during the rainy season, and as a post-rice crop in irrigated areas during the dry season. The main production areas are in northern and northeastern Thailand. Over 90% of the production is for consumption within the country; the rest is exported.

Sorghum is an important cereal crop; about 250 000 t of grain are produced each year from 197 000 ha. Since 1990, the government has been promoting livestock production (especially poultry) and the production of feed (using maize, sorghum, and soybean). Consequently, demand for sorghum is gradually increasing. Grain sorghum, in addition to local feed industry uses and export, is also replacing cassava, which suffers from marketing problems due to overproduction.

Pigeonpea is not produced as a crop, but is grown in backyards in northern Thailand (green pods are eaten as a vegetable). The plant is also used to produce lac. Recently, a private company has shown interest in developing pigeonpea production for export, and a trial production program was initiated in the northern and northeastern regions in 1992.

Pearl millet is not a major crop. However, private companies are interested in increasing production for export. The crop has potential as a forage crop, particularly in northeastern Thailand, where beef production and dairy farming are rapidly increasing.

Research activities

Groundnut. Research on groundnut is conducted by the various divisions of the Department of Agriculture (DOA). The major research center is the Khon Kaen Field Crops Research Center (KKFCRC). The universities (Prince of Songkhla, Chiang Mai, Khon Kaen, and Kasetsart) also have small research programs on groundnut.

1. Field Crops Research Institute, Department of Agriculture, Chatuchak, Bangkhen, Bangkok 10900, Thailand.

Scientists from these institutes formed the Thailand Coordinated Peanut Improvement Working Group in 1982. Collaboration with ICRISAT started in 1984, and with AGLN in 1986.

Sorghum and pearl millet. Research on sorghum and pearl millet is the responsibility of the Suphan Buri Field Crops Research Center (SBFCRC), which has been collaborating with ICRISAT for more than 10 years. In collaboration with ICRISAT, we have been conducting cooperative trials and testing elite materials.

Pigeonpea. Pigeonpea research is conducted by the DOA on a far more modest scale than for groundnut. Programs were initiated in collaboration with the Australian Centre for International Agricultural Research (ACIAR) and ICRISAT in 1983 (and with AGLN in 1986) to study the crop's adaptability to Thai conditions and identify the major production constraints. ACIAR provided research funds and some breeding materials; AGLN/ICRISAT provided both expertise and seeds for a number of trials. ACIAR research funding was terminated in 1987, but the research program was revived in 1990 with AGLN/ICRISAT support. Most pigeonpea research is conducted at the KKFCRC.

Future research plans

The national groundnut research program will focus mainly on breeding varieties with high yield, early maturity, resistances to rust and leaf spots, and large seeds (suitable for boiling). Evaluation and testing of genotypes will continue.

Pigeonpea research activities will aim at varietal improvement and crop management for biomass production (green manuring), and grain types adapted to the conditions in northeastern Thailand.

Sorghum research will focus on breeding for short duration; adaptation to different agroecological systems; resistance to diseases and insects, specifically to head molds and shootfly; dual-purpose sorghums with some degree of tolerance to stress conditions; and resistance or tolerance to heat and drought stress. Work on the latter two objectives is minimal at present, but will be intensified in collaboration with ICRISAT. Nurseries and trials for CLAN crops will continue.

Usefulness of network activities

Exchange of germplasm and breeding materials. ICRISAT/CLAN is the main source of materials for breeding and crop improvement programs in Thailand. Groundnut germplasm and breeding materials have been provided since 1991 for collaborative trials; sorghum trials (for crop improvement) have been conducted since 1975. Suphan Buri 1 (a dual-purpose variety) was developed using ICRISAT-supplied material, and released for cultivation.

In pearl millet and pigeonpea also, breeding materials provided by ICRISAT are evaluated by the national program, and adapted high-yielding lines selected. Exchange of materials is constrained by budgetary limitations in Thailand. We would prefer to receive a limited number of advanced lines rather than early-generation material. Due to limitations on staff and resources, large-scale international trials are difficult to handle. Additional funding would be required, especially for trials (e.g., ISVHAT) that continue over several years.

Information and technology exchange. ICRISAT has been our major source of information on CLAN crops. The publications we receive are very useful, as are meetings and workshops. Meetings should be arranged every year either in Thailand or preferably, at ICRISAT Center.

Human resource development. Many scientists from various institutes in Thailand have been trained with assistance from ICRISAT. More than half of them underwent the 6-month in-service program on crop improvement, crop production, agronomy, and resource management at ICRISAT Center. Our scientists are interested in attending 2 to 4-week special training courses on biotechnology methods and screening techniques. Others want to visit ICRISAT Center to refresh their knowledge and learn the latest crop improvement techniques.

Support to the national program

According to the Thailand-CLAN/ICRISAT Work Plan 1993/94, ICRISAT would provide funds to evaluate a set of groundnut and sorghum germplasm lines. Recently, the Country Coordinator arranged a meeting to organize a coordinated program for sorghum and pearl millet. Scientists from the Department of Livestock Production, Khon Kaen University, Kasetsart University, and FCRI participated, and agreed to initiate collaborative research projects. Additional support from the network is needed for some areas, where national program budgets are insufficient.

CLAN in Vietnam

Ngo The Dan[1] and Nguyen Xuan Hong[2]

Introduction

Vietnam has a total arable area of about 5 million ha, 80% of which is occupied by rice. Groundnut is a major export commodity, and the most important among the CLAN priority crops grown in the country. It covers the largest area of any legume, and the fifth largest (after rice, maize, sweet potato, and cassava) of any crop. Groundnut is grown on over 200 000 ha; average yields are 1 t ha^{-1}. Sorghum is a minor crop, grown in scattered areas in some mountain provinces. Pigeonpea has shown high yield potentials in the central coastal region, but has yet to be introduced in suitable areas elsewhere in Vietnam. Chickpea is a new crop, and is currently being tested in northern Vietnam for its adaptability.

Groundnut

Groundnut research is being given high priority, especially after ICRISAT and Vietnam signed a Memorandum of Understanding in 1989. In collaboration with AGLN (now CLAN), an Asian Grain Legumes On-farm Research (AGLOR) project began in early 1991 (and is continuing) to help Vietnam tackle the major constraints and thereby improve groundnut production. In 1991, Vietnamese and ICRISAT scientists jointly conducted diagnostic surveys in the major groundnut areas. These surveys identified, for the first time, the key constraints to groundnut production in Vietnam; components of promising technologies are now being tested on farmers' fields.

Several promising technologies have been identified through AGLOR activities, and will be recommended for rapid application in the major groundnut-growing areas in Vietnam. They include lime application, rhizobium inoculation, and need-based sprays against foliar diseases and insects. High priority will be given to breeding high-yielding varieties with a suitable maturity period and resistance to major insect pests and diseases, and to the implementation of integrated pest management strategies. Research on bacterial wilt of groundnut will be strengthened, and research on aflat oxin contamination will be initiated.

1. Ministry of Agriculture and Food Industry, Hanoi, Vietnam.
2. National Institute for Agricultural Sciences, D-7, Phuong Mai, Dongda, Hanoi, Vietnam.

Pigeonpea

Pigeonpea research has focused largely on the testing of ICRISAT-developed short-duration genotypes for adaptability to different ecological conditions. This crop has shown high yield potentials in the central coastal areas in the dry season. Studies are in progress on the possibility of intercropping pigeonpea with other crops such as cotton, mulberry, tea, and fruits. However, pigeonpea suffers from severe attacks by pod borers (*Helicoverpa armigera* and *Maruca* sp) and the pod fly *(Melanagromyza obtusa).* Utilization and marketing are additional problems, on which research will be initiated in the future. Research on the major insect pests and diseases, and appropriate control measures, will continue.

Sorghum

Sorghum is grown in some mountain provinces where severe, lengthy droughts prevent rice and maize from being successsfully grown. In recent years, ICRISAT sorghum lines/varieties have been tested in Vietnam for their yield potential, resistance to major insect pests and diseases, and tolerance to local stress environments. ICRISAT genotypes have shown high yield potentials, but most of them are highly susceptible to fusarium grain mold. The identification of resistant varieties will therefore be given high priority.

Impact of network activities

Germplasm and breeding material. Vietnam has benefitted from CLAN activities in many ways. Germplasm, breeding material, and trials provided by ICRISAT have been particularly useful. ICRISAT's groundnut germplasm is a major source of drought tolerance and resistance to diseases (especially foliar diseases and bacterial wilt) and insect pests. ICRISAT genotypes are now being widely used in Vietnamese breeding programs for varietal improvement. Several ICRISAT groundnut lines/varieties have been found to be promising, e.g., ICGS (E) 56 is suitable for intercropping with cassava and maize in the southeastern (coastal) and southern regions. More recently, the Institute of Agricultural Sciences for South Vietnam has started a collaborative program with ICRISAT's Genetic Resources Program for the evaluation of groundnut germplasm in Vietnam. We hope that this collaboration, which will further improve Vietnamese access to ICRISAT germplasm, will also benefit ICRISAT.

Information and technology exchange. CLAN activities have greatly improved the access of Vietnamese scientists to information on research and development of CLAN crops, especially groundnut. ICRISAT publications play an important role in the development of new research approaches and in technology transfer to farmers. Interaction between ICRISAT and Vietnamese scientists has been significantly improved by the exchange of visits. This in turn has helped Vietnamese scientists to improve their knowledge and research skills. The seminars given by ICRISAT scientists (during their visits to Vietnam) on specific problems of interest to Vietnamese scientists were extremely useful, and should be further promoted.

We request CLAN's support in developing more bilateral contacts for specific research objectives. For example, seminars and/or exchange of visits with Indonesian or Chinese scientists on groundnut bacterial wilt (or training courses on the subject, to be held in China) would be valuable.

Human resource development. CLAN has provided opportunities for Vietnamese researchers and extension workers to undergo training at ICRISAT. However, training opportunities are still inadequate. Vietnam, being the 'youngest' CLAN member, needs more training opportunities than do countries where research and development programs are stronger. The number of slots allotted to Vietnamese scientists should therefore be increased. In addition to the regular courses at ICRISAT Center, additional courses for Vietnamese scientists could be organized in other countries, depending on their research strengths and the availability of training facilities.

Workshops and meetings. CLAN-supported review and planning meetings, which are attended by both Vietnamese and ICRISAT scientists, have helped the national program identify research strategies and priorities. They have also strengthened interaction and information exchange between scientists working on CLAN crops. CLAN should also help the national program develop contacts with other IARCs, on specific problems (e.g., with ACIAR on groundnut bacterial wilt).

Future collaborative activities

In the coming years, the following areas of collaborative research should be given priority:

- Bacterial wilt resistance in groundnut. We would like to participate in the Working Group on the disease, and to draw on the experience of scientists from ICRISAT and CLAN countries (e.g., China and Indonesia). Vietnam will emphasize breeding for resistance to bacterial wilt, and can provide hot-spot locations for testing the resistance of ICRISAT germplasm;
- Biological nitrogen fixation. Promising technologies such as the use of *Rhizobium* strains have been identified by the AGLOR project, but more research is required to identify suitable *Rhizobium* strains. Technology exchange on the subject should also be emphasized;
- Aflatoxin contamination in groundnut. In Vietnam, the groundnut harvest usually coincides with periods of high rainfall, Aflatoxin research is therefore crucial, but no research programs exist to date;

- On-farm trials. We are seeking support and continued technical assistance from CLAN/ICRISAT for expanding on-farm trials and building on the achievements of the AGLOR project;
- Integrated Pest Management in groundnut and other legumes;
- Breeding for drought tolerance and resistance to foliar diseases in groundnut;
- Identification of pigeonpea cultivars suitable for Vietnam, and research on processing and utilization of pigeonpea;
- Identification of sorghum cultivars with high yield potentials and resistance to grain mold;
- We would like to participate in the proposed Working Group on Acid Soil Tolerance in Legumes with a view to developing indigenous research capabilities in this area.

CLAN in Malaysia

H.A. Saharan, T.Y. Tunku Mahmud, and M.N. Ramli[1]

Introduction

Rice (grown on 0.7 million ha) is by far the most important annual crop in Malaysia, although some commercial perennial crops (e.g., rubber, oil palm, and cocoa) occupy similar or larger areas. Among the five crops (sorghum, pearl millet, chickpea, pigeonpea, and groundnut) of primary interest to CLAN, only groundnut is grown in Malaysia.

Groundnut

Groundnut is a smallholder crop concentrated mainly in Peninsular Malaysia. It is intercropped with perennials such as rubber, or grown as a rotation crop between rice, tobacco, maize, or vegetables. The popular variety Matjam (introduced from Indonesia) has been grown for oil extraction and food processing for the last two decades. Recently, MKT 1, a new variety superior to Matjam in both yield and quality, has been released by the Malaysian Agriculture Research and Development Institute (MARDI).

The area under groundnut in Malaysia has declined from 6 000 ha in the 1970s to about 1 600 ha in the 1980s, and an estimated 1 300 ha today. The crop is grown in the period following the main rainy season. However, there is adequate rainfall (up to 1500 mm) during this period too, and consequently there is an often high incidence of fungal and bacterial diseases. Bacterial wilt is the most widespread of these diseases, and one of the main reasons for the decline in groundnut cultivation. The other reasons include shortage and high cost of labour, inadequate seed supplies, lack of suitable machinery for planting and harvesting, postharvest losses, and the availability of many other investment alternatives.

The import of groundnut to Malaysia is increasing. In 1990, 86 344 t of groundnut products were imported, valued at RM 54.4 million (US$ 21 million). In 1992, the quantity increased to 164 054 t (RM 74.9 million or US$ 28.8 million). Shelled groundnut is still the major import (RM 34.6 million), followed by oilcake (RM 19.2 million), groundnut oil (RM 6.1 million), peanut butter (RM 4.2 million), unshelled groundnut (RM 2.6 million), and nine other products together worth about RM 10.8 million.

1. Malaysian Agricultural Research and Development Institute (MARDI), P.O. Box 12301, GPO 50774, Kuala Lumpur, Malaysia.

Chickpea

Chickpea is not grown in Malaysia, and imports are increasing. In 1986, 1 550 t of chickpea worth RM 1.6 million (US$ 631 000) were imported; by 1992 imports rose to 3 853 t (RM 4.2 million). Chickpea is consumed as boiled or roasted seed, or as packed snack foods. It is also re-exported to other countries after being processed into snack foods in Malaysia.

Cereals

Other crops imported include millets and sorghum. In 1991, imports were 1 796 t of millets, worth RM 1.1 million, and 477 t of sorghum, worth RM 163 000. Cereals imports include about US$ 200 million per year for poultry feed, mainly maize from Thailand and Vietnam. There is a need to substitute imported maize with locally grown sorghum. In addition, sorghum research needs to be intensified in future to develop fodder varieties.

Pigeonpea

A major popularization program was launched in the 1970s, but interest declined after an initial successful period. There is now a renewed interest in pigeonpea, for use as a food (*dhal)* and for green manure. The crop is sought to be grown in rotation with rice, tobacco, and vegetables.

Research activities

Research activities in Malaysia are largely confined to groundnut. Significant increases in acreage are unlikely. The emphasis is therefore on increasing productivity and quality, and promoting high value-addition processes. The major areas of current (and future) interest are:

- Germplasm introduction and varietal evaluation (for yield, quality, and seed size) of groundnut introduced from ICRISAT and Southeast Asian countries;
- Development of screening techniques for resistance to bacterial wilt;
- Screening for resistance to seedborne virus diseases in introduced varieties;
- Plant nutrition;
- Agronomic practices and cropping systems;
- Management of pests and diseases;
- Mechanization to reduce production costs;
- Postharvest handling techniques, processing, and product development to improve product quality and intensify downstream activities.

Achievements by MARDI

There are several achievements to our credit in groundnut research. In 1991 a new variety (MKT 1) was released; it is capable of being harvested in 100-110 days, and yielding 3.2 t ha^{-1}. Research work extends also to storage and packaging. Raw groundnut stored in high-barrier plastics and laminated aluminum containers showed no aflatoxin contamination after 4 months of storage. Other achievements cover crop management, plant nutrition, and control of pests and diseases.

Agricultural machinery. Mechanization, particularly of sowing and harvesting operations, is seen as an important way to reduce production costs. Several seeding machines have been tested, modified, and/or developed by MARDI since 1990. These include a rotational injection planter costing US$ 500, using which only 12 manhours are required to sow a hectare of groundnut, a 2-wheel rotor-mounted multicrop seeder (US$ 800, 4 manhours ha^{-1}), and a tractor-mounted seeder costing $ 2400, with which planting takes only 3 manhours ha^{-1}.

The harvest machinery developed by MARDI includes a tractor-mounted digger/lifter for groundnut harvesting (5 manhours ha^{-1}) costing US$ 2400. A smaller, less expensive model is now in the final stages of testing.

Opportunities for collaboration

There is a need to take stock of the research work accomplished under the purview of CLAN. The exchange of information on research results can be facilitated through seminars or workshops, and publication of their proceedings. Research funding from CLAN could also be made available after careful scrutiny of research proposals. ICRISAT and MARDI have signed a Memorandum of Understanding for formal collaboration in research and development. As for training, this should be conducted only when a new methodology or technology is available for dissemination. Although Malaysia is not considered a major groundnut-producing country, it can still contribute to CLAN in terms of exchange of information, and technologies for agricultural machinery and food processing.

CLAN in the Lao People's Democratic Republic

Bounkong Souvimonh[1]

Introduction

The Lao People's Democratic Republic has a land area of 23.7 million ha, of which only about 1 million ha is cultivated, almost entirely occupied by rice. The croppable area is limited by topography: only 20% of the country is flat or undulating land (the rest is hilly or mountainous), and nearly half of this area is covered by lakes or waterways.

Climatic variations are considerable. Areas in the Annamite mountains along the Laos-Vietnam border receive 2 500 mm of rainfall per year, while Vientiane in the southern plains receives only an average of 1 330 mm per year. There are large seasonal variations in temperatures; winter temperatures fall to 5 ° C in the northern mountains while in the south, summer temperatures reach 37°C.

Most of the available lowland is already cultivated. Much of the remainder is under grass or scrub, has poor fertility, and is unsuitable for agriculture. Because there is so little arable lowland, farm families are forced to cultivate fragile upland areas, where population pressure has led to unsustainable land use practices. Soils in the hilly areas are generally strongly leached and acidic, with limited depth and fertility. There are a few upland locations with better soils. These are less acidic and have higher organic and nitrogen levels, but erode rapidly.

These constraints pose formidable problems to both farmers and researchers. In proposing modified or new cropping systems, on-farm verification is required to ensure the feasibility of the cropping system, and the profitability of production levels that farmers are likely to achieve.

Groundnut, sorghum, and pigeonpea

The national 5-year plan stresses the rapid development of agriculture—improving productivity, diversifying crop production, and improving processing technology—in order to build up sufficient food stocks. In parallel with efforts to increase production there are plans to improve processing capabilities, by promoting small-scale agro-industries at village or even household level. These would relate to the processing of sorghum and pigeonpea for feed (mainly for pigs and poultry) and the processing of groundnut into snack foods or cooking oil.

1. Hatdokkeo Agricultural Station, Department of Agriculture and Extension, Ministry of Agriculture and Forestry, Vientiane, Lao Peoples' Democratic Republic.

Groundnut. Cultivation is still on a small scale, centered in two large regions (Vientiane province and the Bolovens plateau). Groundnut is also grown on rivershores after the rainy season (Oct-Mar). The area under groundnut is presently about 6 000 ha and seems to increase every year by 500 ha. The groundnut varieites used in Laos are local ones, yielding about 0.9 t ha^{-1}. The use of introduced or improved varieties is negligible. Groundnut grows well in newly deforested areas, but some disease and insect problems (e.g., leaf spot, and unfilled or damaged pods) still occur. In addition, yields decline in a few years. Chemical sprays are not widely used to control pests and diseases.

The use and processing of groundnut is limited to boiling the young pod, and selling it as a snack food. There is no agro-processing industry for groundnut.

The Government of Laos recognizes the importance of groundnut as a nutritive diet supplement to staple foods (rice throughout the country, and maize and cassava in the hills), to improve soil, and increase farmers' incomes. Through collaboration with different institutions, we would like to introduce improved groundnut varieties in the country. This, however, requires an appropriate mechanism for technology exchange and upgrading of staff at different levels.

Sorghum and pigeonpea. Besides groundnut, sorghum and pigeonpea are also cultivated, but still on a very small scale. Small quantities of pigeonpea are grown in household gardens; green pods are eaten as a vegetable. Demand for these two crops will increase in the future for use as animal feed, mushroom culture media, etc.

Current research thrusts

There is little agriculture research at present in Laos. Groundnut research is at the initial stage of germplasm collection; selection and breeding work will follow in the future. For sorghum, a few researchers are involved with selection to improve local varieties (earlier, sorghum grain was imported). There is considerable potential for expanding sorghum production. Such expansion, however, would depend on how successfully the research programs can produce suitable varieties and promote appropriate management practices.

Future collaboration

Collaboration between Lao PDR and CLAN has not yet reached the implementation stage. We recognize that the involvement of CLAN is fundamental to the development of groundnut, sorghum, and pigeonpea production in the country. Since agricultural research and technology development in Lao PDR is still in its infancy, collaboration with CLAN should include institutional support, training, and financial support to the extent possible.

Working Groups in Technology Generation and Exchange

A. Ramakrishna and C.L.L Gowda[1]

Introduction

A Working Group consists of a group of scientists who share a common interest, and are committed to working together to collectively address a high priority regional problem, and to sharing their research results with others. Working Groups coordinate and stimulate cooperative research by pooling expertise from both developing and developed countries, and building up the critical mass needed to find quick answers. Working Groups use existing staff and facilities, and avoid duplication of effort.

Why Working Groups?

Working Groups have several advantages in terms of their ability to carry out collaborative research within a network such as CLAN:

- They can solve high priority problems more quickly than institutions or researchers working independently;
- They are sharply focused, because they are created in response to a specific problem, and can be terminated once the problem is solved;
- They are small, and therefore cost-effective and easy to operate;
- They can share facilities and support each other in areas of overlap (e.g., sponsorship or organization of training courses and meetings);
- The parent network can be used to identify research targets, disseminate results quickly, and provide feedback.

How do they operate?

A Technical Coordinator, usually an expert in the subject concerned, is nominated by the Group to coordinate the research. Working Group members include scientists from NARS, international and regional institutes, and laboratories in developing and developed countries. Logistics and coordination are provided by the Network Coordination Unit (Fig. 1).

Four Working Groups currently operate under CLAN; two others are planned. Their activities are briefly described below.

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1. ICRISAT Center, Patancheru, Andhra Pradesh 502 324, India.

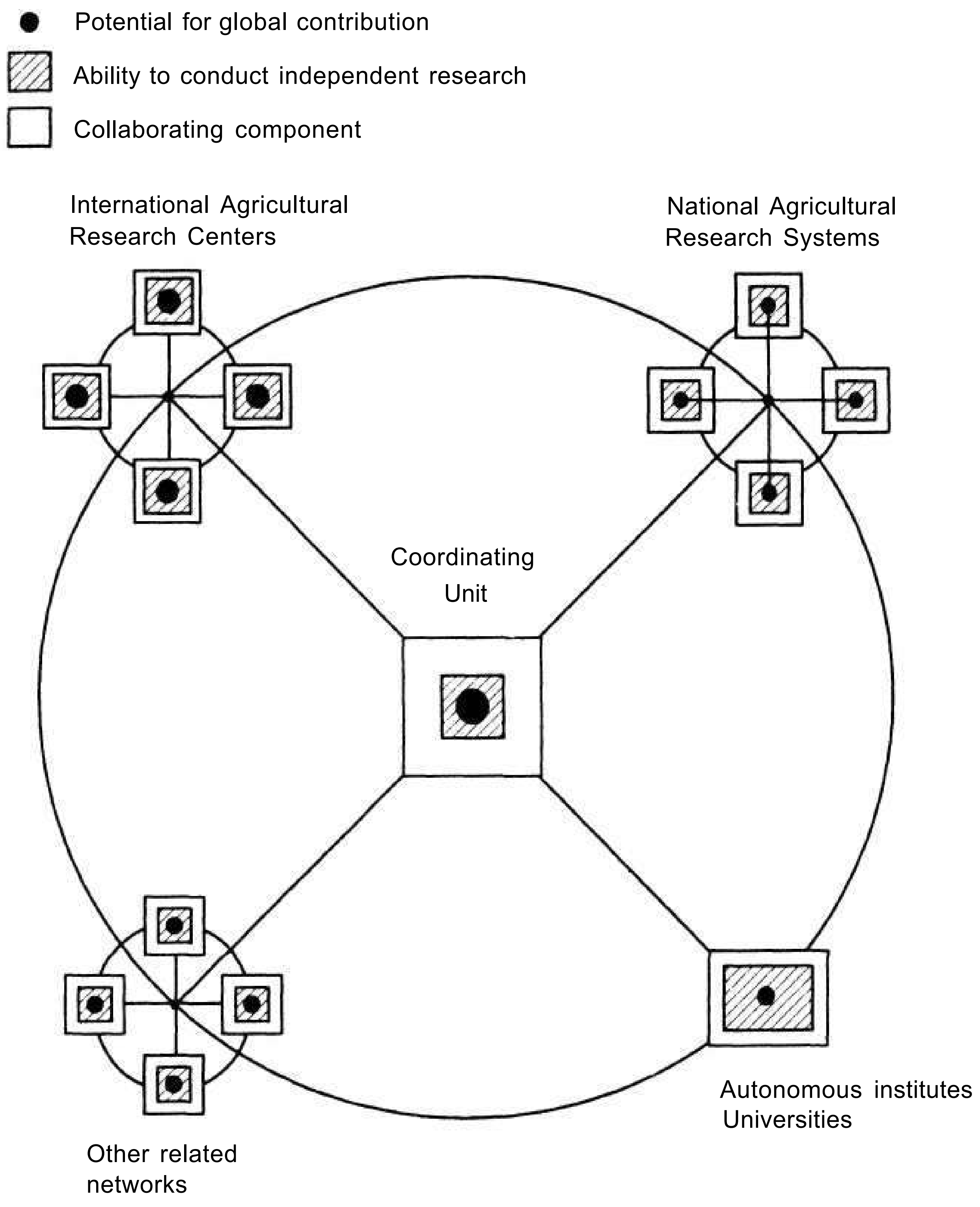

Figure 1. Structure of a Working Group.

Asia-Pacific Working Group on Groundnut Viruses

This started off as the Peanut Stripe Virus (PStV) Working Group in 1987, and involved ACIAR, ICRISAT, Peanut-CRSP, and NARS scientists from China, Indonesia, Philippines, Malaysia, and Thailand. In 1990, the scope of the WG was expanded to include other groundnut viruses, and the name was changed to its present form. Two regional training courses were conducted on the detection and diagnosis of groundnut viruses (Indonesia, 1988 and ICRISAT Center, 1990). A recent publication on PStV (Demski et al. 1993) contains more information on research coordinated by this WG. Several recommendations were agreed to at a recent meeting (15-18 Aug 1993) in Dundee, UK:

- The next Working Group meeting will be held in early 1995 in Thailand;
- A training workshop on the identification of economically important groundnut viruses in Asia would be held in Thailand in conjunction with the meeting;
- Proper plant quarantine procedures would be established to contain the seed transmission of viruses;
- Surveys would be undertaken to assess the occurrence and importance of viruses for which no data are available.

Groundnut Bacterial Wilt Working Group

This WG was formed in 1990 as a result of discussions at a joint ACIAR/ICRISAT Collaborative Research Planning Meeting on Bacterial Wilt of Groundnut (Malaysia, 18-19 Mar 1990). The major research plans of the WG were: characterization of the pathogen, host-range differentiation, epidemiology and survival, and host-plant resistance.

The second meeting of the WG was held in Taiwan on 2 Nov 1992 in conjunction with the International Symposium on Bacterial Wilt (28-31 Oct 1992). The summary proceedings of the WG meeting were published by ICRISAT (Mehan and Hay ward 1993). The following proposals and recommendations were made for future research:

- Greater emphasis would be placed on host-plant resistance; germplasm would be screened to identify new and diverse sources of resistance, and resistant sources exchanged through an international nursery;
- The influence of different cropping systems and management practices on disease incidence and severity would be investigated;
- Integrated disease management systems would be developed, using wilt-resistant cultivars in combination with appropriate cultural practices;
- Researchers and extension workers from NARS would be trained in pathogen detection, disease diagnosis, and integrated disease management.

Working Group on Integrated Pest Management (IPM) and Insecticide Resistance Management (IRM) in Legume Crops in Asia

Legume crops are particularly susceptible to a wide range of pests. The injudicious use of pesticides can disrupt natural control processes and lead to the development of insecticide resistance, and often to massive pest resurgences. At a meeting held in Thailand in Mar 1991, representatives of NARSs, IARCs, and the agrochemical industry mooted the formation of a WG to support integrated pest management (IPM) and insecticide resistance management (IRM) in legume crops. The main objectives are to facilitate the exchange of information on grain legume pests, coordinate research on different insect species and across farming systems, help to ensure that IPM research and application are in line with farmers' requirements, identify/develop monitoring techniques, and provide training to NARS staff.

Working Group on Botrytis Gray Mold of Chickpea

Botrytis gray mold is one of the major constraints to chickpea production in Bangladesh, and parts of India, Pakistan, and Myanmar. In view of the destructive potential of the disease in South Asia, a Working Group was formed in Mar 1991. The research plans were to assess the actual economic losses through surveys, identify resistant material by field screening in hot-spots, conduct epidemiology studies, improve the exchange of material and visits, and develop integrated management methods against the disease.

Accordingly, farmers' fields were surveyed in Bangladesh and Nepal in 1992, to assess occurrence and extent of damage. BGM was severe in the humid regions of Bangladesh, but less so in the dry Barind region. Damage was sporadic in Nepal owing to the virtual absence of winter rains during the survey period.

Field screening of chickpea genotypes for BGM resistance was undertaken at Pantnagar (India) and Ishurdi (Bangladesh). Ten lines in Bangladesh and six lines in India showed fairly stable but moderate levels of resistance. Three accessions of *Cicer bijugum* were identified as resistant at ICRISAT Center.

Epidemiology studies have been initiated by the WG on survival of the pathogen *(Botrytis cinerea),* microclimatic factors, pathogenic variability, etc.

The second WG meeting was held at Rampur, Nepal (14-17 Mar 1993); the proceedings were published by ICRISAT (Haware et al. 1993). Future plans include:

- Integrated management of the disease, including studies on the role of infected seed and debris in epiphytotics;
- Attempts to transfer resistance genes from *Cicer bijugum* to C. *arietinum* (to be initiated at ICRISAT);
- Studies on environment x genotype x pathogen interaction, and on pathogen variability among the isolates.

In addition to the above, two new Working Groups are being planned. These are:

Biological nitrogen fixation in legumes

The proposed WG attempts to bring together Asian scientists concerned with biological nitrogen fixation (BNF) in legumes, for coordinated research. BNF in legumes is a major factor in the sustainability of cropping systems. Recent research strongly suggests that host-plant characteristics and environmental factors play an important role in the symbiosis between host plants and various *Rhizobium* species. There is a widely-felt need to intensify research in this area, particularly to ensure sustainability at higher production levels.

The first meeting of the Asia Working Group on Biological Nitrogen Fixation in Legumes (AWGBNFL) is scheduled for 6-8 Dec 1993 at ICRISAT Center. Members will discuss and formulate a work plan for the future. A newsletter, AWGBNFL Notes, is being produced, initially twice a year. The first issue was published in Jul 93.

Acid soil tolerance in grain legumes

Acid soils constitute about 38% of the world's arable lands and pose a significant problem to crop production in general, and legumes in particular. Although the application of lime in large quantities can alleviate acid soil problems, this method is expensive. One management option is to exploit the potential genetic variability for tolerance to acid soils. However, genetic improvement alone cannot be expected to fully overcome acid soil limitations.

At the Third International Symposium on Plant-Soil Interaction at Low pH (12-16 Sep 1993, Brisbane, Australia), the establishment of a Working Group was proposed to explore genetic variability for acid soil tolerance in selected legume crops. The Group will involve NARS scientists from countries where acid soil is a constraint to legume crop production. The specific objectives are to:

- Establish a database of institutions working on acid soil tolerance;
- Organize collaborative research to quantify yield losses due to soil acidity;
- Screen for grain legume genotypes tolerant to acid soils and symbiotic with *Rhizobium* strains, and develop acid soil tolerant cultivars;
- Facilitate the exchange of germplasm and information on acid soil tolerance in grain legume crops;
- Stimulate strategic research at selected centers to understand the mechanisms of acid soil tolerance.

Future plans

The network will identify and strengthen 'lead centers' among its members, where the staff, facilities, and infrastructure are adequate for research on one or more specific topics. Other institutions will be identified as 'satellite centers'; these will support the research at lead centers by undertaking additional research or multilocational testing of technology. It is envisaged that in the future, responsibilities will be transferred to the NARS in stages, so that much of Working Group research will be conducted, and later coordinated, by NARS.

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Report of the Asian Sorghum Researchers' Consultative Meeting

J.W. Stenhouse[1]

Introduction

In 1991, sorghum researchers from 11 countries in Asia and representatives of several international organizations met at ICRISAT Center to consider the formation of a sorghum research and development (R and D) network for Asia. Such a network was then established, in order to improve research coordination and information/technology exchange throughout the region.

Subsequently, CLAN was formally established in Apr 1992. Since its mandate overlapped that of the sorghum network, there was a need to clarify the role and scope of activities of the sorghum network in relation to those of CLAN. A second Consultative Meeting (ICRISAT Center, 27-29 Sep 1993) was held immediately prior to this meeting to review collaborative research activities on sorghum, and to consider whether it would be beneficial to integrate all such research into CLAN, so as to more effectively utilize existing resources and manpower.

Presentations and discussions

A complete report on the Consultative Meeting is being published by ICRISAT. A summary is given here, since the meeting recommended (subsequently ratified by CLAN) that collaborative research programs on sorghum be integrated into CLAN.

Reports were presented on research progress, identified needs, and future research priorities for each country; and also the countries' expectations from and potential contributions to network research.

Collaborative research

The meeting commended the collaborative research approach, which has been found to be effective in the past, and is likely to be even more crucial in future, as R and D efforts intensify in the various member countries. Several areas were identified for possible collaboration between NARS from different countries. In addition, the role of mentor institutions was recognized as being vital in generating and exchanging technology (for example, in genetic engineering) which developing countries could use.

1. ICRISAT Center, Patancheru, Andhra Pradesh 502 324, India.

Specifically, the approach of a 3-way collaborative research program involving the Indian Council of Agriculture Research, ICRISAT, and Australian research institutions on drought stress, insect resistance, and transformation studies (being submitted to ACIAR and GRDC for funding) was commended. The meeting recognized that such collaboration would strengthen NARS research capabilities in a number of disciplines, and could also be used in the improvement of crops other than sorghum.

Identification of priorities

Five major sorghum production systems were identified: monsoon (rainy), postrainy (winter), summer, rice-fallow, and cool/temperate. Although some constraints (e.g., drought) were common to several production systems, it was felt that each system should be considered individually, in order to provide the most effective solutions under local conditions. The participants provided inputs on the various constraints to crop production, their perceptions of the seriousness of each constraint, and specific areas of interest/priority. We were thus able to roughly quantify and prioritize the various stresses and constraints, and identify those which affected several countries.

Priority areas

The priority areas for future research by the network include:

- Control of diseases (e.g., grain mold) and pests (e.g., shoot fly);
- Development and popularization of drought-resistant varieties for each production system;
- Industrial uses (starch, sugars, alcohol, particle board, etc.). This would require (limited) basic research with a view to influencing policy and applied, product-specific research to determine the economic viability of alternative-use projects, and match breeding/varietal improvement work with end uses;
- Non-traditional food uses, e.g., in syrups, beverages, and composite flour;
- Information exchange through newsletters, co-publications, workshops/meetings, training programs, the creation of comprehensive databases, etc.

Recommendations

After extensive discussions, the meeting made several recommendations which, when implemented, would contribute greatly to sorghum R and D activities in the region, and to the development of a coherent perspective on sorghum research in Asia.

There was unanimous agreement that the role of sorghum was changing throughout Asia, and that this trend would shape future research objectives. Once primarily a food crop, it has become important as a fodder and feed source in many areas.

Patterns of utilization could change further, if efforts to promote sorghum use in food-processing and other industries are successful.

The meeting strongly supported the CLAN proposal for collaborative research submitted to the Asian Development Bank for funding. It was felt that the proposal should emphasize two key areas: alternative uses of sorghum, which is the key to increased production; and linkages with industry. Linkages with industry would ensure, in conjunction with extension work and surveys, that research work was in tune with current realities in terms of product development, industry/consumer preferences, and patterns of utilization.

The other key recommendations include:

- Integration of collaborative sorghum research into CLAN, to create a comprehensive R and D network to serve Asian needs;
- Formation of a study group to identify needs and research opportunities to develop alternative uses of sorghum (e.g., in food-processing and chemical industries). Studies would also be conducted on economic/viability aspects and current and projected utilization patterns;
- Formation of four Working Groups on:
  - Drought tolerance
  - Shoot pests
  - Grain molds
  - Forage sorghums.

Detailed draft work plans for each priority area would be prepared by the group coordinators identified at the meeting, and circulated to all network members. Once feedback is obtained, these draft work plans would be finalized for ratification by CLAN.

ICRISAT Activities

ICRISAT's Genetic Resources Program in Asia

Melak H. Mengesha[1]

One of ICRISAT's mandates is to act as a world repository for the genetic resources of its five mandate crops. In addition, the Genetic Resources Program (GRP) at the Institute also works on germplasm conservation of finger, proso, foxtail, little, barnyard, and kodo millet species. The GRP is responsible for collecting, assembling (from collections available elsewhere), and conserving available germplasm from all possible sources. The nucleus of the present collection was built up by the Rockefeller Foundation in India and by several scientists in the national agricultural research system (NARS), who contributed their entire collections. This germplasm is an important raw material for crop improvement programs in Asia and elsewhere, and one of the GRP's most crucial roles is to ensure that this material is accessible to researchers. In fulfilling these objectives, we have received substantial support from several donor agencies, particularly the Asian Development Bank (ADB).

Status of germplasm

The GRP collection contains 55 311 accessions from Asia and a total of 109 812 from all over the world (Table 1), including 1 819 accessions of wild relatives. We have 33 766 accessions of sorghum {*Sorghum bicolor* (L.) Moench), 24 199 of pearl millet (*Pennisetum glaucum* (L.) R. Br.), 16 877 of chickpea (*Cicer arietinum* L.), 12 393 of pigeonpea (*Cajanus cajan* (L.) Millsp.), 13 915 of groundnut (*Arachis hypogaea* L.), and 8 662 samples of the six other millets.

Germplasm collection

After identifying the geographic and taxonomic gaps in the collections, ICRISAT launched several collection missions in Asia jointly with NARSs, with funds made available by the ADB. In India, we collaborated with the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, and the All-India crop improvement programs. So far we have worked in India, Indonesia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Russia, and Yemen. All the material collected is shared between ICRISAT and the collaborating NARS. Any exotic material brought to India is first inspected by the Indian Plant Quarantine Authority (at the NBPGR Quarantine

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Table 1. Germplasm from Asia available at ICRISAT Center.

Country	Sorghum	Pearl millet	Chick-pea	Pigeon-pea	Ground-nut	Minor millets[1]	Total
Afghanistan	6	-	686	-	-	37	729
Bangladesh	9	-	170	73	-	2	254
China	282	-	-	1	217	61	561
India	5 116	11 406	7 008	9 799	3 452	3 756	40 537
Indonesia	32	-	-	17	286	-	335
Iran	7	-	4 856	_	11	13	4 887
Iraq	4	-	18	-	-	2	24
Israel	22	-	48	-	88	-	158
Japan	111	-	-	-	48	165	324
Jordan	-	-	25	-	-	-	25
Kampuchea	-	-	-	-	1	-	1
Korea	77	1	-	-	89	125	292
Lebanon	360	109	19	-	-	33	521
Malaysia	-	-	-	-	54	-	54
Maldives	10	-	-	1	-	3	14
Myanmar	8	-	129	70	89	_	296
Nepal	8	-	80	116	28	768	1 000
Pakistan	75	156	441	14	1	75	762
Philippines	5	-	-	59	57	-	121
Saudi Arabia	1	-	-	-	-	-	1
Sri Lanka	25	2	3	77	24	36	167
Syria	4	-	224	-	1	411	640
Taiwan	14	-	-	3	48	28	93
Thailand	5	-	-	41	6	-	52
Turkey	51	2	449	-	7	71	580
Russia and CIS	350	14	124	2	63	212	765
Vietnam	-	-	-	-	4	-	4
Yemen	2 052	61	-	-	1	-	2 114
Total (Asia)	8 634	11 751	14 280	10 273	4 575	5 798	55 311
Total (worldwide)	33 766	24 199	16 877	12 393	13 915	8 662	109 812

1. Finger, foxtail, proso, little, barnyard, and kodo millets.

Station in Hyderabad) and then planted in the Post-entry Quarantine Isolation Area at ICRISAT Center for further inspection and seed increase. Accessions free from pests and pathogens are released to ICRISAT.

Conservation

Accessions are stored for either medium-term or long-term conservation. All the Asian accessions are maintained in medium-term storage chambers (4°C, 20% relative humidity). The quantity of seed stored varies from 400 g in sorghum and pearl millet to 1 kg in groundnut. For long-term conservation, seeds are dried in special cabinet dryers at 16° C and 16% relative humidity till the moisture content is reduced to 4-5%. About 100 g of dry seeds are then vacuum-sealed in aluminum foil packets for long-term storage at -18° C. The viability of stored germplasm is monitored by periodic germination tests; accessions which start losing viability are rejuvenated. An ADB grant has allowed us to install essential items like safety devices (e.g., smoke detectors) and stand-by generators.

Maintenance

Accessions are increased in the field as and when seed stocks become low, or seed viability starts declining. To maintain genetic purity during seed increase, appropriate pollination control methods are followed for crops which are not naturally self-pollinated: selfing in sorghum, intermating by cluster-bagging in pearl millet, and avoiding cross-pollination by insects in pigeonpea.

Characterization

To facilitate utilization, all the accessions are evaluated at ICRISAT Center for important morphological and agronomic characters, using internationally agreed descriptors, which are published jointly by ICRISAT and the International Board for Plant Genetic Resources (IBPGR). Evaluation is done under favorable conditions, including good management practices, during the rainy season, which corresponds to the normal cropping season. In India, evaluation is done in collaboration with NBPGR and the various All-India crop improvement programs.

Regional evaluation

After preliminary selection at ICRISAT Center, further evalaution is done at regional centers, jointly by ICRISAT and the respective NARS, in order to identify germplasm which will perform well under local conditions. Such regional evaluation has been done in India, Nepal, Myanmar, Vietnam, and Thailand. Several accessions of chickpea were jointly identified, and will be tested further. Groundnut was evaluated in Myanmar, and 63 accessions were selected for further evaluation. In 1993, 500 selected diverse grain and forage sorghum accessions of different maturity periods were sown in Thailand, and 500 groundnut accessions in Thailand and Vietnam, for joint evaluation. Such joint multilocational germplasm evaluation will help us identify source material for crop improvement programs.

Documentation

Both passport and evaluation data are computerized to facilitate retrieval of information, data upgradation, and information exchange. Since computer facilities are limited in some countries, catalogs are also published. Chickpea and pigeonpea germplasm catalogs were published by ICRISAT in 1988, and catalogs for sorghum and pearl millet are under preparation. Catalogs for sorghum and pearl millet germplasm evaluated in India have been published jointly by ICRISAT and NBPGR.

Germplasm utilization

All the assembled germplasm is freely available for research purposes. So far ICRISAT has supplied 123 087 sorghum, 59 935 pearl millet, 88 560 chickpea, 38 193 pigeonpea, 52 566 groundnut, and 21 596 minor millets samples to scientists in Asia (Table 2). Several germplasm accessions have been used directly in Asia and elsewhere. For example, ICP 11384, a pigeonpea germplasm collected from Nepal, was released as Bageswari in Nepal. Three chickpea accessions from India (ICCs 552, 4951, and 6098) were released in Myanmar and Nepal. ICC 8649 from Afghanistan was released in Sudan; and ICC 11879 from Turkey and ICC 13826 from the former USSR were released in Syria.

Human resource development

For a country to collect, conserve, and effectively utilize genetic resources, its young scientists and technicians require practical training. ICRISAT, in collaboration with NBPGR, has organized a comprehensive training workshop for scientists and technicians in Asia. ICRISAT also provides on-the-job training in collection and characterization to NARS staff during the course of our field activities in almost all the countries in which we work. There have been tangible results: for example, Pakistani and Nepali scientists who were involved in germplasm collection with ICRISAT teams were trained, and later organized independent collections in their own countries. We hope that such training programs result in the building up of adequate numbers of skilled personnel, so that CLAN countries can manage their germplasm resources for the present and for the future.

Table 2. Germplasm from ICRISAT genebank distributed to scientists in Asia.

Country	Number of samples distributed						Total
	SG[1]	PM	CP	PP	GN	MM	
Afghanistan	-	-	54	-	-	-	54
Bangladesh	618	10	570	89	575	522	2 384
China	4 381	17	6	56	550	466	5 476
India	108 888	58 512	47 936	34 829	34 903	18 292	303 360
Indonesia	80	22	-	134	9 953	48	10 237
Iran	958	-	3000	-	-	-	3 958
Iraq	118	5	5	5	7	-	140
Israel	120	30	6 204	103	-	-	6 457
Japan	996	55	591	183	100	-	1 925
Jordan	-	-	5	-	-	-	5
Kampuchea	-	-	-	-	1	-	1
Korea	1 205	366	27	94	376	392	2 460
Laos	-	-	-	45	-	-	45
Lebanon	105	-	2 177	-	-	-	2 282
Malaysia	103	-	30	60	356	10	559
Maldives	-	-	50	20	-	-	70
Myanmar	8	-	176	68	958	-	1 210
Nepal	25	5	1 882	502	234	1 316	3 964
Pakistan	386	358	7 393	352	1 101	64	9 654
Philippines	379	82	969	1 001	902	-	3 333
Saudi Arabia	128	120	20	1	-	60	329
Sri Lanka	63	-	29	194	472	220	978
Syria	119	-	17 100	-	1	-	17 220
Taiwan	-	-	20	-	601	-	621
Thailand	-	103	29	134	949	-	1 215
Turkey	100	-	82	-	-	-	182
Russia and CIS	1 613	250	165	138	14	206	2 386
Vietnam	5	-	-	95	513	-	613
Yemen	2 689	-	40	90	-	-	2 819
Total	123 087	59 935	88 560	38 193	52 566	21 596	383 937

1. SG = Sorghum, PM = Pearl millet, CP = Chickpea, PP = Pigeonpea, GN = Groundnut, MM = Minor millets.

Future plans

The germplasm capability of the Asian region will be further strengthened by accelerated germplasm collection missions elsewhere, particularly in high-diversity areas in Africa and South and Central America.

We propose to continue joint evaluation of the germplasm of ICRISAT mandate crops in close collaboration with national programs.

Germplasm collection efforts have been inadequate in many countries. Table 3 shows a list of relative priorities for different crops and different countries. In collaboration with the respective NARS, we propose to organize collection trips to these countries, particularly for 'high priority' crops.

Table 3. Future priorities for germplasm collection in Asia.

Country	SG[1]	PM	CP	PP	GN	MM
Afghanistan		H[2]	H			
Bangladesh		M		M	H	
China	H	H			H	H
India	M	M	M	-	M	M
Indonesia	M	-	-	H	-	L
Iran	-	H	-	-	-	-
Kampuchea	-		-	-	M	-
Korea		H				
Myanmar	H	H	-	M	-	H
Nepal	M	M	H	-	-	M
Pakistan	M	M	-	-	-	M
Philippines	M		-	-	M	L
Saudi Arabia		M				
Sri Lanka	-	M	-	-	M	-
Syria	-	H	-	-	-	-
Thailand	H	-	-	M	M	L
Turkey	H	M	H	-	-	L
Russia and CIS	H					H
Vietnam	-	-	-	-	M	-
Yemen	M	-	-	-	-	L

1. SG = sorghum, PM = pearl millet, CP = chickpea, PP = pigeonpea, GN = groundnut, MM = minor (i.e., finger, foxtail, proso, little, barnyard, and kodo) millets.
2. H = high priority, M = medium priority, L = low priority.

Sorghum and Millet Improvement at ICRISAT—Research, Research Support, and Technology Exchange for Asia

D.E. Byth[1]

ICRISAT has a global mandate for the improvement of sorghum and pearl millet, and also undertakes focused improvement of finger millet in eastern Africa. Some aspects of the Cereals Program at ICRISAT are reviewed briefly, as a background to the future.

Crop improvement centers

Cereal crop improvement research in ICRISAT is highly decentralized, with staff and facilities at a number of regional centers.

Sorghum

- ICRISAT Center, Patancheru, India;
- Southern African Development Community (SADC)/ICRISAT Program, centered in Bulawayo, Zimbabwe;
- West African Sorghum Improvement Program (WASIP), in Nigeria and Mali;
- East African Regional Cereals and Legumes Program (EARCAL), centered in Nairobi, Kenya;
- Latin American Sorghum Improvement Program (LASIP), currently located at CIMMYT in Mexico.

Pearl millet

- ICRISAT Center, Patancheru, India;
- ICRISAT Sahelian Center (ISC), Niamey, Niger;
- SADC/ICRISAT, Zimbabwe;
- EARCAL, Kenya.

ICRISAT Center is the oldest and largest of the centers, and is well structured for strategic research in addition to its role of serving the needs of the Asian region. It has disciplinary resource units in breeding, entomology, pathology, physiology, and cell biology, and these are complemented by a range of research-support and administrative units.

1. ICRISAT Center, Patancheru, Andhra Pradesh 502 324, India.

Research goals

The major objective is to contribute to the achievement of sustained improvements in productivity and adaptation of sorghum and millets through improved genetic materials and management systems. Increasingly, this work will be targeted at specific production systems in each region. The use of production systems as targets will foster the integration of crop improvement and resource management research, facilitate technology exchange and impact assessment, and help strengthen collaboration between ICRISAT and the national agricultural research systems (NARS). The major research goals are to:

- Collaborate with ICRISAT's Genetic Resources Program in assembly and characterization of a comprehensive collection of germplasm;
- Identify, develop, and enhance sources of resistance to major biotic and abiotic constraints to productivity and adaptation;
- Enhance yield potential and stability;
- Improve the quality of grain and fodder;
- Identify new and improved uses for food, feed, and industry;
- Collaborate with NARS in the development and evaluation of improved genetic materials;
- Exchange technology with NARS;
- Establish, where appropriate, collaboration with mentor institutions in specific research areas.

Networks

Technology exchange and research networks play an important role in a number of ways; as vehicles for communication and collaboration among NARS; to help NARS achieve their primary goals; to exchange technology through training and other means; and to achieve spillovers across regions.

The Cereals Program at ICRISAT is involved with a number of regional networks. These include: CLAN (linked to ICRISAT Center), CLAIS (Comision Latinoamericano de Investigadores en Sorgo; linked to LASIP), WCAMRN (West and Central African Millet Research Network; linked to ISC), WCASRN (West and Central African Sorghum Research Network; linked to WASIP), SMIP (Sorghum and Millet Improvement Program; linked to SADC/ICRISAT), and EARSAM (East African Regional Sorghum and Millets Network; previously linked to EARCAL).

Some improvement perspectives

Over the last 20 years, ICRISAT's sorghum and pearl millet improvement programs have helped to significantly improve crop performance in Asia, Africa, and Latin America. Breeders collaborate very closely with scientists from other disciplines (entomology, pathology, physiology, and cell and molecular biology) in seeking the resolution of biotic and abiotic constraints, and the improvement of yield potential and stability.

The program is adopting an increasingly strategic research role in response to the greater strengths of the NARS and the need for ICRISAT to focus on longer-term and less tractable constraints. Major current initiatives are in genetic diversification of breeding populations and the use of trait-specific gene pools and population improvement to combine introgression with directional improvement.

A wide range of materials is made available to interested NARS partners for evaluation in their test environments, through international nurseries and trials.

Linkages with Asia

The Cereals Program at ICRISAT has a number of collaborative research projects with the Indian NARS on sorghum and pearl millet improvement. The program also has linkages with Pakistan, and to a much lesser degree with Russia, China, Indonesia, Thailand, and Myanmar in sorghum. In other Asian countries, sorghum remains a minor crop.

The primary biotic and abiotic constraints to sorghum and pearl millet production tend to recur in comparable production systems across Asia. For each of these constraints, substantial knowledge and genetic materials exist, particularly in India (Indian NARS and ICRISAT) and China for sorghum; and in India (Indian NARS and ICRISAT) for pearl millet. This creates the opportunity for effective spillover of technologies through a network of NARS in which ICRISAT is a member. There is a need to exploit the technological and manpower strengths that exist in some countries in the region to alleviate these constraints throughout the region.

ICRISAT's role within CLAN

The future role of ICRISAT's Cereals Program within CLAN will depend on the nature of the Institute's research agenda and on the needs and opportunities recognized by the NARS in the region. These are related matters.

The priority research themes in cereal crop improvement in the ICRISAT Medium Term Plan for 1994-98 (Table 1) were developed in consultation with NARS from various parts of the world. Most of these themes impact on Asia to some degree. Three primary areas of work are envisaged:

- Yield potential and stability;
- Abiotic constraints and adaptive mechanisms;
- Biotic constraints and crop protection.

Specific constraints and objectives are involved for each of these. The balance of work differs somewhat between the crops, with the sorghum agenda placing greater emphasis on insect pests, and that of pearl millet on yield improvement and

Table 1. ICRISAT Medium Term Plan research themes for sorghum and pearl millet[1].

	Sorghum			Pearl millet		
Primary areas	No. of themes	Activity[2] (%)	Theme	No. of themes	Activity (%)	Theme
Yield potential and stability	2	17	Grain/stover Forage	3	33	Grain/stover Adaptation to arid areas
Abiotic constraints and adaptive mechanisms	3	25	Low temp. adaptation Drought adaptation Acid soil adaptation	2	23	High temp, adaptation Drought adaptation
Biotic constraints and crop protection	8	58		5	44	
Disease	3	21	Grain mold Anthracnose Leaf blight	2	24	Downy mildew
Insects	4	32	Stem borer Head bug Midge Shootfly	2	13	Head caterpillars Stem borer
Other	1	5	*Striga*	1	7	*Striga*

	Share of cereals research budget (%)	
Type of research	Sorghum	Millets
Strategic	39	48
Applied	52	46
Adaptive	9	6

1. Finger millet themes are: improvement of grain yield, and resistance to blast disease.
2. Indicative only. Figures show the share of respective themes in total research budget for cereals.

disease. Most of the research themes are multidisciplinary and global in scope, with inputs from more than one ICRISAT location. A significant overall shift towards strategic research is envisaged (though the crop improvement research partnership with NARS will continue), reflecting the increased capability of many NARS. This shift is uneven across the crops and research themes, reflecting differences in current comparative advantages.

Increasingly, ICRISAT's research in future will focus on specific production systems. CLAN will be pivotal in identifying priority needs and opportunities in regional production systems, and in guiding technology exchange and spillover between such systems.

ICRISAT cereal scientists could help to catalyze greater interaction among the NARS, to exploit areas of current strengths and identify areas of weakness. ICRISAT can contribute in two major areas:

Research support

- As a strategic research resource for the region to exploit and contract;
- As a partner in research for specific objectives;
- Assistance in formulating and promoting regional research proposals to international donors and mentor institutions.

Communication and coordination

- Information exchange through newsletters, publications, electronic systems, etc;
- Technology exchange, by workshops and consultancies in addition to targeted nurseries, genetic materials, and development of methodologies;
- Training, including staff secondments and specialized short courses.

Research Support and Technology Exchange for Legumes in Asia

D. McDonald and C. Rajagopal Reddy[1]

In his overview of CLAN activities, Dr Gowda has touched upon many of the cooperative research and technology exchange activities of the Legumes Program at ICRISAT. We shall provide some additional information on these activities, and will indicate where our emphasis has been placed in the past and where we plan to concentrate our attention in the future.

The Legumes Program is involved in several collaborative research activities in each of our mandate legumes—chickpea, pigeonpea, and groundnut—with the national agricultural research systems (NARS) of the CLAN countries. We present below some examples of this cooperation.

Crop improvement

For chickpea, we are involved in breeding for short duration in Bangladesh and India, and for resistance to drought and low temperatures in northern India. We are involved with chickpea botrytis gray mold research in Bangladesh, India, Nepal, Myanmar, and Pakistan and a Working Group has been formed to stimulate and coordinate research into this difficult problem. We also have a strong interest in integrated pest and disease management. Our interest in biological nitrogen fixation is at present focused mainly on chickpea.

In pigeonpea we are also involved in breeding for short duration. The major problem with this crop is with pests, especially pod borers, and this is reflected in our collaborative work in South Asia, Indonesia, and Thailand. We have active collaboration with the Indian NARS in several areas of hybrid pigeonpea improvement and seed production technology. ICRISAT also acts as a base for UK scientists to make major inroads into understanding and managing insecticide resistance problems in Asia.

In groundnut we concentrate on breeding for short duration, resistance to insect pests and diseases, and on integrated pest and disease management. We have had considerable collaboration with Thailand in research on groundnut viruses, and with Vietnam in the development of confectionery groundnuts.

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Biotechnology

Recent developments in transformation and regeneration of crop plants have raised expectations of being able to obtain groundnut plants expressing genes for resistances to virus diseases for which we have found no resistance in the cultivated germplasm. Recent meetings of the Asia-Pacific Working Group on Groundnut Viruses, and of the more recently formed International Working Group on Transformation *and* Regeneration of Groundnut and Utilization of Viral Genes to Induce Resistance to Virus Diseases, have resulted in valuable exchange of research findings and assisted in the formation of cooperative research linkages between NARS, international and regional institutions, and research institutions in developed countries.

Integrated disease and pest management

Breeding of cultivars to use as components of management systems is of course a fundamental requirement, and should be done in close cooperation between NARS, ICRISAT, and other international and regional institutions. Our activities in integrated disease management mainly focus on: organizing surveys involving NARS scientists to determine the economic importance and distribution of diseases, estimation of crop losses caused by specific diseases (e.g., peanut bud necrosis virus in India and botrytis gray mold of chickpea in Bangladesh), screening of genotypes in hot-spot locations to determine their reactions to specific diseases (e.g., peanut stripe virus in Indonesia), and studying the epidemiology of the various diseases to provide a sound basis for developing effective management practices. We organize training courses on the identification and management of economically important diseases, provide diagnostic aids, and arrange access to facilities in advanced laboratories in developed countries.

Similar activities in respect of integrated pest management are also being carried out in close collaboration with the Asian NARS. On-farm IPM trials have provided information about the roles of pesticides for insect and disease control. Implementation activities also involve socioeconomists and breeders. It is becoming apparent that female members of farm families are active in decision making and should therefore be made aware of the benefits and hazards of pesticides. Some other activities include organizing IPM courses in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and national programs. An IPM sub-network and working group cluster has highlighted priority areas. ICRISAT has shifted emphasis to accommodate problem topics, and is encouraging other organizations to do likewise.

Crop physiology

Activities in the area of crop physiology include development of screening techniques to identify genotypic differences in our three legumes in their response to photoperiod, drought, waterlogging, cold, shading, and salinity. Progress has been made in the identification of genotypes with comparative resistances to drought, waterlogging (in pigeonpea), cold (in chickpea), salinity (in pigeonpea), and soil acidity (in groundnut). Of particular interest is a project on drought research involving groundnuts, set up in India in 1993 jointly by the Indian Council of Agriculture Research (ICAR), the Australian Centre for International Agricultural Research (ACIAR), and ICRISAT.

In the area of biological nitrogen fixation (BNF) our emphasis has been on the identification, production, and supply of effective rhizobial strains, and development and supply of nodulation variants of chickpea and pigeonpea for research purposes to several NARS in Asia.

Genetic improvement

Seed materials and information on our mandate legumes have been provided to several CLAN member countries. Several countries have released cultivars of our three legume crops based on selections made from international trials and breeding lines, and from cooperative breeding research. Details of these releases are given in the CLAN Coordinator's Report.

With a shift in our priorities from production of 'finished' cultivars to developing genotypes with enhanced levels of such traits as resistance to pests and diseases, drought tolerance, specific maturity duration, etc., we shall in future see fewer releases of varieties bred at ICRISAT Center. But it is pleasing to note that many cultivars are being released by countries where our role has been to assist with provision of breeding lines and to pass on material developed by other programs. A considerable number of finished lines produced in this collaborative mode are at the prerelease stage in various countries.

Human resource development

Several aspects of human resource development have been covered elsewhere in this publication. However, it is worthwhile to mention our increased emphasis on short-term courses on specific subjects where the NARS, ICRISAT, and mentor institutes combine to transfer the latest information and technologies to NARS scientists. High on our list of priorities are courses on transformation and regeneration in legumes, and on survey methodology and yield loss assessment for pests and diseases.

Information exchange

A detailed report on information exchange activities appears elsewhere in these proceedings. We regard our three legumes Newsletters as important vehicles for the rapid exchange of information. They form an important part of the legumes information network activity associated with CLAN. During recent years we have responded to many requests for preparation of field handbooks to assist in the identification of pests and diseases of our crops. These are initially produced in English; cooperative efforts are resulting in their subsequent appearance in several other languages.

Future research for the Asian region

In January 1994 ICRISAT will move into its next Medium Term Plan (MTP) period of 1994-98. This plan envisages a greater concentration of research efforts into problem areas or themes which have been judged to have the highest priority for particular ecoregions.

An overall picture of our priorities for chickpea, pigeonpea, and groundnut is shown in Table 1. The various research themes have been aggregated and approximate proportional funding indicated for work on various abiotic and biotic stresses, etc. The development process that led to the formulation of ICRISAT's MTP was centered on prioritization in terms of the importance and solvability of research problems. The many themes reflect current activities, so that although new avenues will inevitably open, there will be no loss in the continuity of our efforts, especially where ongoing activities with Asian NARS are concerned.

Table 1. Legumes research priorities, as reflected in ICRISAT's Medium Term Plan, 1994-98.

Research theme	Chickpea	Pigeonpea	Groundnut	Funding (% of legumes total)
Defoliating pests			+ + +	20
Pod borers	+	+ + + + +		
Soil pests			+	
Nematodes	+	+	+	4
Foliar fungal diseases	+ +		+ + +	23
Soilborne fungal diseases	+ +	+ (+)		
Aflatoxin			+	7
Virus diseases	+	(+)[1]	+ + + + +	15
Drought	+	+	+	17
Waterlogging		+		1
Cold	+			2
Biological nitrogen fixation	+			1
Low yield/Adaptation	+	+	+	10

Each + represents an MTP theme. (+) = linked research areas under one MTP theme.
1. Disease of unknown etiology.

Resource Management Research at ICRISAT

K.K. Lee[1]

Introduction

The Resource Management Program (RMP) at ICRISAT has not been as deeply involved in CLAN as have the Legumes or Cereals Programs. In this presentation, I will briefly discuss RMP's goals, structure, and activities. This information may be useful to the Country Coordinators when they consider future collaboration involving RMP.

Objectives of RMP

The production of food in the semi-arid tropics (SAT) is severely limited by the scarce and erratic nature of the region's resources. The broad goal of RMP is to find efficient, sustainable ways to manage these resources in order to increase the productivity and income of farm households. The means to achieve these objectives are:

- Measuring and assessing SAT resources (physical, biological, and human);
- Understanding the mechanisms of resource capture and use by crop plants in order to identify factors limiting yield;
- Developing and testing systems which minimize production constraints, monitoring their adoption, and assessing the economic consequences of introducing such systems.

Structure of RMP

In order to achieve its objectives, RMP is structured into five groups—agroclimatology (which includes microclimatology), agronomy (production agronomy and cropping systems), economics, soil fertility (soil biology and soil chemistry), and land and water management (which includes soil physics). In addition, a Geographic Information System (GIS) unit provides support to these groups, and to the crop improvement programs at the Institute. Research studies are conducted by each group; there are also a number of interdisciplinary projects which involve scientists from different RMP groups, and from different disciplines in other ICRISAT programs.

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Research activities

Research projects can be divided into four groups—they may be related to agronomy, economics, or soil, or they may be interdisciplinary. A list (largely self-explanatory) of current RMP projects is given below. Because RMP research is wide-ranging and often interdisciplinary, such a list would provide a simple but fairly comprehensive summary of research activities, and thus of areas where ICRISAT's RMP scientists could contribute to collaborative research under CLAN.

Agronomy projects

Agroclimatology. Characterization of agroclimatic environments in the SAT; modeling growth and yield of groundnut, chickpea, and pigeonpea; studies on crop-weather modeling for sorghum and pearl millet; resource characterization for the dry farming regions of India.

Microclimatology. Effects of weather on sorghum grain mold and groundnut foliar diseases.

Production agronomy. Income-generating production systems; long-term evaluation of production constraints; pigeonpea-based production systems.

Cropping systems. Agroforestry systems for the SAT.

Economics projects

Fodder, agricultural research, and drought management; economics of soil and water conservation; quantifying sustainability, and component analysis of alternative cropping systems; groundwater management in dryland agriculture; gender analysis of selected technologies in India; differential impact of new technology on income and employment in India's SAT; dynamics of supply and demand for ICRISAT mandate crops; adoption and consumer preferences of improved chickpea and groundnut cultivars; alternative indicators of food and nutrition security in the Indian SAT; decision support systems for research evaluation and impact assessment.

Soil-related projects

Soil biology. Establishment and long-term manipulation of indigenous and applied mycorrhizae in the SAT.

Soil chemistry. Long-term effects of cropping systems/rotations on crop productivity and soil fertility in assured-rainfall areas.

Soil physics. Effect of water erosion on Alfisol productivity; soil water dynamics of stony Alfisols and Vertic inceptisols; surface roughness for in situ soil and water conservation on Alfisols; runoff collection/storage, and optimal use of supplemental water.

Land and water. Response of soil physical processes to soil management in an Alfisol; conservation effects of porous and vegetative barriers.

Interdisciplinary projects

Land and water + soil biology. Soil floral and faunal activity in relation to cropping practices.

Soil physics + production agronomy. Effect of raised land surface configuration on groundnut growth and yield.

Land and water + cropping systems. Variations in soil factors and their effect on crop establishment.

Soil chemistry + soil biology. Mechanics of residual effects of legumes.

Production agronomy + crop improvement programs. Diagnosis of farmer-level production constraints.

***Production agronomy, soil biology, soil physics + cropping** systems.* Water balance and nutrient cycling of promising cropping systems on Alfisols.

RMP and CLAN

Although RMP does not have a formal involvement in CLAN, some RMP scientists have participated in activities sponsored or coordinated by the network. RMP's contribution has been mainly expertise, e.g., assistance from agronomists and economists in planning on-farm research. RMP scientists have been interacting with their counterparts from NARS in on-farm research and information/technology exchange. Collaboration with NARS includes diagnosis of production constraints, monitoring production technology, assessment of technology components in on-farm trials, and assessment of technology (varieties and management practices) adoption.

ICRISAT's Human Resource Development Program in Asia

B. Diwakar[1]

Introduction

Human resource development is important to any nation, and especially to developing countries. It is for this reason that human resource development amongst the national agricultural research systems (NARS) is an important part of ICRISAT's mandate. The NARS in many developing countries are faced with the challenge of building up a large cadre of trained personnel, while simultaneously pursuing an ambitious research agenda. There is often a shortage of adequately trained personnel; ICRISAT, through a series of training programs run by its Human Resource Development Program (HRDP), helps NARS develop a sufficiently high level of competence in agricultural research and development.

According to a Food and Agriculture Organization (FAO) classification, there are four categories of personnel engaged in agricultural research and development: professionals (with at least a bachelor's degree in agriculture), senior technical personnel (usually with post-secondary technical training or relevant experience equivalent to diploma level), junior technical personnel (usually with 1 or 2 years of training), and vocational staff or artisans (with on-the-job training leading to recognition of competence). These usually constitute the potential pool for a NARS human resource.

The HRDP training programs range in duration from 1-2 weeks to 2 years and include: on-the-job training, post-graduate professional training, short-term theory-oriented courses, research management training, and technical study programs. Such programs are aimed at making NARS scientists/research workers familiar with research technologies, particularly those directly concerned with ICRISAT's mandate.

The number of participants in the HRDP programs has increased steadily, from an average of about 70 per year (1974-78) to 260-280 per year from 1979 onwards.

Study programs

Study programs ranging in duration from two weeks to 2 years are designed to accommodate persons with diverse education and experience. Individual programs are developed in association with scientific and HRDP staff at ICRISAT, and permit each participant to conduct his/her own experiments and trials using ICRISAT facili-

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improvement and Resource Management programs at ICRISAT, and usually form a part of ongoing projects. In addition, comprehensive individualized programs are also available; these are designed on the basis of pre-course evaluations and interviews with applicants. In all cases, practical training forms the core of the study program. Study programs are normally adjusted to allow participants to collect sufficient data. All field and laboratory studies are supervised by research scientists and HRDP staff.

Selection criteria

Applicants must:

- Be employed or recommended by a national agency or international institution;
- Be already working, intending to work, or show an aptitude for working in SAT agricultural programs;
- Rank within the top four applicants from their country;
- Demonstrate a reasonable level of proficiency in English.

Cooperation with other institutions

Several institutions at Hyderabad cooperate with ICRISAT to ensure that HRDP training is of the highest possible quality. Participants from other than Anglophone countries are given intensive instruction in English at the Osmania University, Hyderabad. In addition, special extension methods, lectures, and laboratory exercises are provided by other institutions such as the Andhra Pradesh Agricultural University, National Institute of Nutrition, etc. ICRISAT also has special cooperation agreements with agricultural universities in India and abroad. The Institute has facilitated the enrollment of a number of students at these universities; they frequently pursue doctoral or masters research at ICRISAT while enrolled at the university. Indian universities, institutions, commercial companies, and local farmers are also involved during educational visits arranged for the participants.

Follow-up activities

NARS scientists, in-country development program staff, network coordinators, and former participants assist in improving selection procedures and course content, and identifying areas where additional training programs are needed. Contact is maintained through correspondence and personal visits by ICRISAT staff who are working/travelling in areas where former participants are employed. Germplasm, reports, publications, etc. are provided to former participants to keep their information up-to-date. Such follow-up contact is being maintained with 60% of the Asian participants.

Future orientation

From 1994, HRDP orientation will change, with a gradual devolution of the 6-month in-service programs to NARS. We believe that NARS, over the years, have acquired the skills required to organize such courses. However, the ICRISAT HRDP will assist NARS, if required, in conducting these courses in their respective countries.

Devolution of group training programs will enable ICRISAT to concentrate on short-term scientific courses at ICRISAT Center and elsewhere. The number of requests for pigeonpea, chickpea, groundnut, and resource management training programs will significantly increase as the national programs expand their research and development activities. The major responsibilities of NARS researchers include management of research farms and training of junior personnel. Thus, ICRISAT will continue to emphasize research farm management and development and updating of training material.

ICRISAT will, as a part of the follow-up program, continue to communicate research findings and new developments to former participants for their professional development.

Information Management and Exchange in Asia

R.P. Eaglesfield and L.J. Haravu[1]

Introduction

A research network such as CLAN needs to consider two broad sources of information. The first is information emanating from within the network. Information resulting from network activities; e.g., breeding trials, socioeconomic surveys, on-farm experiments, etc., is of general value and needs to be shared efficiently. Such information is exchanged both formally and informally, using conventional means such as newsletters, workshops, meetings, and training programs. Where possible and where telecommunications facilities permit, electronic mail and computer conferencing techniques can be useful for the sharing of such information.

The second broad source of information originates in the environment external to the network, i.e., information which is generated by cereals and legumes researchers, government, trade, and industry worldwide. Scientific and technical information, especially from the third world, does not always get into formal channels of communication such as journal literature. Similarly, socioeconomic, trade, and marketing information about cereals and legumes in Asia is not easily accessible and requires to be painstakingly collected.

We believe that CLAN needs to consider:

- How to ensure the effective flow of information generated within the network;
- Mechanisms to allow network participants free and continuous access to external sources of information.

This paper highlights some roles that ICRISAT can play in helping CLAN participants gain efficient access to information of both kinds.

Information management at ICRISAT

Editorial, translation, publications production, public awareness; and library, documentation, and information retrieval services are integrated as a single Information Management and Exchange Program (IMEP) within ICRISAT. This facilitates coordination between the different information specialities, and promotes the sharing of resources and the adoption of mutually compatible software and standards. IMEP provides support services to ICRISAT's research staff, and products and services to the scientific community external to ICRISAT.

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IMEP's Library and Documentation Services Unit provides access to worldwide sources of information on subjects of interest to ICRISAT and its collaborators, while the Editorial and Publishing Units are concerned primarily with the production of a wide range of scientific publications on agricultural development on ICRISAT mandate crops. These units also help spread the message about the value of the work we do (in collaboration with NARS), to encourage continued support.

SATCRIS

The Semi-Arid Tropical Crops Information Service (SATCRIS) has been in operation since 1986. Its objectives are to:

- Maintain a comprehensive bibliographic database of scientific and technical information on ICRISAT's mandate crops;
- Provide current awareness services to researchers working on ICRISAT's mandate crops;
- Provide information retrieval services on demand;
- Deliver documents needed by researchers working on ICRISAT's mandate crops and farming systems;
- Produce information analysis products in collaboration with specialists;
- Develop and promote a time-series numeric database of information on crops, resources, and other socioeconomic parameters of interest;
- Experiment with new information technologies such as expert systems and electronic publishing as means of disseminating information.

The central resource of SATCRIS is its database. This has been developed and maintained by obtaining monthly subsets of the CAB International (CABI) and International Information System for Agricultural Sciences and Technology (AGRIS) databases in machine-readable form. These are integrated with ICRI SAT-generated input to create a single, multi-disciplinary database on all ICRISAT's mandate crops. The SATCRIS database is thus more comprehensive than either of the two global databases from which it draws the bulk of its data.

The SATCRIS database is resident on ICRISAT's MicroVAX 3900 computer and is interactively searchable from within ICRISAT Center via a user-friendly interrogation package developed for this purpose. Researchers at ICRISAT now conduct their own searches. The MicroVAX 3900 is an X.25 node on INET, India's packet-switched data network. In principle, this permits remote users in India or outside to access the SATCRIS database in an on-line mode. However, facilities for such remote access to our database have not yet been provided, since many centers in NARS do not have the appropriate infrastructure for such access.

The SATCRIS SDI Service

IMEP operates a monthly alerting service called Selective Dissemination of Information (SDI), which now goes to 410 users in 40 SAT countries, including several in

South and Southeast Asia. In this automated service, user interest profiles are matched against new data received from CABI, AGRIS, and local sources. The SDI output contains abstracts of papers that match a given user's interests. The idea is to provide outputs tailored to the broad or specific interests of individual users, enabling them to keep abreast of current literature. SDI has a built-in feedback, allowing interest profiles to be modified if necessary. The service also delivers the full text (in regular printed outputs) of documents that users find relevant. During 1992, for instance, we provided copies of 3 900 papers to the users of our SDI service.

Many research stations within the SAT do not have the resources to acquire costly information sources such as journals and conference proceedings; for them the SAT-CRIS SDI service is often the only source of current-awareness. Further, since the service draws its information from two global sources, it ensures that a recipient's information is comprehensive.

Information retrieval services

IMEP receives several requests for retrospective searches of information. Such requests are met by searching not only the SATCRIS database but also other databases accessible to IMEP. IMEP uses the AGRICOLA (Agricultural Online Access) database of the US National Agricultural Library (NAL), and the AGRIS database of FAO on CD-ROM (Compact Disc-Read Only Memory) to meet requests that cut across crops and thus require means other than the SATCRIS database.

IMEP also has access to the Pesticide CD-ROM compiled by the Royal Society of Chemistry, UK, containing four databases. These databases provide quick access to information on pesticide products available in Europe, and their active ingredients, structure, properties, and manufacturers. A database for Francophone users, developed by CIRAD in France, provides access to literature produced in West Africa. The Dissertation Abstracts International (DAI) database on CD-ROM provides access to theses of interest to researchers.

More than 750 searches were conducted in 1992 for users in 35 SAT countries.

Information analysis services

In this service IMEP collaborates with specialists to develop products that consolidate information on a specific topic. A comprehensive database relating to the groundnut aflatoxin problem was developed during 1992, and is available for use on PCs. Similarly, a handbook of information on the stem borer *Busseola fusca* has been developed in close collaboration with entomologists at ICRISAT and at the CAB Internationa! Institute for Entomology, UK.

IMEP also produced on behalf of 14 International Agricultural Research Centers (IARCs), a Union Catalog of Serials. This is a product of special interest to NARS libraries since it permits access to the relatively rich serials resources of the IARCs.

The Union Catalog is available as a database under the freely-available information retrieval package CDS/ISIS, and has been distributed to over 300 libraries worldwide.

Expert systems

Expert systems are computer programs that mimic human experts in a narrow domain of knowledge. Such systems contain a knowledge base built with inputs from specialists in that particular field. A computer program provides the interface and inference capabilities which enable users to consult the computer 'expert'. This technique is particularly useful in diagnostic applications.

Since 1991, IMEP has been working on the development of an expert advisory and diagnostic system on groundnut crop protection. This work has been conducted in close collaboration with crop protection specialists at ICRISAT and in research stations in India. The system is targeted at researchers and extension workers. We are now close to the development of a prototype system which will be tested in India, other parts of Asia, and in Anglophone Africa. Following the feedback that we expect to receive, a fully-fledged product will be produced for distribution to research stations and others interested in groundnut improvement. We are also considering the broad relevance of these 'expert system' technologies for workers in other aspects of SAT agriculture.

Software development

IMEP has made CDS/ISIS-based software freely available to several libraries in the SAT to facilitate access to information related to ICRISAT's mandate crops. We recognize that CLAN participants require access to information on other cereals and legumes. This can sometimes be provided by redirecting such requests to other IARCs potentially better equipped to respond. However, we do provide for retrospective searches on crops not mandated to one or other of the IARCs. Some CLAN researchers are already using SATCRIS-related services; others are welcome to enrol.

Time-series numeric database

Research project planning and impact assessment requires access to numeric/statistical data on production, yield, consumption, utilization, etc., of crops, and on related socioeconomic parameters. Such data is often not widely disseminated and tends to be distributed within governmental departments. IMEP is working on the development of such a numeric database using both paper-published and machine-readable sources. The intention is to provide user-friendly access to a variety of data, together with the possibility of using such data for statistical analysis or for the production of charts and figures in publications.

Travelling workshops

One way of improving awareness of ICRISAT's information resources and services is for IMEP staff to travel to user sites and make presentations and demonstrations of our products and services. Under the aegis of the CLAN, a series of travelling workshops is planned throughout Asia. One such workshop was recently held in Sri Lanka. These visits are also used to foster better relationships between NARS and ICRISAT, and the exchange of databases.

ICRISAT's publications program

ICRISAT's publications portfolio includes a variety of publications aimed at communicating ICRISAT's research results, and meeting identified needs of researchers and others in the NARS. These include formal Research and Information Bulletins, Pest and Disease Identification Handbooks, Plant Material Descriptors, and the proceedings of ICRISAT-sponsored workshops. Three newsletters, one on each of ICRISAT's mandate legumes, are published by our Legumes Program. These newsletters are an excellent medium for the communication of information among researchers working on legume improvement. ICRISAT is planning to produce a similar newsletter on sorghum and millet. Annual Reports are also published, both by the individual ICRISAT research programs, and by the Institute as a whole.

On request and by individual agreement, IMEP is willing and able to provide advice and guidance that may be useful to the CLAN community; for example, on publication planning, editing, use of computer graphics and publishing systems, and printing.

ICRISAT also produces electronic publications. The Aflatoxin database and the Union Catalog of Serials are two examples already mentioned. Plans are afoot to produce ICRISAT's germplasm catalogue on CD-ROM. This will provide multi-dimensional access to the germplasm information. Similarly, there are plans to produce computer-aided training materials which CLAN members may find valuable.

Electronic communications

It may be useful for CLAN to examine the potential use of microcomputer-based electronic mail systems which use existing voice grade telephone lines. Examples of such networks are FIDONET and GREENET using communications software such as 'Frontdoor' and 'Procomm'. These are relatively inexpensive to set up. One center acts as the central hub; the others become nodes, but can communicate multilaterally through the central system. Such a channel could be used to set up electronic discussion forums, and provide a quick and easy means of exchanging information.

Assistance to NARS in information management and exchange

Important objectives for IMEP are to be a significant provider of information to the NARS of the semi-arid tropics, and to help NARS to improve their own capabilities for managing information. Let us conclude by reiterating how we expect these objectives to be realized.

- Effective publishing (research results, pest and disease handbooks, workshop proceedings);
- Computer-accessible databases, diagnostic and educational tools;
- Information access (SDI service, use of the ICRISAT Library, search services);
- Development of expertise in CLAN countries (updates on information technologies, on-the-job training for NARS staff, training for specialized skills, guidance to NARS departments).

Grain Quality, Processing, and Utilization of ICRISAT Mandate Crops

Umaid Singh[1]

Introduction

The ICRISAT mandate crops—sorghum, millets, chickpea, pigeonpea, and groundnut—are valuable source of nutrition in many developing countries. Sorghum and millets are staple foods and provide carbohydrates, proteins, and minerals; chickpea and pigeonpea are primarily protein sources. Groundnut is a major source of edible oil, and is also grown for direct consumption and confectionery use in many Asian countries. Breeding programs must therefore work for not only stable, high yields, but also for nutritional and grain quality characters. The Crop Quality Unit (CQU) at ICRISAT provides support to the crop improvement programs in analyzing the quality characters of our mandate crops. CQU studies deal with various aspects of grain quality, processing, and utilization, including consumer acceptance. Food product evaluation in relation to grain characteristics is another important activity. These activities are briefly described in this paper.

Sorghum

Sorghum genotypes exhibit a wide range in chemical composition (Table 1). The large variation in protein content is attributed to variations in the environment and in cultural practices (e.g., fertilizer and irrigation), in addition to genotypic variation. A study conducted at ICRISAT using two high-protein and high-lysine sorghums (IS 11167 and IS 11758) as parents, suggested that the high-lysine gene may not be stable in normal seed with a plump endosperm background (Riley 1980). No further breeding work on developing high-lysine and high-protein sorghum was attempted because of this instability.

A number of foods are prepared from sorghum in African and Asian countries. Sorghum can be puffed, popped, extruded, shredded, or flaked to produce snacks and breakfast food products. Malted sorghum is used to produce traditional fermented beverages in China and several countries in Africa. The main use of sorghum in India is to make unleavened breads, called *roti* or *chapati,* from whole-meal flour. The quantities of water-soluble protein, amylose, and sugars jointly influence *roti* quality (Subramanian and Jambunathan 1981). There were significant cultivaral differences in gel consistency (which provides an index of quality of porridge-type food

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Table 1. Variability in chemical composition of sorghum, pearl millet chickpea, pigeonpea, and groundnut.

Parameter	Sorghum	Pearl millet	Chickpea[1]	Pigeonpea[1]	Groundnut
100-seed mass (g)	2.7 (1.2-5.5)	0.8 (0.5-1.0)	17.9 (11.5-28.4)	9.9 (6.3-13.9)	46.0 (26.2-69.3)
Protein (%)	11.0 (6.2-21.0)	10.5 (5.8-20.7)	20.3 (10.5-31.5)	20.4 (13.2-26.5)	25.8 (15.5-34.2)
Starch (%)	71.0 (56.5-75.3)	71.0 (63.0-78.8)	55.6 (51.1-58.1)	60.7 (56.3-64.1)	13.8 (11.8-16.3)
Soluble sugars (%)	1.8 (1.2-4.0)	2.0 (1.4-2.5)	5.0 (4.1-6.2)	5.2 (4.7-5.8)	5.6 (3.6-7.0)
Crude fiber (%)	1.8 (1.2-3.3)	1.3 (1.1-1.8)	1.1 (0.7-1.3)	1.2 (1.0-1.3)	2.4 (2.1-2.8)
Fat (%)	3.3 (2.1-7.6)	5.1 (4.1-6.4)	5.5 (3.5-6.8)	1.6 (1.2-2.2)	43.5 (31.8-55.0)
Ash(%)	2.1 (1.6-3.3)	1.9 (1.1-2.5)	2.9 (2.1-3.7)	3.9 (3.3-4.3)	2.5 (2.3-2.8)
Calorific value (Cal $100g^{-1}$)	349.0 (336.5-352.0)	361.0 (353.5-374.0)	347.6 (334.0-387.5)	335.0 (328.0-343.5)	567.0

1. *Dhal* samples (decorticated split cotyledons). Range for each parameter shown in parentheses.

products). Consistency is also affected by season and soil moisture, and by dehulling and grinding methods (Murty et al. 1981). Some work on the industrial uses of sorghum (e.g., starch, malt, feed by-products, and sugars) has also been carried out.

Pearl millet

Pearl millet genotypes showed a large variation in protein content (Table 1). Considerable emphasis has been placed on improving the nutritional quality of pearl millet, and two high-protein genotypes (WC 190 and 700112) have been developed at ICRISAT. These and other high-protein genotypes are available, and can be suitably processed and used in baby foods. Pearl millet is also a good source of fat and has high calorific value (Table 1). Like sorghum, it can be used in both traditional and non-traditional foods. Pearl millet flour could be used to make extruded, sun-dried products which serve as acceptable snacks. Pops and flakes made from pearl millet grains are palatable.

Another important area of use is in bakery products. Pearl millet protein lacks gluten. The flour cannot therefore be used as the sole material for bakery products, but fine-flour genotypes with low starch damage can be blended with wheat flour and used. For novel food uses, the grain quality needs improvement through the selection of grain types for specific end-products, and the use of improved processing methods.

Chickpea

There are two main types of chickpea, desi and kabuli. Desi types are generally darker in color (yellow to black) and have smaller seeds than kabuli types, and are preferred for food use in the Indian subcontinent. Kabuli types are preferred in the Mediterranean region. Traditional processing of whole chickpeas generally involves sprouting, boiling, cooking, frying, or roasting.

Among pulses, chickpea shows the largest variation in protein content (Table 1). Salinity was found to significantly reduce both protein content and seed size. Although seed protein content is influenced by environment, genotype x environment interactions were not significant, suggesting that breeding for improved seed protein content in chickpea could be effectively carried out at a single location. The dehulling process results in considerable losses in protein, calcium, iron, and zinc, but does not adversely affect protein quality.

Though nutritive in terms of fats (3.5-6.8%) and minerals content (2.1-3.7%), particularly iron (3.9-9.8 mg 100 g^{-1}), chickpea also contains several anti-nutritional constituents. These include enzyme inhibitors such as trypsin, chymotrypsin, and amylase, and flatulence-causing oligosaccharides such as stachyose, raffinose, verbascose, and polyphenols that reduce protein digestibility (Singh 1985). In general, desi chickpeas have higher levels of these constituents than do kabuli types.

Physical factors such as dispersed solids, texture, and water absorption, and chemical factors such as phytic acid and magnesium content were observed to influence the cooking time in chickpea. Kabuli types are generally preferred to desi types as they require less time to cook and produce a better flavor.

Pigeonpea

Pigeonpea genotypes, like those of the other crops, showed a wide variation in chemical composition (Table 1). Some high-protein lines (HPL 8 and HPL 40) superior to control cultivars (C 11 and ICPL 211) were developed. Pigeonpea contains such anti-nutritional factors as protease inhibitors (which reduce protein quantity), flatulence-causing sugars (raffinose, stachyose, and verbascose), polyphenols, and phytic acid. Some wild species (e.g., *Rhyncosia rothi)* contain very high levels of protease inhibitors; it is therefore important that lines obtained from intergeneric crosses of *Cajanus* with related wild species be tested for the levels of such anti-nutritional factors. However, the anti-metabolic nature of such compounds could provide chemical resistance against some storage insect pests, and this needs to be explored.

Cooking significantly increases protein digestibility in pigeonpea; cooking time and cooking quality are therefore important parameters. Cooking quality is better in rainy season pigeonpea than in postrainy season pigeonpea, and in short-duration cultivars than in medium- and long-duration ones. The cooking time is determined by physico-chemical characteristics such as water absorption, the presence of dispersed solids, and seed texture (Singh et al. 1984).

Green, immature seeds, which are used as a vegetable in India, contain more protein, sugar, and fat than do mature seeds. In addition, their protein is easier to digest. Pigeonpea has a number of potential uses, e.g., in noodles, where it can replace mungbean.

Groundnut

Groundnut is a good source of protein and improves the nutritional quality of cereal-based diets (for example, the protein of ICGS 21 is more digestible than casein). In protein quality evaluation by rat-feeding trials, groundnut was found to be comparable to the reference protein, casein (Jambunathan 1991). However, there are some deficiencies in amino acids, notably methionine, cystine, lysine, threonine, and valine when compared with World Health Organization (WHO) standards.

By simple roasting or grinding, groundnuts can be converted into a variety of quality food products. The flavor of roasted groundnut is very important to consumers. Gas chromatography studies of flavor compounds showed genotypic differences in the flavor component. Sugar composition also influences flavor.

Fatty acid composition, specifically the ratio of oleic to linoleic acids (0:L), plays an important role in determining the stability or shelf life of groundnut oil. In ICRISAT-bred cultivars the 0:L ratio varied between 0.91 and 1.75, and was highest in ICGS 76 (ratios >1.6 are desirable). Some of the lines developed recently by mutation breeding at ICRISAT have shown 0:L ratios higher than 4.0; more work is in progress in this direction.

Blanching quality is important for various food uses (e.g., candies, butter, and confectionery use). There are significant differences between genotypes in terms of blanching quality, which appears to be influenced by seed size. The blanching quality of Spanish types is better than that of Virginia types.

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On-farm Adaptive Research in Asia

D. McDonald, S.N. Nigam, and C.L.L Gowda[1]

Introduction

In the late 1980s ICRISAT became involved with the Indian national agricultural research system (NARS) in on-farm research on groundnut, pigeonpea, and chickpea, with the major objective of transferring improved production technology to farmers in the semi-arid tropics of India. The results obtained were promising; trials on farmers' fields over a 3-year period showed increases in groundnut yield over traditional systems of 32% from the use of improved varieties, 25% from the use of improved cultural practices, and 50-150% from the combination of these two factors. Several Asian countries expressed interest in this approach, and funds were provided by the United Nations Development Programme (UNDP) for ICRISAT to organize a meeting with NARS representatives from Asia, to formulate proposals for on-farm adaptive research on ICRISAT mandate legumes. Based on the recommendations of this meeting, ICRISAT prepared a project proposal which was submitted to the UNDP for possible funding. This was approved by UNDP as a component of the UNDP/FAO RAS/89/040 project, to support adaptive on-farm research on ICRISAT mandate legumes in Indonesia, Nepal, Sri Lanka, and Vietnam. The main objectives of this project are:

- To assist the NARS to assemble information from research and extension sources within the project countries and the region that could be used in generating production technologies;
- To generate and test crop production technology under research station and farmers' field situations;
- To modify the most effective production technologies to suit real farm situations;
- To enhance the adaptive research capabilities and interest of NARS in legumes production.

We followed a four-stage approach: identifying the constraints, finding suitable technologies or solutions, evaluating the solutions in single-factor or multifactor diagnostic experiments, and finally formulating a basket of technology options for the farmers.

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Diagnostic surveys

The target areas for on-farm research were chosen by the national program administrators based on the cropped area, potential for improvement, and other factors that could eventually facilitate the adoption of improved technologies. Diagnostic surveys, using rapid rural appraisal methods, were conducted in the target areas by multidisciplinary teams of scientists from the national programs and ICRISAT. The survey teams included agronomists, breeders, entomologists, economists, pathologists, and soil scientists. The teams visited the target areas and discussed the project with farmers and village leaders. The interviews were informal, but each team member had a check list of questions designed to provide an understanding of the local agroecosystems and agronomic and crop management practices, and to identify the causes of low yield.

Plans for on-farm and supportive back-up research to address the farmer-perceived production constraints were then prepared. For example, the farmer-perceived constraints to groundnut production in two provinces in southern Vietnam are shown in Table 1. The survey team prepared experimental plans for addressing the biotic and abiotic constraints. Suggestions were also made to the concerned

Table 1. Farmer-identified constraints to groundnut production in Tay Ninh and Long An provinces, southern Vietnam.

	Ranking[1]		
Constraint	Tay Ninh Province	Long An Province	Overall priority
Socioeconomic			
Lack of cash for input	**	** *	High
Lack of irrigation	*	** *	Medium
High cost of input	-	* *	Low
Input not available	-	*	Low
Unstable/low price for groundnut	*	*	Low
Spurious pesticides	-	*	Low
Abiotic			
Lack of coconut ash	* * *	* *	High
Lack of farm machinery	**	* *	Medium
Quality of canal water	-	* *	Low
Biotic			
Weeds	**	**	Medium
Leaf eaters *[Helicoverpa* and *Spodoptera)*	***	** *	High
Damping-off disease	**	**	Medium
Lack of high-yielding variety	***	***	High
Yellow leaf disease (?)	*	**	Low

1. Ranking based on yield loss and temporal and spatial occurrence of the problems: * = low, *** = very high importance.

Table 2. Single-factor diagnostic experiments for groundnut on-farm research in Nepal.

Type of experiment	Treatment	Purpose
Seed dressing with fungicides	Thiram + Vitavax (50:50) 3 g kg^{-1} (just before sowing)	To determine whether seedling disease is a constraint
Seed dressing with insecticides	Chlorpyriphos (12.5 mL kg^{-1} seed)	To determine whether soil insects (white grubs) reduce plant stand
Rhizobium inoculation	New culture of NC 92	To see if *Rhizobium* can improve pod yield, particularly in rice fallows
Foliar diseases control	Daconil® (chlorothalonil) 50-60 days after sowing or when around 10 spots $plant^{-1}$ appear	To determine whether foliar diseases are a constraint
Insect pest control	Folithan/Sumithion® 0.5% at 40 days or when insects present	To determine whether insect pests are a problem
Micronutrient spray	Tracel® spray, 30 days after sowing	To determine whether micronutrient deficiency reduces yield
Optimum seed rate (plant population)	60 kg ha^{-1}; 40 x 20 cm spacing	To observe the effect of plant population on pod yield
Gypsum application	400 kg ha^{-1} at peak of flowering with second weeding. Placed near the base of plants on both sides of a row	To determine the role of gypsum in pod filling and pod yield

government authorities to consider how to alleviate the socioeconomic constraints faced by farmers.

Planning meetings

Planning meetings were held in each of the project countries, usually after the diagnostic surveys, and involved the survey team members and administrators, extension staff, and research scientists from the national program. The participants reviewed existing information, and documented the available technology and current ideas as to solutions. The farmer-identified constraints were matched with the available solutions and technology options, and plans were prepared for both on-farm research and supportive back-up work in research stations. Most of the on-farm trials planned were single- or two-factor diagnostic experiments (Table 2). In Indonesia, however, the

NARS scientists were of the opinion that they had some of the technology options needed, and these were combined into sets of production packages and compared with farmers' practices.

On-farm research

The on-farm research in each country followed a farmer-participatory approach. The extension staff and scientists discussed the diagnostic experiments with the farmers and explained the rationale behind the selection of each factor; and they ensured farmer input into the trial design and management. The farmers agreed to implement and manage the individual trials. Research scientists' inputs were to monitor the progress of trials, and to provide timely advice and suggestions on the operations to be undertaken.

On-station research

Whenever the identified production constraints were complex and needed controlled experimentation, experiments were proposed to be conducted by scientists before the farmers tested the technology package. These back-up research plans included, for example: identification of suitable pre- or post-emergence herbicides, determination of the optimum need-based fertilizer requirements for different soils, optimum plant populations for different areas, optimum irrigation schedules, etc. In some cases, the long-term back-up research included varietal development and identification of suitable varieties for different locations/situations.

Results

In countries where single-factor or two-factor diagnostic trials were conducted, the treatment factors that showed consistent yield advantages were combined into sets of improved practices, and then compared with farmers' practices. The national program scientists in Nepal have formulated packages of improved practices for groundnut, chickpea, and pigeonpea. The Vietnamese scientists will formulate the packages after considering the 1993 results. Results from trials in Sri Lanka have not been consistent, and the trials are being repeated. In Indonesia, farmers' practices were compared with both low-input and high-input packages of practices. Average groundnut yields for 1991/92 are shown in Table 3.

During 1993 the Indonesian scientists tested the improved package on a large scale (about 25 ha) to disseminate technology more widely in the village and in nearby villages.

Table 3. Groundnut yields in farmers' fields in Indonesia, 1991/92.

	Yield (dried pods, t ha^{-1})				
		Improved production		Yield increase (%) from	
Target district	Farmers' practices	Low-input package	High-input package	Low-input package	High-input package
Tuban	1.24	1.46	1.94	17.8	56.5
Subang	1.23	1.56	1.62	26.8	31.7

Future plans

We realize that on-farm research is an important activity for the network. However, there are limitations on staff and resources from NARS and the AGLOR Special Project. Therefore, we would like to have your views on how we should proceed with this activity to obtain the best possible results from past and future inputs. Some possibilities could be:

- To provide support for large-scale testing of legumes production technology in Nepal and Vietnam;
- To request Indonesian NARS to take over the development-oriented activity to popularize the improved production technologies;
- To extend the project to one or more new countries.

Funding Institutions
and
Potential Collaborators

Opportunities for Collaboration between the Asian Development Bank and CLAN[1]

M. Dembinski[2]

Introduction

I would like to thank ICRISAT for inviting me to discuss opportunities for collaboration between the Asian Development Bank (ADB), ICRISAT, and the CLAN member countries. I would like to use this occasion to review ADB's support of agricultural research, discuss research-related issues, and present some principles behind the Bank's approach to project design. This may be of assistance to ICRISAT/CLAN as it formulates new proposals for consideration by the ADB.

ADB support for research

As a multilateral development financing institution, it is the Bank's policy to support agricultural research at regional and national levels (ADB 1983). At the regional level, the Bank has been providing support to international research centers including ICRISAT, with a view to ensuring that issues of particular concern to its developing member countries (DMCs) in the Asia-Pacific region are adequately addressed, and that research results are shared with the Bank's DMCs. At the national level, the Bank has provided support to national research institutes for carrying out applied and adaptive research, in close association with extension services to ensure the dissemination of research results to farmers.

As of Jun 1993, the Bank has provided more than US$ 25 million as grants to international research centers. Since 1976, support for ICRISAT has amounted to US$ 4.445 million in grants for a total of nine projects.

Presently there are two ongoing Regional Technical Assistance (RETA) projects involving ICRISAT: RETA no. 5393, Strengthening Grain Legumes Research in Asia—Phase II, approved in Sep 1990, and RETA no. 5405, Strengthening of the Genetic Resources Unit of ICRISAT, approved in Nov 1990.

As a matter of policy, the Bank does not contribute to the core program or budget of any International Agricultural Research Center (IARC), including ICRISAT, but limits itself to financing selected projects. Annual disbursements (using the RETA modality) vary considerably from year to year, and in 1993 are estimated to be US$ 3.12 million.

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1. The views expressed in this paper are those of the author and not necessarily those of the Asian Development Bank.

2. Agriculture Department, Asian Development Bank, P.O. Box 789, Manila 1099, Philippines.

Issues in agricultural and natural resources research

In our view, there are four major issues that influence the nature and priorities for agriculture research.

- Rising food requirements;
- Constraints to food supply;
- Sustainability and environmental considerations;
- Deforestation and loss of biodiversity.

Rising food requirements. As a result of population growth, increasing incomes, and urbanization, demand for food in the region is growing at an average rate of 3.1% per year. The annual growth rate in per capita Gross Domestic Product (GDP) in the region is projected at 5% per year. Higher incomes will imply increased demand for livestock products and vegetables; increases in livestock demand will in turn lead to expanded demand for feed grains. Diets will shift from coarse grains, roots, and tubers, to livestock products and high-value cereals such as wheat and rice; an increase in urban populations will contribute to this shift in food preferences (ADB 1993).

Constraints to food supply. Food production in the region is expected to increase at 3% annually up to the year 2000, slightly below demand, thus making the region a net importer of food. Most production growth will be due to investments in irrigation, improved seeds, and higher input levels, the latter two largely influenced by technology development.

The key constraint to production is the declining availability of arable land. The total arable land area in the Asia-Pacific region amounts to 448 million ha, or an extremely modest 0.2 ha per capita. There is little room for expansion, particularly since arable land is being lost due to degradation (wind and water erosion, salinity, and flooding) and urbanization.

Sustainability of agricultural production, and environmental considerations. While problems such as soil erosion, salinization, waterlogging, desertification, and pollution threaten the sustainability of agriculture in large areas in the region, agricultural activities themselves can adversely affect other resources. Lowland agriculture often affects fisheries, and the overuse or inappropriate use of fertilizers and pesticides affects water bodies. Irrigation sometimes leads to serious salinity and waterlogging. Efforts to increase agricultural production substantially in the future will exacerbate these problems unless new strategies are adopted.

It is important to recognize that, within certain limits, sustainability, increased production, and environment conservation are compatible goals. Increased production on existing agricultural land reduces pressure to clear and develop new lands.

Therefore, high priority should be given to research designed to increase yields with technologies which are environmentally benign but allow for cost-effective and sustainable production.

Deforestation and loss of biodiversity. Projects for which ADB funding is sought should be in line with the Convention on Biological Diversity, and specifically Articles 12 and 15-18, which address research and training, access to genetic resources, transfer of technology, and technical and scientific cooperation. In line with these articles, the Bank promotes biodiversity research, and assists in the conservation of biodiversity and the creation of conditions facilitating access to genetic resources by countries and farmers. RETA no. 5405 (Strengthening of the Genetic Resources Unit of ICRISAT), which was funded by ADB, was formulated to address these issues.

Project design

In addressing its objectives and priorities in agriculture and natural resources research the Bank is guided by the following principles (ADB 1993).

Linkage to ADB's objectives. All research technical assistance (TA) and loan projects must clearly support the Bank's strategic objectives, and the needs and priorities of the concerned DMCs. These specifically include economic growth, poverty reduction, women in development, and environment conservation and management. Thus, a research project would have to demonstrate that it does indeed focus on crops in which the concerned country has a comparative advantage, that the technology takes adequate account of poverty and equity considerations, and that it is environmentally friendly.

Linkage to beneficiaries and market. In the design of research projects (TAs or loans), the linkage between the project and potential beneficiaries and the market must be substantially demonstrated. Thus, the potential target users of the technology must be identified; their capacities concerning the proposed technology must be taken into account; an analysis of the market for the products of the research must be undertaken; and the implications of all these must be built into the project design.

Timebound, monitorable targets. Given the nature of research projects, there is a general, though understandable, reluctance to tie them down to quantifiable and/or tangible deliverables. However, in view of the Bank's accountability to its shareholders and borrowing member countries, every effort must be made in Bank-financed research projects to identify specific outputs of such projects, the linkage of these outputs to the stated objectives of the project, and a schedule for their achievement.

Technology transfer. An intrinsic objective of every research project financed by the Bank, particularly those implemented by the IARCs, is the transfer of technology to local research and implementing institutions. As such, building up of local research and implementing institutions is an essential feature of such projects. Thus, each Bank-financed research project should have specific provisions for such transfers of technology. Related institution-building of local institutions should be part of such projects.

Proposed new project for cereals and legumes research—Phase III

In early 1987, ICRISAT requested the Bank's support to finance AGLN activities. Technical assistance for Phase I, which involved four South Asian countries—Bangladesh, Myanmar, Nepal, and Sri Lanka—was approved by the Bank in Dec 1987 and was completed satisfactorily in Jun 1990.

In Jul 1990, the Bank approved Phase II of the technical assistance for Strengthening Grain Legume Research in Asia, now involving seven more countries: People's Republic of China, India, Indonesia, Pakistan, Philippines, Thailand, and Vietnam. The scope of the technical assistance was designed to cover three major components—research, training, and coordination and planning by ICRISAT in cooperation with the NARS. This resulted in considerable opportunities for scientists from the 11 countries to cooperate with ICRISAT and with each other. Each participating country has formulated and implemented a detailed plan of research and training on grain legumes; and ICRISAT and the participating countries, with few exceptions, have developed effective means for channelling Bank grants from ICRISAT to the national cooperators. An extension of the technical assistance by 1 year has been suggested, as disbursements have not been completed as of Sep 1993, the original completion date.

The Bank has now received the outline of a project proposal to develop and test integrated management systems for aflatoxin contamination, using cultural practices and varietal resistance.

Without being able to make any commitment at this point, I wish to invite the participants of this workshop to discuss the achievements to date of RETA 5393 on grain legumes research, and the suggested objectives and scope for Phase III of the Cereals and Legumes Research Program. The results of the discussions will facilitate the Bank's consideration for further support to grain legumes research in Asia through ICRISAT.

In conclusion, I wish the participants success in their deliberations. I do hope that the Bank's modest support will continue to be a catalyst for promoting grain legumes research, and that such research will produce tangible benefits for the small farmers and the rural poor in Asia.

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Opportunities for Collaboration between AVRDC and CLAN

D.H. Kim, S. Sundar, and C.Y. Yang[1]

The mandate crops of the Asian Vegetable Research and Development Center (AVRDC) are Chinese cabbage, pepper, tomato, onion, garlic, shallot, soybean, and mungbean. Since its establishment in 1971, AVRDC has been active in (but not restricted to) Asia; the demand for collaborative activities from other regions continues to be strong. The Center is in the process of expanding its research globally. In order to bring some of its activities closer to its partners and to respond more effectively to differences in needs and capabilities of various regions, regional centers are being established. The AVRDC-Thailand Regional Training and Outreach Program has been expanded to become the Asian Regional Center (ARC). Two other regional centers have also been established in southern Africa and Central America.

ARC serves three subregions—Southeast Asia, South Asia, and China—in research, training, and information exchange. The mungbean and grain soybean programs of AVRDC have been transferred to, and are now implemented from, ARC because of the importance of these crops in the region.

This paper highlights some of AVRDC's activities on mungbean and soybean, and the possible areas of collaboration between AVRDC and CLAN. In fact, the possibility of collaboration has already been discussed at the previous AGLN Coordinators' Meetings, and also in 1988, at a meeting organized by the Australian Council for International Agricultural Research (ACIAR) and the International Development Research Centre (IDRC) in Bangkok. AVRDC hopes that some solid conclusions can be reached during this meeting.

Mungbean and soybean research

AVRDC is the only international agricultural research center with a mandate on mungbean, and has played an important role in mungbean improvement. It has the world mungbean collection with about 6 000 accessions. AVRDC-improved lines are moderately resistant to *Cercospora* leaf spot and powdery mildew, early-maturing with a uniform maturity period, and have reduced photothermal sensitivity, improved plant type (with pods above the canopy) and larger seed weight. Yields as high as 3 t ha^{-1} have been obtained in experimental plots. As of November 1992, 53 cultivars from AVRDC breeding lines have been officially released in 19 countries in collaboration with the national partners. Recently, AVRDC has focused on the devel-

1. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

opment of lines with resistance to mungbean yellow mosaic virus (MYMV) and bruchids, and on the application of biotechnology. In collaboration with the University of Minnesota, USA, we have identified over 200 RFLP markers, including some associated with MYMV and other diseases. Using RFLP-assisted breeding techniques, we have been successful in removing undesirable donor parent traits in 2-3 backcrosses, as against 5-6 backcrosses required by conventional methods.

AVRDC initiated its tropical soybean improvement program in 1973. In the first decade, efforts were concentrated on assembling a germplasm collection and on screening germplasm for photothermal insensitivity, high yield, adaptation to a rice-based cropping system, and disease resistance. At present AVRDC has more than 12 000 accessions. AVRDC's improved lines carry reduced sensitivity to photothermal variation, specific adaptation to tropical environments and rice-based cropping systems, and resistance to bacterial pustule and downy mildew. Some level of soybean rust tolerance has also been incorporated. Under experimental conditions a yield potential of 6 t ha^{-1} has been demonstrated, and yields of 4 t ha^{-1} have been consistently obtained with a number of our lines. As of Aug 1993, 25 cultivars developed from AVRDC breeding lines have been officially released in 11 countries, in collaboration with national partners.

In the second decade we focused on the development and promotion of vegetable soybeans. Priority was given to improving resistance to diseases and insects (e.g., stink bug and pod borer), and quality characteristics of grain and vegetable soybean (e.g., by including lipoxygenase null genes). As a result of these efforts, Taiwan and Thailand have officially released vegetable soybean varieties for both export and domestic consumption.

Potential for collaboration

CLAN and AVRDC are currently linked, as members of IPM groups for insect pests. However, these links are restricted and very specific, and should be expanded considerably. AVRDC has a strong presence in Asia, in 10 Southern African Development Community (SADC) countries in Africa, and in parts of South America. This represents a considerable overlap with ICRISAT and CLAN; more extensive collaboration would therefore be of mutual benefit. AVRDC can contribute to CLAN in many areas: collaborative research programs with NARS, supply of germplasm and breeding materials, including several nurseries, information exchange, human resource development for NARS scientists, sponsorship of meetings and workshops, etc. If AVRDC is invited to join CLAN, and the CLAN mandate extended to include mungbean and soybean, it would further strengthen the network.

Opportunities for Collaboration between ICARDA and CLAN

W. Erskine and M.C. Saxena[1]

Introduction

The International Center for Agricultural Research in the Dry Areas (ICARDA) was started in 1977 with worldwide responsibility for research and training on the improvement of faba bean and lentil, and a regional responsibility for the improvement of both pasture and forage legumes and of kabuli chickpea, the latter in association with ICRISAT. Following the recommendations of the 1988 ICARDA External Program Review, research on faba bean improvement has been discontinued at ICARDA headquarters and devolved to collaborating national programs; genetic resources and documentation activities on the crop have continued at ICARDA. Research and training towards the improvement of kabuli chickpea, lentil, and forage legumes are now concentrated within the Legume Program at ICARDA.

The Cereals and Legumes Asia Network (CLAN) assists national programs in Asia to improve ICRISAT mandate crops by providing a forum for technology and information exchange. The aim of this brief discussion paper is to explore areas of common interest, where CLAN and ICARDA can cooperate.

Previous cooperation

Links between ICARDA and the Asian Grain Legume Network (AGLN), one of the predecessors of CLAN, were forged through cooperation in the fields of training and travelling workshops and breeders' meets. ICARDA senior staff participated in short-course group training on grain legumes in Nepal in 1988 and in Bangladesh in 1989. There was participation from ICARDA in travelling workshops and breeders' meets in Pakistan in 1986, at ICRISAT in 1987, and in Nepal in 1989. The AGLN coordinator participated in the workshop 'Lentil in South Asia' in New Delhi in March 1991. Many AGLN (now CLAN) cooperators receive ICARDA/ICRISAT kabuli chickpea and other international nurseries from ICARDA, and test the material for adaptation to their specific cropping sytems.

1. International Center for Agricultural Research in the Dry Areas, P.O. Box 5466, Aleppo, Syria

Future cooperation

We envisage that cooperation in the fields of group training *(e.g.,* in-country short courses) and participation in travelling workshops/breeders' meets will continue.

However, it is particularly in the field of lentil improvement that we are looking to increase collaboration. Half the world's sown area of lentil is in South Asia—Bangladesh, India, Nepal, and Pakistan. The ICARDA headquarters are situated in West Asia, the second main area of lentil production. ICARDA's principal research thrust on lentil was initially targeted at the West Asia and North Africa region, with little spin-off from that work to other areas. Principally, this was because the adaptation of Mediterranean germplasm does not extend to South Asia because of differences in temperature and daylength in these contrasting growing environments (Erskine et al. 1990). More recently, ICARDA has intensified its efforts to improve lentil in South Asia: joint research programs have been initiated, particularly in breeding, with the Pakistani and Indian national programs.

We aim to further strengthen research by initiating a regional lentil research network. An ICARDA/ICAR sponsored seminar on 'Lentil in South Asia' was held in Delhi in March 1991 to review lentil improvement work to date, and collectively define the need and scope of a regional lentil network. Specific technical goals were set for such a network. Participants from South Asia were emphatic about the need for such a network and its potential for the development of the crop in their individual countries. We are now seeking funding for such a network with the intention that it will dovetail very closely with CLAN, and complement its activities. As International Agricultural Research Centers become increasingly eco-ecological in their orientation, collaboration between ICARDA, which has a world mandate on lentil, and ICRISAT, with its eco-regional mandate in South Asia, will increase. As the shape of the lentil network becomes clearer, so will specific new areas of collaboration with CLAN emerge.

Table 1. International trials and nurseries in lentil coordinated by ICARDA.

	Target traits in different regions		
Trial/Nursery	Mediterranean region	Southern latitudes	Highlands
Yield trials	Large-seeded Small-seeded	Early-maturity	Cold tolerance
Nurseries	Large-seeded Small-seeded Wilt-resistance	Early maturity Ascochyta resistance Rust resistance	Cold tolerance
Segregating populations	Large-seeded Small-seeded	Early maturity	Cold tolerance

Meanwhile, there is already considerable cooperation between ICARDA and national programs in Asia through international breeding and agronomy trials (Table 1), training, documentation (such as the LENS newsletter and other services), and visits. Although this activity does not come under the aegis of CLAN, national programs in the area usually have a research team working on *all* the grain legume crops with which ICARDA and CLAN work. Our common goal must be to increase the success of these national teams in grain legume improvement—without over-networking them!

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Opportunities for Collaboration between ESCAP CGPRT and CLAN

C.E. van Santen[1]

Mandate of ESCAP CGPRT

The Regional Coordination Centre for Research and Development of Coarse Grains, Pulses, Roots, and Tuber Crops (CGPRT) is a subsidiary body of the United Nations Economic and Social Commission for Asia and the Pacific (UN/ESCAP). It works on socioeconomic and related aspects of a variety of crops throughout the Asia-Pacific region, and in particular South and Southeast Asia. The mandate crops are coarse grains (e.g., maize, barley, sorghum, and millets), pulses, and root and tuber crops (e.g., yam, potatoes, and cassava). The Centre aims to promote socioeconomic research and development on the production, marketing, and use of these crops.

Our objectives also include the initiation and promotion of research, training, and dissemination of information in Asia and the Pacific for the members and associate members of ESCAP, through partnerships with national research and development institutes and regional and international agencies.

ICRISAT and ESCAP CGPRT: common interests

ICRISAT and ESCAP CGPRT share the following fields of interest, in terms of their respective mandates and objectives.

- The mandate crops—sorghum, pearl millet, chickpea, pigeonpea, and groundnut, although the Centre's mandate also includes other crops;
- The Asia-Pacific region;
- Development of improved farming systems through more effective use of natural and human resources;
- Identification of constraints to agricultural development, and their alleviation through technological and institutional changes;
- Providing assistance for development and technology transfer to farmers through cooperation with national partner institutes, and by providing a forum for researchers and other specialists by sponsoring workshops and international meetings, operating training courses, and assisting extension activities.

1. UN ESCAP CGPRT Centre, Jalan Merdeka 145, Bogor 16111, Indonesia.

Previous cooperation

ICRISAT and ESCAP CGPRT have cooperated in several areas in the past. Since 1984, senior staff members of each institution have participated as resource persons in workshops and regional meetings organized by the other. ICRISAT and CGPRT were partners/subcontractors in the Regional Cooperative Programme for the Improvement of Food Legumes and Coarse Grains in Asia, the UNDP/FAO RAS/82-02 and 89/040 projects. The Deputy Director General of ICRISAT and the CGPRT's Director are members of the Steering Committee for the RAS/89-040 project. In addition staff from both institutions worked closely to organize training courses and workshops, and supervise national studies under these projects. The ICRISAT Assistant Director General (Liaison) participated in the Centre's External Review Mission in October 1991.

Potential for future cooperation

Recently the Centre prepared a Strategic Plan outlining the directions of its activities for the 1990s and beyond. In principle, it is interested in cooperation with CLAN/ICRISAT on the major issues mentioned in the Strategic Plan:

- Market development and postharvest processing;
- Changing demand and production systems;
- Sustainable agriculture and resource management;
- Agricultural diversification and poverty alleviation; and
- Regional cooperation and policy analysis.

These themes form the basis of the future work plans within the context of ESCAP CGPRT's interest in the agroeconomic and socioeconomic aspects of research and development of CGPRT crop production, marketing, and use within the Asia-Pacific region.

In view of the Centre's responsibilities for human resources development for the above, it would be interested to jointly organize with CLAN/ICRISAT training courses, workshops, and study tours on subjects of mutual interest, continuing the close cooperation as existed under the RAS/89/040 project on on-farm research. CLAN/ICRISAT's contribution would be largely on the technical/biological aspects, and that of ESCAP CGPRT on socioeconomic aspects.

Databases. Another issue suitable for cooperation would be database management of information on crops and related issues of mutual interest. The Centre's input would in this case be the Regional Statistical Database System (RSDS) for CGPRT crops, which covers information from production up to use.

RSDS covers at present information from seven countries: Indonesia, Philippines, Thailand, Vietnam, Sri Lanka, Pakistan, and Myanmar, and will be expanded to other countries. The crops covered by the database include rice, maize, cassava, sweet potato, potato, groundnut, and soybean. Individual countries may want to expand the database to include other crops which may be important in those countries; the ESCAP CGPRT will assist them in doing so, as was done in Sri Lanka for black gram, green gram, cowpea, and millets. The Centre also provides technical assistance on how best to access/analyse information from existing databases, and how to update such databases.

Opportunities for Collaboration between Australian Programs and CLAN

R.G. Henzell[1]

Pearl millet is the only ICRISAT mandate crop not researched in Australia, although pigeonpea research is currently very limited. There are major programs for sorghum and groundnut, and a smaller breeding and agronomy program for chickpea.

Sorghum

In sorghum, breeding is the major research activity, there being two public and three private sector breeders. The major objectives are to develop:

- Higher-yielding hybrids under water-limited conditions (staygreen, etc.);
- Host-plant resistance to the sorghum midge. Over 50% of the hybrids now grown are moderately resistant; further improvement is sought in resistance levels and adoption of such hybrids;
- Short-duration varieties;
- Grain types for feed (red grain is acceptable).

Sorghum research activities include several other areas:

- Physiology, especially the contribution of osmotic adjustment and staygreen character to yield under water-limited conditions;
- Development of molecular markers to aid selection of characters such as osmotic adjustment, staygreen, and midge resistance, which are difficult to select for;
- Exploring the possibility of breeding for nitrogen-use efficiency;
- Development and use of a sorghum growth model which can be used to assess traits and target environments, and in risk management, etc.
- Developing integrated pest management practices (especially biological control measures) for *Helicoverpa* control in a range of crops including sorghum;
- Developing transformation protocols including *Agrobacterium* and microprojectile-mediated DNA transfer;
- Exploring the potential of wild species of sorghum native to Australia to provide useful genes, and the development of methods to transfer any such genes to *Sorghum bicolor.*

1. Queensland Department of Primary Industries, Hermitage Research Station, via Warwick, Queensland 4370, Australia.

Groundnut

Australia was involved in an ACIAR-funded project on Peanut Improvement in Indonesia (1986-91). Drought was identified as a major production constraint; and another ACIAR project on Selection for Water-use Efficiency in Food Legumes commenced in 1993. This project involves groundnut, chickpea, soybean, navy bean *(Phaseolus* sp) and cowpea. The collaborators for both projects are/were the national program, ICRISAT, and the Queensland Department of Primary Industries. Positive outcomes from these studies are likely to apply throughout the CLAN region.

Groundnut research in Australia has involved:

- Breeding;
- Foliar disease control through fungicides;
- The effects of land management (crop rotation, minimum tillage, stubble retention) on soilborne fungi, water retention, and storage. The objectives include improvement of decision making on fertilizer use;
- Management of aflatoxin (i.e., testing and resistance breeding);
- Weed control.

Chickpea

Australian farming systems involve mainly wheat and barley; the addition of a winter legume is desirable. Chickpea is not grown on a large scale: the cropped area is about 200 000 ha. Most varieties now grown are desi, but kabuli types are being developed. The present objective is to adapt chickpea to mechanized farming systems in Australia. The significant constraints are abiotic (drought and low temperatures) and biotic factors. Several of the latter (e.g., *Helicoverpa,* gray mold, viruses, and broad-leaved weeds) are major problems in some Asian countries also. Closer links with Asian scientists to develop solutions to these problems would therefore greatly benefit the Australian chickpea industry.

Research cooperation between ICRISAT and Australian institutions also covers other areas. Australian programs make extensive use of ICRISAT germplasm. Cooperation is also being implemented in the Global Grain Legumes Drought Research Network (GGLDRN) which is being led by ICRISAT and the International Center for Agricultural Research in the Dry Areas (ICARDA). Outcomes from this research, once again, are likely to apply to the CLAN region.

Pigeonpea

The large-scale introduction of pigeonpea as a summer grain legume is constrained by several factors. The Australian grain cropping environments where pigeonpea is of interest are characterized by generally low and extremely erratic rainfall patterns, and very high *Helicoverpa* pressure. Development of large-seeded, extra short-duration, *Helicoverpa*-resistant cultivars in conjunction with Asian scientists is of vital importance if this crop is to be successful in Australia. We are particularly interested in collaborative research programs on biological control of insect pests.

Collaboration with CLAN

Australia could contribute to CLAN activities in several ways:

- Human resource development;
- Provision of germplasm (especially sorghum) adapted to water-limited conditions;
- The proposed ICRISAT-ICAR-Australian project on sorghum, which is expected to benefit both Australia and much of the CLAN region.

Recommendations

Recommendations

The participants formed two groups (South Asia and Southeast Asia), and discussed both ongoing and future activities of CLAN. The Chairperson of each group presented a report, which was discussed by the meeting before recommendations were framed. The following recommendations were agreed upon:

Objectives. The objectives of CLAN were reviewed and accepted with minor modifications. The overall objective is to facilitate, support, and coordinate research and information/technology exchange on sorghum, millets, groundnut, chickpea, and pigeonpea among the Asian NARS. The specific objectives are to:

- Strengthen linkages and enhance the exchange of germplasm, breeding material, technical information, and technology options among members;
- Facilitate collaborative research among members to address high-priority production constraints. Research planning should take into account both poverty alleviation and gender equity issues;
- Help to improve the research and extension capabilities of member countries through human resource development;
- Improve coordination of regional research on sorghum, millets, chickpea, pigeonpea, and groundnut;
- Contribute to the development of stable and sustainable production systems through a responsive research capability in member countries.

Funding for CLAN activities. The participants strongly endorsed the proposed activities under CLAN and recommended that the Asian Development Bank be requested to provide funds for future CLAN activities.

Working Groups. Working Groups were considered to be very useful, and the meeting recommended that existing Working Groups be strengthened, and new ones identified in areas of need. The Working Groups in turn would identify lead and satellite centers among NARS, which would constitute the focal points for network-supported research. Eventually, the coordination of Working Groups would be transferred to these lead centers.

On-farm adaptive research. The group felt strongly that on-farm adaptive research (OFAR) was an essential component of research, and should be a major network activity. CLAN should increase its involvement in training in OFAR methodologies, and collaborate with NARS in the planning and implementation of OFAR programs.

Information exchange. Efficient exchange of information, research results, and technology is crucial to the success of network collaboration. ICRISAT's Information Management and Exchange Program, especially its library and documentation unit, should continue, and even intensify, its involvement with the network. In-country information exchange networks using the latest electronic/computerized systems should be developed with technical assistance from CLAN. Co-publications (disease and pest identification handbooks, bulletins, etc.) should be increased.

Human resource development. ICRISAT's contribution to this vital activity should move towards high-tech training; responsibility for the existing production-type training courses (which are very useful) could be devolved to NARS. CLAN should provide information to members on training opportunities available regionally and globally.

Linkages between members. Various types of network activities that bring members together should be continued and strengthened. These could involve: review and planning meetings, monitoring tours (in-country and regional) and surveys, exchange of visits by scientists, and workshops and meetings. It was recommended that policy makers from the member countries should also be involved in such activities to strengthen their support for (and appreciation of) CLAN activities.

Coordination. The Country Coordinators strongly recommended that ICRISAT should continue to support the CLAN Coordination Unit. The national programs were currently not in a position to take up responsibility for network coordination, but this issue could be considered later, say after 3-5 years.

It was considered necessary to increase NARS involvement in coordination as a preliminary to eventual devolution of coordination responsibilities to NARS. To this end, it was agreed to consider the establishment of a Visiting Scientist position in the Coordination Unit. The proposal was supported by by representatives from South Asian countries, and some (but not all) from Southeast Asia. The Visiting Scientist will work as Associate Coordinator, thus gaining experience in network coordination, and acquiring a transnational perspective. Selection would be from nominations received from the member countries. The position should be on a short-term (6 months) rotation basis to ensure that most member countries can participate. Nominated candidates should have special skills in research, technology, or extension work that will help improve the working of the Coordination Unit.

Steering Committee. Although the meeting recognized the importance of an advisory body for the network to complement the role of Country Coordinators, opinion was divided on the formation of a smaller Steering Committee. In the absence of a consensus, it was agreed that the Steering Committee will, as at present, comprise all the Country Coordinators, who would collectively oversee the work of the Coordination Unit. It was recognized that Country Coordinators' meetings will necessarily be infrequent because of funding limitations, but the Coordination Unit should try to organize these meetings as often as funds permit. The CLAN Coordinator would send half-yearly progress reports to all Country Coordinators and seek their advice and guidance.

Collaborative breeding research. The group expressed appreciation for the collaborative breeding endeavors (cooperative breeding, population improvement, and polygon breeding) and supported an extension of similar collaborative endeavors to other research areas.

Newsletters. There was no need at this stage to publish a separate CLAN newsletter; existing newsletters (published by ICRISAT and others) should be used for information dissemination. Additional information of specific interest to CLAN cooperators could be provided in the half-yearly Coordinator's Report.

Communication using electronic mail and other channels, which are improving rapidly, should be encouraged.

Videos and slide sets. Slide sets were found to be useful in information dissemination. This activity could be continued on a limited scale, as at present. Videos, which are expensive and time-consuming to make, should be used only in cases where they are clearly the best and most cost-effective means of communication.

Collaboration with other networks. The participants recognized that crops other than those mandated by CLAN may be important in some (perhaps several) countries. CLAN should be encouraged to establish links with other networks, especially those on mungbean and lentil, to maximize benefits to members. This could be accomplished by reciprocal participation in meetings, workshops, and training activities organized or supported by the respective networks. Joint meetings and surveys and common in-country review and planning meetings would encourage closer interaction, and save on operational costs.

Appendices

Appendices

Appendix 1. Recommendations of the Asian Grain Legumes Network (AGLN) Coordinators' Meeting, ICRISAT Center, 10-12 Dec 1990.

Germplasm

- That AGLN procure all released varieties of AGLN crops from member countries and redistribute them among AGLN countries;
- That germplasm lines of AGLN crops suitable for rice-based cropping systems be supplied to AGLN countries;
- That for groundnut, cold-tolerant and early-maturing lines from China, shade-tolerant lines from Philippines, and acid soil tolerant lines from Indonesia be made available to Bangladesh, India, Myanmar, and Nepal;
- That for chickpea and pigeonpea, efforts be intensified to identify and distribute lines with tolerance to saline soils, waterlogging, and *Helicoverpa* pod borer (in chickpea and pigeonpea), podfly, and *Maruca* pod borer (in pigeonpea).

Breeding materials and trials

- That major problems in AGLN crops be identified for each country, and where common, resistant material be crossed with adapted local varieties, and segregating material supplied;
- That ICRISAT continue to supply nurseries and trials on request.

Training

- That the regular training conducted by ICRISAT continue;
- That training programs for technicians be increased, and be of 1-2 month duration;
- That training programs not be confined to ICRISAT Center;
- That the training program include training of trainers;
- That in-country training based on identified priorities be included in the training program;
- That in-service fellowships at ICRISAT for participants from AGLN countries be increased.

On-farm research

- That on-farm research be strengthened within the network.

Information transfer

- That surveys, monitoring tours, and workshops be organized to understand production constraints and identify methods to overcome them;
- That teams for survey and monitoring tours be multidisciplinary and include scientists from NARS and ICRISAT.

Information exchange

- That publications on AGLN crops be supplied to all research institution libraries and AGLN members;

Continued

Appendix 1. *continued.*

- That AGLN play a key role in the exchange of germplasm, and that members develop germplasm catalogues of AGLN crops available in their country;
- That AGLN prepare a compendium of crop production technologies being followed in AGLN countries;
- That ICRISAT prepare primers on AGLN crops for farmers;

countries on request.

Funds

- That in each country, the country-AGLN Coordinators be given the flexibility to reallocate funds according to their country's priorities, but only to activities agreed upon.

General

- That efforts continue to establish a larger network that can interact with AGLN, and includes soybean, mung bean, urdbean, and lentil as well as the AGLN crops.

Appendix 2. Germplasm material distributed to Asian countries, Jan 1991 to Jun 1993.

	Number of samples					
Country	Sorghum	Pearl millet	Chickpea	Pigeonpea	Groundnut	Total
Bangladesh	-	-	31	-	70	101
China	-	-	-	-	6	6
India	15 743	6726	4986	3118	2326	32 899
Indonesia[1]	36	-	-	34	138	208
Myanmar	-	-	111	68	500	679
Nepal	20	-	522	-	-	542
Pakistan	3	4	2	-	-	9
Philippines	5	-	-	-	-	5
Sri Lanka	-	-	-	20	10	30
Thailand	30	-	-	-	-	30
Vietnam	5	-	-	-	6	11
Total	15 842	6730	5652	3240	3056	34 520

1. In addition, 36 samples of minor millets were supplied to Indonesia during 1992.

Appendix 3. Groundnut breeding material supplied by ICRISAT Center to Asian countries, Jan 1991 to Jun 1993.

		Number of samples				
Country	Trials	Released varieties	Advanced lines	Segregating populations	Others	Total
Bangladesh	5	7	-	-	-	12
China	15	3	86	-	9	113
India	57	329	1 024	804	74	2 288
Indonesia	7	4	20	-	3	34
Iran	-	-	11	-	2	13
Malaysia	3	-	20	-	-	23
Myanmar	10	1	20	-	1	32
Nepal	8	1	83	-	3	95
Pakistan	3	-	1	-	-	4
Philippines	-	-	9	-	2	11
Sri Lanka	4	-	75	-	-	79
Vietnam	43	-	80	-	-	123
Thailand	7	-	38	-	5	50
Total	162	345	1 467	804	99	2 877

Appendix 4. Chickpea breeding material supplied by ICRISAT Center to Asian countries, Jan 1991 to Jun 1993.

		Number of samples				
Country	Trials	Released varieties	Advanced lines	Segregating populations	Others	Total
Bangladesh	13	4	89	186	62	354
Bhutan	2	2	87	3	8	102
India	131	204	385	1 494	61	2 275
Indonesia	-	-	4	-	1	5
Iran	7	-	-	1	-	8
Myanmar	8	6	7	-	18	40
Nepal	6	1	32	89	11	139
Pakistan	18	-	6	106	-	130
Philippines	4	11	11	12	4	42
Thailand	-	-	2	-	1	3
Vietnam	5	-	2	-	1	8
Total	194	228	625	1 891	167	3 106

Appendix 5. Pigeonpea breeding material supplied by ICRISAT Center to Asian countries, Jan 1991 to Jun 1993.

Country	Trials	Released varieties	Advanced lines	Hybrids	Male steriles	Segregating populations	Others	Total
	Number of samples							
Bangladesh	-	8	11	-	-	-	4	23
Bhutan	5	-	-	-	-	-	5	5
India	222	376	1 048	56	147	43	239	2 131
Indonesia	7	7	22	-	-	-	4	40
Laos	-	3	13	1	-	-	5	22
Myanmar	6	3	13	1	1	-	-	24
Nepal	26	-	12	-	-	-	-	38
Philippines	-	5	16	-	-	-	-	21
Sri Lanka	11	4	54	-	-	102	4	175
Thailand	7	7	18	-	-	-	11	43
Total	284	413	1 207	58	148	145	272	2 522

Appendix 6. Sorghum breeding material supplied by ICRISAT Center to Asian countries, Jan 1991 to Jun 1993.

Country	Number of samples				
	Breeders' seed	Breeding lines	Trials and nurseries		Total
			Sets	Entries	
Bangladesh	-	6	-	-	6
China	-	249	14	338	587
India	55	10 565	204	5 061	15 699
Indonesia	-	5	14	281	286
Iran	-	479	22	532	1 011
Myanmar	-	72	12	228	300
Nepal	-	80	5	130	210
Pakistan	-	164	20	387	551
Philippines	-	55	-	-	55
Thailand	-	242	29	734	976
Vietnam	-	117	2	52	169
Total	55	12 034	322	7 743	19 850

Appendix 7. Pearl millet breeding material supplied by ICRISAT Center to Asian countries, Jan 1991 to Jun 1993.

	Number of samples				
			Trials and nurseries		
Country	Breeders' seed	Breeding lines	Sets	Entries	Total
Bangladesh		6	-	-	6
China		11	-	-	11
India	1 431	7 563	216	5 842	14 846
Indonesia		-	3	57	57
Nepal		-	2	28	28
Pakistan		120	4	102	222
Philippines		10	-	-	10
Thailand		-	2	38	38
Total	1 431	7 710	227	6 067	15218

Appendix 8. Chickpea, pigeonpea, and groundnut varieties and promising lines in Asian countries developed from seed supplied by ICRISAT (as of 1 Sep 1993).

Country	Chickpea	Pigeonpea	Groundnut
Bangladesh	ICCL 81248 Nabin*	76012[1]	ICGS(E) 11
	ICCL 83228	760131	ICGS(E) 55
	ICCL 83105		
	ICCL 83149		
	ICCL 86237		
	ICCL 83007		
	ICCL 83008		
	ICCL 83103		
	ICCL 83107		
	ICCL 86237		
China			ICGV 86269
			ICGV 86289
			ICGV 86187
			ICGV 87187
			ICGV 86330

Continued

Appendix 8. *Continued*

Country	Chickpea	Pigeonpea	Groundnut
India	ICCV 1 * (ICCV2) Swetha* (ICCV 37) Kranthi* RSG 44* (JG62 x F496) GNG 149* (Sel L550 x L2), Anupam* (F378 x F404) ICCV 10* (Bharati) ICCV 6 ICCV 42 ICCV 88102 ICCV 88202 ICCV 89701 ICCV 89230	(ICPL 87) Pragati* (ICPL 151) Jagriti* (ICPL 332) Abhaya* (ICP 8863) Maruthi* ICPH 8* ICPL 87119* ICPL 85012* Birsa Arhar 1 * ICPL 270 ICPL 85010	ICGS 1* ICGS 5* ICGS 11* ICGS 37* ICGS 44* ICGS 76* ICG (FDRS) 10* ICGV 86590* Girnar-1* ALR1* RG141* Konkan Gaurav* ICGV 86014 ICGV 86143 ICGV 88398 ICGV 88438 ICGV 87354 ICGV 87359 ICGV 86325* ICGV 86031 ICGV 86564
Indonesia	-	Mega*[2] ICPL 147 ICPL 85063	Zebra (MGS 9-2-5)
Myanmar	(P436)Yezin 1* (K850 x F378) Shwe kyehmon* ICCV 2 ICCV 5 ICCC 37 ICCC 42 ICCL 82225 ICCV 88202 ICCV 10	ICP 7035 ICPL 87	(JL 24)Simpadetha2* (Robut 33-1) Simpadetha3*
Nepal	(JG 74) Radha* (ICCC 4) Sita* (ICCL 82108) Kalika* (ICCC 32) Kosheli* ICCL 85309 ICCX 880508-21 ICCX 840508-38 ICCX 840508-40	(ICP 11384) Bageswari* (ICP 6997) Rampur Rhar 1*3 ICPL 366 ICPL 146 ICPL 8645	ICGS(E) 52 ICGS(E) 56 ICGV 86010

Continued

Appendix 8. *Continued*

Country	Chickpea	Pigeonpea	Groundnut
Pakistan	ICCC 32	(ICPL 295-1) Brooks* (ICPL 295-4} Saluder*	BARD 699* BARD 479* BARD 92* ICGV 86014 ICGV 86015
Philippines	ICPL151	(JL24) UPLPn 10* ICPL 323 ICP 7035	ICGV 87350 ICGV 86564
Sri Lanka		ICPL 87 ICPL 161	ICGV 87151 ICGV 86564 ICGS11 ICG(CG) 49
Thailand		ICPL 151 ICPL 87 ICPL 83009 ICPL 83024 ICPL 86008	
Vietnam			(ICGS E 56) HL25* ICGV 86055 ICGV 86015 ICGV 86048 ICGV 86105

Released varieties are marked (*). All others are promising lines being considered for identification.
1. Promising lines obtained from ICRISAT through the University of Florida.
2. In cooperation with the ACIAR pigeonpea project.
3. Germplasm line collected in Nepal by ICRISAT-GRP and returned to Nepal, where it was identified as a new variety.

Appendix 9. Workshops and meetings organized in Asia, Jan 1991 to Jun 1993.

Scientists' meetings and regional monitoring tours	
17-25 Jan 1992, Myanmar	Monitoring tour on role of legumes in rice-based cropping systems
8-12 Feb 1993, Nepal	Study tour of on-farrn trials on chickpea and pigeonpea
15-17 Feb 1993, Vietnam	Study tour of on-farm trials on groundnut
Working Group meetings	
4-8 Mar 1991, Bangladesh	First Working Group Meeting on Botrytis Gray Mold of Chickpea
2 Nov 1992, Taiwan	Second Working Group Meeting on Bacterial Wilt of Groundnut
14-17 Mar 1993, Nepal	Second Working Group Meeting on Botrytis Gray Mold of Chickpea
Special workshops to share information	
19-22 Mar 1991, Thailand	Workshop on Integrated Pest Management and Insecticide Resistance Management of legume crops in Asia
17-25 Jan 1992, Myanmar	Workshop on managing groundnut, chickpea, and pigeonpea crops in rice-based cropping systems
4-15 May 1992, India	Regional Crop Modeling Workshop, co-sponsored by AIDAB/COMCIAM[1]
28-30 Oct 1992, Taiwan	International Bacterial Wilt Symposium
18-20 Feb 1993, Vietnam	Workshop on On-farm Adaptive Research

1. Australian International Development Assistance Bureau, Commonwealth Climate Impact Assessment and Management Programme.

Appendix 10. Travel and visits of scientists associated with AGLN (CLAN), Jan 1991 to Jun 1993.

	Trips by NARS scientists to ICRISAT or ICRISAT-supported meetings/workshops			Trips by ICRISAT scientists to Asian countries (outsi de India)		
Country	No. of trips	No. of visitors	No. of mandays	No. of trips	No. of scientists	No. of mandays
Bangladesh	13	33	127	9	17	137
Bhutan			-	1	1	10
China	3	9	59	4	5	85
India	79	266	507	_	_	-
Indonesia	4	12	214	7	14	99
Japan	2	4	14	-		-
Malaysia	2	2	70	3	3	17
Myanmar	1	3	21	10	16	215
Nepal	11	13	159	17	37	302
Pakistan	5	7	82	3	4	26
Philippines	4	11	59	3	5	25
Sri Lanka	14	29	307	13	28	330
Taiwan	1	1	1	1	1	12
Thailand	4	14	121	15	18	104
Vietnam	5	7	370	12	19	245
Total	148	411	2 111	98	168	1 607

Appendix 11. Human resource development for Asian NARS, Jan 1991 to Jun 1993.

Country	No. of participants								
	PDF[1]	Res. Fellow	Sr. Res. Fellow	Res. Sch. (PhD)	Res. Sch. (MSc)	In-servi.	Nat. Sc.	Appren-tice	Total
Afghanistan						2			2
Bangladesh		1					2		3
China		4				6	2		12
India	10	14	6	7	6		7	7	57
Indonesia			3			3	3		9
Laos							2		2
Malaysia			1			1	2		4
Myanmar						4	2		6
Nepal		3		1		2	3		9
Pakistan		4							4
Philippines		4				3	2		9
Russia		1							1
Sri Lanka		2		1		6	6	1	16
Thailand						3	3		6
Vietnam		2	1	1		6	4		14
Total	10	35	11	10	6	36	38	8	154

1. PDF = Post-doctoral fellow, Res. Fellow = Research Fellow, Res. Sch. = Research Scholar, In-Servi. = In-Service Trainee, Nat. Sci. = National Scientist.

Appendix 12. Special training courses for Asian participants, Jan 1990 to Jun 1993.

In-country: Research methods for crop improvement and crop production		
1-7 Mar 1990	Myanmar	Germplasm collection, evaluation, and preservation
7-25 May 1990	Nepal	Use of statistical packages for data analysis and report preparation
9-17 Jul 1990	Sri Lanka	Groundnut, pigeonpea, chickpea, cowpea, mungbean, and blackgram (with AVRDC and DOA, Sri Lanka)
15-26 Oct 1990	China	Virus identification in legumes (with Peanut-CRSP and OCRI/CAAS, China)
2-6 Mar 1992	ICRISAT	Detection of seedborne groundnut viruses, Center (with ICAR, India)
July 1992	Myanmar	Conservation of plant genetic resources (with Myanma Agricultural Service)
Special courses: To improve skills or acquire new skills in a specialized research area		
11 Jan-11 Mar 1992	ICRISAT Center	Research station management
17Feb-13Marl992	ICRISAT Center	Groundnut production technology
16Mar-3Aprl992	Hyderabad and ICRISAT Center	Quality aspects of food legumes and coarse grains (in collaboration with NIN, Hyderabad, funded by FAO RAS/89/040 Project)

Appendix 13. Special training courses planned tentatively for 1994-98.

1. Use of wide hybridization in crop improvement
2. Disease and pest surveys, and crop loss assessment
3. Biotechnology methods and their application
4. Biotechnology in the detection and identification of plant viruses
5. Hybridization and breeding techniques for mandate crops
6. Hybrid seed production technology in pigeonpea
7. Methodologies for the detection and identification of the bacterial wilt pathogen *(Pseudomonas solanacearum)*
8. Detection methods and resistance screening against aflatoxin *{Aspergillus flavus)* fungi
9. Detection and identification of parasitic nematodes
10. Tissue culture and transformation procedures in crop improvement
11. Computer applications for plant breeding
12. Seed multiplication and maintenance breeding in cereals
13. Applied aspects of population improvement
14. Participatory varietal evaluation with farmers
15. Screening methods for insect resistance in sorghum
16. Screening techniques for major diseases of sorghum and pearl millet
17. Development of data sets for molecular mapping, and strategies for marker-assisted selection
18. Agroclimatic analysis for agroecozonation, and constraint analysis
19. Application of Geographical Information Systems in agricultural research and development.

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About ICRISAT

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

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

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

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