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STRENGTHENING NATIONAL WHEAT AND RICE RESEARCH SYSTEMS

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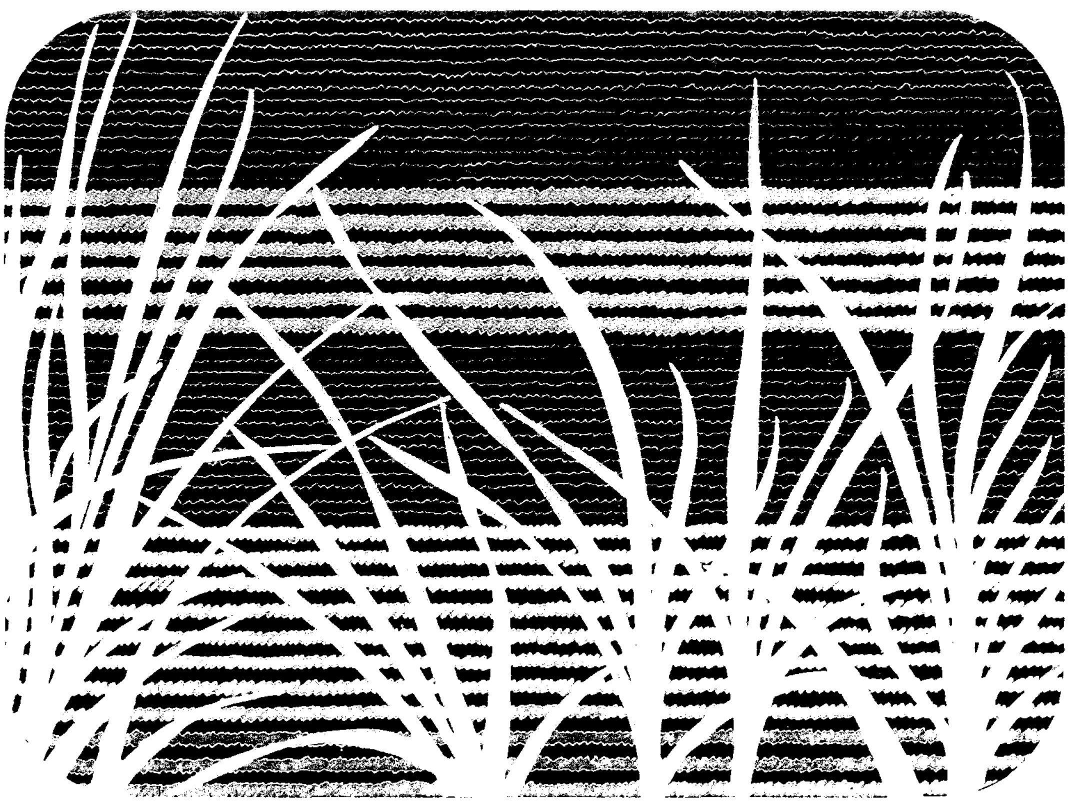

IFAD - INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT

STRENGTHENING NATIONAL WHEAT AND RICE RESEARCH SYSTEMS

A Summary of the International Consultation on *Strengthening National Agricultural Research Systems to Assume an International Role in Specific Areas of Wheat and Rice Research and Training* held 26-28 January 1987. Sponsor: The International Fund for Agricultural Development

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1977
1987

Cosponsors:

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— The Ministry for Development Cooperation of the Federal Republic of Germany

— The Swedish Agency for Research Cooperation with Developing Countries

— The Rockefeller Foundation

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Contents

This publication was written and published with the assistance of Dr. Thomas R. Hargrove and staff of the Communication and Publications Department, International Rice Research Institute.


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Contents

This publication was written and published with the assistance of Dr. Thomas R. Hargrove and staff of the Communication and Publications Department, International Rice Research Institute.

Foreword

The blueprint for a new pattern of partnership was set by leaders of key national agricultural research systems and their counterparts from international agricultural research centres at a Consultation held 26-28 January 1987 in Rome. The Consultation on 'Strengthening National Agricultural Research Systems: Wheat and Rice Research and Training' was hosted by the International Fund for Agricultural Development (IFAD).

For the first time, the partner research systems that stimulated the Green Revolution met under one roof to discuss issues that, in a sense, grew from their own success.

The Consultation set the stage for strong national research systems to share with the international centres certain global responsibilities, including assistance in the strengthening of other national programmes. The dialogue on this new dimension in agricultural development began in Rome but will continue globally and, over time, will have far-reaching implications for research in crops other than rice and wheat.

The Consultation was also the first in a series of year-long activities to commemorate the Fund's Tenth Anniversary. Instead of mere ceremonies, these events will be contributions to the advancement of the causes for which IFAD stands. Placing this Consultation first on the anniversary agenda was a measure of the importance that IFAD attaches to agricultural research.

During its first nine years, IFAD allocated about US$ 80 million in grants to regional and international centres, and additional sums to national programmes, mainly for research to generate new technology for the small farmers who predominate in the rural populations of ecologically vulnerable regions. IFAD-financed projects incorporate such technologies to ensure their direct transfer to the Fund's main target groups: smallholders, the landless, pastoralists, and poor rural women.

Improved technology has already increased food production and distribution considerably in developing countries, but millions of small farmers have not shared in those benefits. IFAD exists to help the rural poor achieve food security; our strategy demands that we pay careful attention to developing the technologies that small farmers need most.

A critical, underlying theme of this Consultation was to examine the highly diverse and location-specific research needs of poor farmers thoroughly, and to explore new and better ways of helping them.

Rice and wheat are the major crops of the developing world. Not only are they commercially important; they are also the staple foods of billions of the world's rural and urban poor. About 60% of IFAD-financed projects include components that address wheat or rice production technologies and their extension to small farmers. These 105 projects represent a total investment of US$5.7 billion, of which IFAD's share is US$1.3 billion.

Drought and flooding are two major problems that affect production for small rice farmers in Asia. IFAD supports a collaborative research effort of the International Rice Research Institute and national programmes in Bangladesh and India. As a team, they are developing rainfed rice varieties that produce higher yields despite prolonged drought at the seedling stage and floods at the growth stage. The traits of the new strains help minimize risks from these natural calamities.

Similarly, new drought-resistant wheat varieties have been developed through the IFAD-supported research programme of the Arab Centre for the Study of Arid Zones and Dry Lands. These varieties out-yield local wheats under low and erratic rainfall conditions in North Africa. Small farmers welcome the added income and food security that the new wheats assure.

But the resources of IFAD and the other CGIAR donors are insufficient to tackle the immense challenge that lies ahead. Thus, sharing global res-

The opening and closing plenary sessions were addressed by Idriss Jazairy (fourth from left), President of the International Fund for Agricultural Development. Other participants (left to right) are Alva A. App, Director of Agricultural Sciences, The Rockefeller Foundation; Donald S. Brown, Vice President, IFAD; and Moïse Mersah, Assistant President, IFAD.

Participants at the opening plenary session of the Consultation on "Strengthening National Agricultural Research Systems: Wheat and Rice Research and Training."

ponsibilities is an urgently needed first step toward meeting the needs of the poor more fully and at lower cost.

The sponsors termed this pioneer meeting a 'consultation' because of its exploratory nature; it was designed to stimulate a broad and open discussion of the many scientific, managerial, political, and financial issues involved in the transfer of international responsibilities in wheat and rice to the national programmes. Considerable time was spent on the identification of specific strengths of national programmes and the essential preconditions for expansion of their roles.

The outcome of the Consultation was fairly specific. Participants identified existing activities of strong national research systems that, with the support of IRRI and CIMMYT, could be internationalized to meet the needs of other national programmes with similar agroecological conditions. This would not only enhance South-South cooperation, but would yield substantial and cost-effective 'multiplier effects' of donor investments in agricultural research.

This Consultation was equipped with the talent and ability requisite for its task. Participants were honoured to have as the keynote speaker His Excellency Mr. G. S. Dhillon, Minister of Agriculture of India, who also kindly agreed to chair a plenary session. We were fortunate to be able to draw from the experience of the agricultural leader of a country that has advanced from being an importer to self-sufficiency in wheat and rice through its transformation from resource- to science-based agriculture.

We are also grateful for the contributions of distinguished leaders of the international agricultural research community, including Professor Guy Camus, Chairman of the Technical Advisory Committee of the CGIAR; Dr. M. S. Swaminathan, Director General of IRRI; and Dr. Donald L. Winkelman, Director General of the International Center for Maize and Wheat Improvement (CIMMYT). Their interventions were lucid and constructive; from their experience we gained knowledge and understanding.

Of course, we are especially indebted to the outstanding national research leaders whose participation formed the centre-piece of the Consultation. Without them, nothing could have been accomplished; thanks to their contributions, we can begin to act on the suggestions presented here.

In addition, we were fortunate to have, as both participants and observers, colleagues from interested UN organizations and the leaders of several other international centres.

This Consultation proved that strong national research systems may feasibly assume responsibility for regional activities. In due course, similar consultations may be initiated for other crops and international centres. IFAD will follow up on progress made at this Consultation with the conviction that its main beneficiaries will be the rural poor — the target group of the global agricultural research community.

Finally, we must give special credit to the cosponsors of the Consultation: the International Development Research Centre of Canada, the Ministry for Development Cooperation of the Federal Republic of Germany, the Swedish Agency for Research Cooperation with Developing Countries, and the Rockefeller Foundation. Their wisdom and foresight in setting this process in motion and their collaboration in establishing the agenda and selecting such able participation have made the new pattern of partnership possible.

Idriss Jazairy
President
International Fund for Agricultural Development

Introduction

A pioneer Consultation to explore ways to open a 'global window' to strong National Agricultural Research Systems (NARS) through the sharing of responsibilities with partner International Agricultural Research Centres (IARCs) was held in Rome from 26 to 28 January 1987.

The International Consultation on 'Strengthening National Agricultural Research Systems in Specific Areas of Wheat and Rice Research and Training' was sponsored by the International Fund for Agricultural Development (IFAD) and other donor members of the Consultative Group on International Agricultural Research (CGIAR). It brought together leaders of the developing world's stronger national systems, counterparts from the International Center for Maize and Wheat Improvement (CIMMYT) and the International Rice Research Institute (IRRI) and other centres, and participants from the donor community.

Background to the Consultation

Two major studies set the stage for the Rome Consultation. First was the 'CGIAR Impact Study,' a project initiated in 1983 to determine the impact that CGIAR centres have made on agriculture in developing countries. The study recognized that the conditions that led to the success of the Green Revolution are changing, and that many developing countries now have strong agricultural programmes capable of conducting adaptive research. At the same time, a need was seen for centres to shift their emphasis from highly applied to more basic research, which will require enhanced links with highly specialized laboratories in developed countries. A basic centre responsibility for the future will be the support of national systems in technology generation and training.

The Technical Advisory Committee (TAC) Review of CGIAR Priorities and Future Strategies examined the CGIAR's long-term strategies and priorities for meeting future challenges. The study emphasized the 'gap-filling' philosophy of the centres. From their beginnings, it was understood that centres would fill, on a temporary basis, those gaps in research and technology generation that could not be handled by national research systems, and that centres should help make basic research results from developed countries available for technology development and utilization in the Third World. The study stressed the need to accelerate the process of turning over primary responsibility for many downstream activities to national systems, but recognized the diversity of their strengths. The review recognized that there is no global solution to such issues; centres and national programmes must find their own balances of responsibilities.

The Impact Study and the TAC Review were discussed at the May 1986 meeting of the CGIAR in Ottawa, Canada. CGIAR members emphasized the need for serious reflection on how stronger national systems could assume, in cooperation with centres, regional or global responsibilities for which they have a comparative advantage, such as the fine-tuning of technologies for specific agroecologies. Members suggested that, because of the diversity of the national systems' capacities to take on broader responsibilities, such a shift must be gradual and well planned. Also, the CGIAR could not 'impose' additional responsibilities on national systems; they must initiate the change. IFAD proposed an 'exploratory meeting' to examine the potential for new dimensions of NARS-centre cooperation and modalities through which advanced national systems could share global responsibilities in the strengthening of other national systems. IFAD offered to coordinate the Consultation and arranged the cosponsorship of four other CGIAR donors.

The Consultation was to focus on research and training programmes in wheat and rice because they are the major food crops of the developing world and were the first crops studied by the CGIAR centres.

Context of the Consultation

The specific roles and functions of international centres are shaped by their partners in the global research system, especially those of their primary clients, the national agricultural research programmes. The growing sophistication of key national research systems has made it highly desirable that they share a greater role in the development of finished technologies needed by Third World farmers, and in the training of fellow research workers in less-developed national systems.

The need becomes even more apparent when one considers the CGIAR's emphasis on extending the Green Revolution to farmers in harsh environments, such as dryland or rainfed regions, or those where yields are held back by agroecological stresses such as cold temperature, saline soils, or seasonal flooding.

The total resources of the 13 CGIAR centres comprise only 5% of those allocated to agricultural research in the developing nations today. Clearly the international centres lack the human, financial, and physical resources to undertake such a colossal task alone.

In this context, the sharing of responsibilities among centres and those national systems with experienced and efficient research teams might contribute substantially to the global research effort.

The Rome Consultation was called to explore ways of strengthening national systems to assume an international dimension in certain programmes of wheat and rice research and training.

The Consultation was not expected to result in decisions. Instead, the Rome Consultation would function as a 'think tank' to explore the major scientific, managerial, and financial issues involved in adding a 'global window' to national systems activities. Participants were expected to clarify issues and generate and discuss new

ideas and procedural methods. It was recognized that once activities with potential for increased centre and national programme collaboration were identified, there would be a need for wider consultation with other components of the global system.

Objectives of the Consultation

The objectives were:

- to explore possibilities for effective transfer of specific responsibilities in wheat and rice research and training to strong national systems;
- to identify the preconditions essential for a national research institution to assume responsibilities beyond its political frontiers;
- to discuss the major scientific, managerial, and financial issues that national systems will face in assuming an international dimension;
- to explore modalities of collaboration among national systems, centres, and advanced institutions in developed countries that would allow centres to shift to more 'upstream' research by gradually sharing leadership in current activities with strong national systems; and
- to identify the types of international activities in which strong national systems, in association with centres, can assist other countries with similar agroecological conditions by sharing in technology generation and adaptation and human resource development.

The Consultation

The keynote address at the 26 January plenary session was delivered by His Excellency Mr. G. S. Dhillon, Minister of Agriculture of India (Annex I). Mr. Dhillon shared the experiences of his country in its transformation from an importer of rice and wheat to a self-sufficient producer. He emphasized the vital role of cooperation between the Indian national system and the international centres in this achievement and stressed India's willingness to share its experience in research and training with weaker systems.

Professor Guy Camus, Chairman of the CGIAR's Technical Advisory Committee, reviewed the history of cooperation among centres and national programmes and pointed out the challenge of meeting world food needs; in the year 2000, for example, rice production will have to be 60% greater to meet global requirements (Annex II). Camus assured TAC's support for still closer collaboration within the global agricultural research system, including a rational division of labour, so that each component can concentrate on its areas of greatest comparative advantage.

Current and potential modalities of IARC-NARS partnership were described by IRRI Director General M. S. Swaminathan, in Annex III and CIMMYT Director General Donald L. Winkelman in Annex IV.

Participants then split into working groups on wheat and rice for the remainder of Day 1, and all of Day 2. Rapporteur for the wheat group throughout the Consultation was Hubert G. Zandstra of the International Development Research Centre of Canada. Ralph Riley of the Institute of Plant Breeding, Cambridge University, U. K., was rapporteur for the rice group.

The final plenary session, on the morning of Day 3, began with presentation of the working group reports, followed by active discussion among national system, centre, and donor participants.

The reports and discussions were summarized by Curtiss L. Farrar, Executive Secretary of the CGIAR. Farrar emphasized the need for follow-up to the Consultation and stressed that national systems should develop specific proposals for closer centre cooperation. He suggested that similar Consultations might be held for other food crops, such as maize or potato, for which the centres have a strong commitment.

In his closing remarks, Idriss Jazairy, President of IFAD, said that two major concepts had predominated throughout the Consultation. First was the willingness of strong national systems to assume additional responsibilities beyond their frontiers in efforts to increase food production. Equally important, Jazairy pointed out, was a desire among all participants to strengthen partnerships in the global agricultural research and training system.

Summary of Working Group Discussions and Reports on Sharing of Responsibilities Among Centres and National Systems

Separate working groups on wheat and rice spent a day and a half discussing preconditions for adding a global window to the responsibilities of national agricultural research systems, modalities for making such a shift, and types of national activities that might be broadened. The wheat and rice working group papers were presented and discussed at the final plenary session. Following is a summary of issues discussed in the working groups and at the final session of the Consultation.

PRECONDITIONS

Participants in both the wheat and rice working groups generally agreed on preconditions essential for strong national systems and centres to share international responsibilities.

Commitment

The first and most important precondition is the commitment and political will to contribute internationally to a specific research or training programme. At least four component partners in the international research effort must express and prove that commitment.

Most obvious, and certainly most essential, is the commitment of the national system to assume the broader responsibility. Within that system, the individual scientists who are to lead the new programme must be committed to a mandate far beyond their nation's immediate interests. Equally important, the leaders of the programme (and, indeed, of the nation) must consider the programme of high national — as well as international — priority. Those leaders must be willing to dedicate, altruistically, their scientists, facilities, intellectual resources, and plant genetic materials in an evenhanded manner for the benefit of researchers and, ultimately, farmers beyond their frontiers.

Beneficiary national systems are the second group that must be committed to the effort. Leadership of a research or training activity cannot be transferred from a centre to a national programme without the agreement and support of other partners. The less-developed national systems must willingly accept leadership by a stronger programme — instead of by a centre that may have greater world credibility — in order to build their own capacities.

Centre involvement is essential to the successful internationalization of a national programme. Centre responsibilities cannot end with the naming of a strong system to a leadership role. The concerned centre must be willing not only to share responsibilities for a specific programme, but also to support the effort actively. The national system that assumes a broader responsibility will probably need, at least initially, training and backup services from the key centre. Moral support is equally important; a centre can facilitate the successful transition by expressing its confidence in the new leader national system and encouraging the full cooperation of less-developed beneficiary programmes in the new effort.

The fourth component — the international donor community — must not only express but also prove its dedication to this effort by providing financial support.

Scientific and administrative competence

Selection of a leader national system to assume international responsibilities will require extensive consultation and consensus among centres, donors, and beneficiary programmes. The scientific ability of such a system must be beyond question. The activity must be timely and relevant for the rural population of the host nation. The national system should also have a stable internal organization.

Comparative advantage

The national agricultural research system must have a comparative advantage over other programmes for the activity, based on human resource capacities, ecological factors, and physical research infrastructure and facilities.

Stewardship

The stewardship of the activity must be equal among scientists of all participating programmes — the host national system, cooperators, and centres.

Freedom of exchange and movement

The host national system must be able to distribute germplasm and information with no international restrictions. Complete freedom of movement for scientists of the host country and all participating nations is also essential. The national system must not have political restrictions on cooperation with any participating nation. Duty-free entry of equipment and supplies for the activity into the host country is highly desirable.

Language

Common working languages among cooperating countries are of paramount importance, particularly for training programmes. The languages should be agreed upon before beginning any programme.

Funding

A national system that accepts an international responsibility must have adequate funding to support the activity at the national level, and should contribute to its international funding.

MODALITIES OF COLLABORATION

Today's international agricultural system differs markedly from that of 25 years ago. Participants agreed that many national systems are now the equals of their centre counterparts in specific areas of research and training. It therefore seemed appropriate that mature national systems begin to share responsibilities in developing the capacities of weaker partners in the global system. Thus the discussions on modalities, or methods of procedure to assure the success of such a transition, were considered of utmost importance.

All agreed that it is too early to establish clear procedures for the internationalization of national system activities. Specific arrangements will vary widely and will often demand unforeseeable changes in policies or administrative procedures. The group felt that both national programmes and centres should experiment courageously, yet cautiously, in their efforts and that 'where there is a will, there is a way.'

All felt that partnership and the sharing of research and training responsibilities among strong national systems and centres — leading to a division of responsibilities and leadership — should be stressed in modalities for expanding national systems' roles. The group thought it unlikely that the global community would give a national system an international mandate that it cannot handle.

Participants recognized that a wide range of such collaborative activities are already in place, including programmes of international germplasm utilization and testing, 'huttle breeding,' 'hot spot' screening, studies of specific agroenvironmental constraints, and training.

Obviously, Mexico and the Philippines alone do not have all the important agroecologies for wheat and rice. Participants felt that centres could work more efficiently and economically in such environments through joint ventures with strong national systems in regions that typify wide agroecologies such as deepwater and upland rice. Centres should not view such arrangements as 'contracting out' research, but as scientific partnership. When feasible, the cooperating national system should bear a reasonable part of the cost in such cases through programmes such as Technical Cooperation Among Developing Countries (TCDC). The national system should handle internal management of locally funded staff and resources. The centre should administer scientists outposted to the national system.

Leaders of national systems felt that centres could help internationalize their scientists' capacities for such leadership by offering specialized, in-service training in advanced research techniques and sabbatics focusing on strategic studies. Adaptive research for weaker programmes might require support from both centres and internationalized national systems, but stronger national systems felt that they could handle these responsibilities locally.

CIMMYT pointed out problems in professional growth and scientific recognition that scientists in developing countries face. The heavy workloads of national system scientists often deprive them of the time for detailed analysis and interpretation of data, writing and presentation of scientific papers, and other professional opportunities that would fully develop their inherent scientific potential. Thus, the research community in both developing and developed countries often lacks access to national system contributions to greater scientific knowledge in agriculture. CIMMYT pointed out that, partly because of this lack of adequate opportunity for professional advancement, many cooperators have recently suffered substantial staff losses. CIMMYT suggested that offering more visiting scientist or fellowship positions at centres might help curtail the loss of talented staff.

The group concurred with observations of the Technical Working Group on Networking of the Special Program for African Agricultural Research (SPAAR) that successful programmes of international cooperation usually have the following common elements:

- They address an international problem that the national systems consider important.
- They formulate a well-defined theme or strategy.
- They are guided by an international steering committee or advisory group.
- Funding for in-country national system activities of the network is met by participating countries. Donor funding may facilitate work of regional or global significance.
- Regular meetings of participating scientists are held to 1) identify objectives, 2) identify and set priorities on problems, 3) identify topics to be studied in all countries, and those to be studied by one or two countries or an international centre, and 4) decide

who will take the lead in developing strategies for each activity.

- Educational and training opportunities are provided, including regular workshops to facilitate discussion of research results and methodologies among scientists.
- A 'harmonizing' (coordinating) organization facilitates international activities, provides technical support, and arranges monitoring tours.
- Plant and animal materials are exchanged freely among members.
- Support is adequate for data analysis, documentation, and information exchange, including a regular newsletter and distribution of reports that are of interest to all participants.

Participants at the Rome Consultancy felt that successful programmes had three additional elements:

- Stewardship of the programme is shared by the partners.
- Priorities for research and training are set jointly, and division of labour is equitable.
- Leaders have a capacity for coordination.

The Australian Centre for International Agricultural Research (ACIAR) described a model for collaboration that has linked national system activities in the Asia-Pacific region with those of leading Australian research institutes. A national system requests collaboration with an institute that is able and willing to respond. Scientists from both programmes then plan the activity, based on the priorities and needs of the national system and available resources of the Australian institute. The national system then applies to an appropriate bilateral donor for funds to support the joint project. The Australian institute is usually responsible for overall management of the funds, but they are allocated to the separate budgets of the partner organizations as agreed upon during the joint planning stage.

This model might also work to transfer basic research findings, such as in biotechnology, from advanced research institutes in developed countries to international centres for application in Third World crop improvement.

IRRI offered, for discussion purposes, 'a model for national system and IRRI collaboration' with operational procedures similar to those of the United Nations University System. Key national systems might be designated to undertake regional or global responsibilities and be developed as 'associate centres of IRRI.' The process would, essentially, transform IRRI from an 'institute' to an 'institution.' The institution might be strengthened by expatriate scientists from both centres and national systems working away from their home bases on its behalf for specified periods through fellowships, sabbatics, or visiting scientist positions. A steering group at the CGIAR level could guide and support implementation of such a programme (see Annex III).

Similar concepts were also discussed for national systems-CIMMYT associations.

A case was made for salary supplements for national system scientists working on global activities. Such subsidies might reduce the loss of national staff as a result of international exposure. But others were concerned about how salary supplements might split allegiances of scientists to national systems, centres, and donors.

A donor participant pointed out the experimental nature of the strategies discussed in Rome; the concept that strong national systems can effectively contribute to the global effort to develop scientific capacity in weaker systems is exciting but, in reality, a hypothesis that in most cases has not yet been tested. He suggested that the process be initiated with strong national system-centre programmes to help solve the immense agricultural problems of Africa.

Participants agreed that operational procedures should be defined as soon as possible so that national systems can begin work on global problems. Concurrently, there was a general plea to keep whatever systems might emerge as simple as possible, and to avoid unnecessary bureaucracy.

EXAMPLES OF SHARED INTERNATIONAL RESPONSIBILITIES

The working groups spent considerable time discussing the types of responsibilities that strong national systems and centres might share. Although discussions sometimes touched on specific programmes, it was earlier agreed that the Consultation would make no direct recommendations.

Germplasm conservation, evaluation, and utilization

All agreed that the collection, testing, and utilization of traditional and wild varieties are, and will remain, essential to the success of international and national varietal improvement programmes.

Both the centres and national systems should intensify germplasm collection efforts in wheat and rice — an obvious area for expanded national system involvement. Needs were expressed to establish regional germplasm working collections, to enlarge long-term base collections, and to increase regional exchange of germplasm with specific traits such as disease and insect resistance. Participants predicted that breakthroughs in biotechnology, genetic engineering, and wide crossing may soon mean a more rapid and intensive linkage in the collection of germplasm and its utilization in varieties.

There was agreement that centre-national system collaboration in germplasm utilization, or breeding and testing, has been remarkably effective, and that the centres must continue to play a catalyzing role in crop varietal improvement.

The wheat group recognized the soundness of CIMMYT's wheat breeding strategy, which is based on adaptation of materials to one or more 'mega-environments.' Although often in different countries and far apart geographically, the megaenvironments are relatively uniform — but rarely completely homogeneous — in moisture, soil type, temperature regime, and biotic stresses. This breeding approach assures that CIMMYT genetic materials perform well in the range of environmental conditions found within the mega-environments; increasingly, 'broad adaptation' Is considered in terms of suitability of materials within at least one mega-environment (Annex IV).

Participants felt that the mega-environment programme could be further strengthened by more active participation of key national systems in planning and refining the crop improvement strategies.

Seeds of Korean breeding lines, multiplied and selected in the Philippines during Korea's winter, being loaded onto a 747 cargo jet for shipment to Korea for the spring planting. This is part of a cooperative IRRI-Korea "shuttle breeding" programme.

In 'shuttle breeding' programmes, alternate generations of genetic materials are evaluated and selected at two different sites. Shuttle breeding really began more than 20 years ago with the classic CIMMYT-Mexico shuttle programme between sites in northern and southern Mexico. The early semi-dwarf wheats, including 8156 or 'MexiPak,' owe their hardiness and insensitivity to photoperiod to this method.

Shuttle breeding has now gone international. CIMMYT, Brazil, and Mexico coordinate a shuttle programme to develop high-yielding wheat varieties with improved tolerance for acid soils. Cooperating scientists screen lines for agronomic type and rust resistance in Mexico and ship the next generation to Brazil, where national system scientists test them for tolerance for aluminum toxicity and resistance to other diseases. Wheats from the CIMMYT-Mexico-Brazil shuttle yield twice as much as previous varieties on acid soils. Scientists from the three organizations are full partners in their development.

CIMMYT suggested similar cooperative shuttle breeding programmes to speed the development of wheat varieties with resistance to drought, heat, and scab disease.

IRRI and Korea cooperate in a 'gene rotation' shuttle to multiply and select an additional generation of experimental lines during Korea's winter and to continuously 'rotate' genes for blast resistance in Korean rice varieties. As many as 125 tonnes of Korean seed have been multiplied in the Philippines during the winter and shuttled, by 747 cargo jet, to Korea in time for the spring planting.

National system cooperation has been essential to the success of the

wheat and rice shuttle programmes. The group saw a great potential for expansion of shuttle breeding and a need for greater recognition of the national system role in the effort.

Networks for genetic testing

International testing networks allow genetic materials developed by either centres or national systems to be uniformly evaluated against various pressures in many environments. They cram years of testing into a single season.

National systems that participate in centre-coordinated networks have released hundreds of nursery cultivars at local varieties for farmers, under many names. A 1984 IRRI-Rockefeller Foundation project showed that of Asian rice varieties bred in one country and released in another, 70% originated in the nurseries of the International Rice Testing Program (IRTP). For example, a Thai rice variety was recently released to farmers in Brazil.

International testing also facilitates the movement of new genes into national varieties; scientists often cross nursery cultivars with local varieties to combine the best traits of each. An IRRI research project showed that Asian breeders obtain about 70% of the 'foreign' non-IRRI germplasm used in their hybridizations from the IRTP.

CIMMYT sends similar nurseries to a worldwide network of collaborators who grow and test the cultivars at more than 250 locations. The return of performance information is 70%.

A study on national systems release or hybridization of materials tested through CIMMYT-coordinated networks would almost certainly show the same trends as studies in rice.

Participants agreed that global networks for the systematic testing of genetic materials are paying enormous benefits, and strongly emphasized that cooperative testing must continue as a pivotal element in the improvement of wheat and rice.

The group noted a declining emphasis on yield trials, and stressed that improvement in the targeting of problem-oriented trials and better sharing of feedback can improve the effectiveness of collaboration.

The organizational structure of IRTP in Asia was considered the key to its success; each participating nation funds its own costs. Reservations were expressed, however, about the IRTP's effectiveness in Africa and, to a lesser extent, in Central America.

Argentina suggested the need for a separate wheat improvement network for the 'Southern Cone' region of South America which might, in some cases, work with programmes in other continents. Such a network might focus on genetic improvement, testing nurseries, the development of production technologies, and training. Argentina could provide leadership and training facilities for such a network, but would need added funding and technical assistance in basic research.

Several national systems involved in collaborative networks focusing on specific constraints or hot-spot screening expressed willingness to support network activities through special short-term training programmes and take in-service trainees from other countries.

Other networks

International networks need not be restricted to the development and testing of genetic materials. For example, agronomists, soil scientists, and social scientists in national systems and centres collaborate to find ways to increase the efficiency of plant nutrient use through the International Network on Soil Fertility and Fertilizer Evaluation for Rice (INSFFER), which is coordinated jointly by IRRI and the International Fertilizer Development Center (IFDC).

CIMMYT pointed out the potential for a new network to focus on crop management problems such as soil structure and tilth, fertility, weeds, and salinity of the intensively farmed lands under rice-wheat rotation on the Indian Subcontinent.

It was suggested that agencies that coordinate regional or global networks might be seen as 'centres of excellence' in specific problems, offering sabbatic-type opportunities for other national system scientists working on the same problems.

Hot-spot screening

International testing of elite germplasm against a specific stress such as rust disease in wheat or peat soils in rice can best be done at a site ('hot spot') where that stress is intense and continuously prevalent.

A study of the influence of hot-spot screening on selection efficiency for disease resistance was recently conducted at the International Center for Tropical Agriculture (CIAT). Hot-spot screening gave 15% better efficiency than when cultivars were screened in a 'general' environment, and 30% better when scientists used 'spreaders' to increase disease incidence.

It was pointed out that donors consider hot-spot screening attractive because it deals with defined constraints. It also lends itself to specialized contributions by several cooperating national systems in areas such as the development of improved screening techniques and methods to monitor stresses, studies of physiological or resistance mechanisms, and access to a range of stresses.

CIMMYT cooperates with national system scientists in Ethiopia in hot-spot screening of durum wheats for stem rust resistance and bread wheats for septoria resistance. Cooperators in Ecuador and Kenya screen for stripe rust resistance; those in Mexico, for multiple disease resistance for highland areas; and those in China, for resistance to scab disease.

Reaction to the increased use of hot-spot screening was mixed. Some participants felt that regional specificity limits the effectiveness of hot spots, but others considered them the most efficient way to identify resistant materials and called for expansion of the strategy.

Pakistan offered to be a hot-spot centre for breeding and screening for resistance to salinity, karnal bunt, and drought.

IRRI felt that the establishment of regional hot-spot facilities would: 1) contribute to the professional growth of young national system scientists; 2) give scientists from developed countries an opportunity to work directly with national system scientists, to the benefit of both; and 3) provide a mechanism through which 'forward-edge' research on the stresses can be channeled to national systems.

IRRI also suggested eight host national systems, from China to Brazil, that might become hot-spot centres based on scientific competence and the prevalence of stresses such as coastal salinity, iron toxicity, brown planthoppers, or tungro virus disease (Annex III).

Training and education

The education and training of national scientists, educators, and extension specialists has been an integral part of the IRRI and CIMMYT programmes since their establishment. About 5 000 rice scientists from 78 countries are alumni of IRRI training and educational programmes and another 2 000 are CIMMYT alumni.

Indonesia is a good example of scientific payoffs made possible by the development of human resources. At the time of Independence, Indonesia had one universityeducated agricultural scientist. IRRI began to train Indonesian staff in 1962. By 1987, IRRI alumni included 531 Indonesian rice workers, including 20 Ph.Ds. Indonesia reached rice self-sufficiency in the early 1980s.

Graduate students from across the rice-growing world — the scientists of tomorrow — study at IRRI. Most take their M. Sc. or Ph. D. coursework at the neighboring University of the Philippines at Los Baños or an institution in their home countries, then conduct thesis research under the guidance of IRRI scientists. Two hundred and fifty rice scientists have received Ph. D., and 521, M. Sc. degrees through IRRI. Another 330 postdoctoral and visiting scientists have worked at IRRI, often using equipment and facilities that are not available back home. Most conduct research on problems specific to their countries.

Partnership of national systems and centres in education and training was an integral part of discussions on almost every topic. Participants felt that the demand for training in fields such as crop production, especially from the weaker national systems, far exceeds the centres' resources to provide it. Participants saw a need to look closely at the supplementation of centre training with human and physical resources available in the national systems.

National leaders stressed that they have the capacity and commitment to provide such training in their countries, if centres collaborate in formulating training methodology and supplying training materials. Participants welcomed such an initiative and agreed that this would greatly help strengthen the global research system.

CIMMYT suggested that strong national systems could share responsibilities for training in procedures for crop management research, plant breeding, and other areas of specialized research. CIMMYT specifically pointed to the strengths of the Turkish National Wheat Programme in dryland production agronomy and suggested that it might initiate in-service training for other national systems. CIMMYT could help develop course curricula, contribute training materials, and provide other support to the teaching staff.

Pakistan, which increased wheat production from 3.5 million tonnes in 1966 to 14 million tonnes in 1986, has a strong history of practical training of wheat scientists at CIMMYT. Of Pakistan's 150 qualified wheat scientists, 58 are CIMMYT-trained. Pakistan emphasized that postgraduate training for young scientists is a key to creating future agricultural leaders, and saw the need for future CIMMYT help in establishing regional training programmes.

Pakistan suggested a strategy of CIMMYT training 'master trainers' for the national systems, who would subsequently train a larger number of scientists at regionalized national-systems or in their home countries.

More than 2 000 wheat workers are alumni of CIMMYT's education and training programmes.

Pakistan also offered to provide training facilities for the region and, through use of existing trained staff, to provide regional training in research methodologies for rice-wheat, cotton-wheat, and rainfed cropping systems. CIMMYT cooperation was sought in developing Pakistan's economic research programme and methodologies for farming systems research in wheat.

Brazil pointed out that EMBRAPA now has a programme of training assistance to Burkina Faso. Although Burkina Faso must further develop its own capacities before it can take full advantage of Brazil's experience, the programme is one of complementarity rather than competition.

Training in hybrid rice technology and seed production might also be institutionalized. China was the world's pioneer in the development of hybrid rice to exploit heterosis, or hybrid vigour. China has provided cytoplasmic male sterile (CMS) lines for IRRI to use in developing CMS lines for the tropics, and most of the restorer lines used in Chinese hybrids are from IRRI.

China and IRRI have initiated a joint training programme in hybrid rice at the Hunan Academy of Agricultural Sciences, which played a key role in the technology's development and spread. Scientists in India, Indonesia, Malaysia, Republic of Korea, Thailand, and Viet Nam have initiated hybrid rice programmes after receiving training, information, and genetic materials at Hunan.

Similarly, training is an integral component of a joint Indonesia-IRRI proposal for the establishment of a Regional Research and Training Programme for Upland Rice-Based Farming Systems in Sumatra, and the strengthening and internationalization of the National Azolla Research Centre in Fuzhou, China (Annex III).

Language problem

It was pointed out that certain organizations, particularly IRRI, have developed techniques of multilanguage publication that can at least alleviate language difficulties.

Upstream research

All participants felt the need for long-term and highly specialized fundamental research to back up regionalized research programmes. There was some disagreement, however, on responsibilities and modalities for conducting such basic research. The TAC, and some national systems, suggested that centres should gradually shift priorities to more strategic and basic research. Such a shift would be facilitated by increased national system responsibility for breeding, testing, and adapting technologies for specific environments, as well as a greater share of maintenance research.

The rice group felt that IRRI should play a leading role in biotechnology for rice, partly to overcome problems associated with technology whose rights might be patented by the private sector. Participants commended the Rockefeller Foundation Program on Genetic Engineering in Rice, a network-type initiative of national institutions with IRRI as the lead centre.

But several participants saw little merit in centres' greatly expanding such basic research as biotechnology or gene splicing if it could be done better or cheaper in specialized laboratories or academic institutions in developed nations.

It was pointed out that the centres, through collaborative efforts with advanced institutions, could adapt and direct such 'cutting-edge' research to the internationalized national systems. The centres have a unique opportunity to bring the advanced biotechnology and genetic engineering laboratories into the global research community — which would benefit all concerned partners. The process would also help build competency in advanced science in developing countries.

IRRI pointed out a trilateral project of upstream training on 'Systems Analysis and Simulation for Rice Production,' involving eight interdisciplinary teams of scientists from six countries, IRRI, and a Netherlands group representing the Centre for Agrobiological Research, the Institute for Theoretical Production Ecology, and the Agricultural University of Wageningen. The teams received two months of instruction in advanced techniques of systems analysis and modelling at Wageningen. The Netherlands Government then presented each team of scientists a microcomputer to take back to their institutions. The teams worked for six months on specific problems such as excessive monsoon cloudiness, then came to IRRI to report on their work and consult with IRRI scientists. The rice group felt that this type of partnership between developed and developing countries, with a centre as both facilitator and research collaborator, illustrates how the potential of all parties can be tapped in both upstream research and human resources development.

Several national systems expressed concern about the private sector's increasing role in basic agricultural science, and foresaw difficulties in future access to its research results. IRRI pointed out that the semi-dwarf wheat and rice varieties were made available freely around the world but it is doubtful that emerging technologies developed by the private sector, such as from genetic engineering or biotechnology, will be made available to the Third World without financial remuneration.

CIMMYT concurred that, while collaboration with advanced academic institutions helps it stay in the forefront of science, it sometimes has difficulty obtaining results from commercial research organizations.

The very high cost of much basic research was pointed out. The advanced upstream knowledge that the global system needs, quickly, requires large financial investments that are probably available only through the private sector. Obviously the private sector expects a return on its investment for upstream research. There was general agreement that upstream progress would now be much less advanced without the private sector, and that the international centres had the most capacity to tap, at lowest cost, this essential resource.

Funding

Funding modalities and potential support channels for international activities were discussed extensively. Most expanded national programmes will address mutual agroecological problems in countries that may be geographically far apart.

The group felt the need for a special effort to convince donors and increase public awareness on the importance and magnitude of this global initiative.

Participants stressed the need for greater flexibility and possible adaptation of 'normal' funding patterns, and suggested that donors might develop a special support process for global NARS-IARC activities, which will certainly increase with the further growth of national systems' competence in research and training. Meanwhile, centres and national systems must explore local, bilateral, and multilateral sources of support.

Participants agreed that host nations must provide some funding from their internal budgets, regardless of whether those funds are generated domestically or through donor support. The possibility of local private-sector support, such as from farmers' groups, was mentioned.

Most national system participants felt that donors should provide bilateral funds directly to key national programmes for the additional costs of internationalizing their responsibilities.

It was pointed out, however, that multilateral donors often have existing mechanisms to channel funds through centres for the support of global or regional activities. Tapping into those mechanisms might make donor funding easier, at least initially.

The idea of providing more CGIAR funds to national systems undertaking international responsibilities, or bilateral funds from CGIAR members, was mentioned. Donor participants pointed out that funding of the diverse activities discussed at Rome already posed a certain danger in overextension of the system and that the primary function of the CGIAR — funding a group of international centres — must not be confused. It was suggested that bilateral funding of programmes that do not involve centres should be sought from donors outside the CGIAR system.

An additional manifestation of national system acceptance of increased responsibilities was pointed out: several national system leaders at the Consultation could have also participated as CGIAR donor representatives. It was anticipated that, as national systems accept a greater role in the global system of international agricultural research, more will do so as full-fledged CGIAR members.

CONCLUSION

The Rome Consultation challenged both national agricultural research systems and international centres. Strong national systems must now share the global work that the centres began two decades ago, and work with them as partners in developing a new range of technology for the harsh agroecological regions bypassed by the Green Revolution.

It is a tribute to the scientists who have dedicated their lives to wheat and rice improvement that they are ready to take the responsibility for opening new 'global windows' of cooperation. The transition will not always be easy — but nothing of truly international significance comes easy. All participants felt that the new approach can work, but it will require the dedication of all partners in the global system.

National agricultural research systems have emphasized their abilities and confidence to take on the new responsibilities. Centres have expressed willingness to form new types of partnership with national programmes to assume new mandates to make a still greater contribution to the global system. Major donors said they would welcome such initiatives and urged strong national systems and centres to prepare detailed proposals for their consideration.

The success of this Consultation will be measured by the increased food-producing capacity of the millions of underprivileged farmers that have yet to benefit from new cereal technology. Such a success would then serve as model for cooperation to improve other Third World food crops.

The Rome Consultation closed with a feeling of hope and confidence that the men and women of the global agricultural research community can work together through the bond of science to help Third World farmers produce more, and better, food from the land.

A Blueprint for a New Pattern of Partnership

The participants at the Rome Consultation generally agreed that the job that remains to be done is far beyond the scope of the CGIAR centres alone, and that the time is right to shift gears and increase the momentum of the global research effort. International centres and national research programmes must enter into a new pattern of partnership, each contributing the best of its abilities and resources in the areas where it has a comparative advantage.

Although national programmes have generally been on the receiving end of the international agricultural research system, many of them have developed into capable, independent institutes. Strong national systems might now assume increased leadership for responsibilities such as:

- location-specific breeding and testing;
- adapting technologies to specific agroecological environments;
- a greater share of maintenance research; and
- assistance to the weaker national systems for greater development.

The opening of global windows for national systems will also allow centres to increase their research focus on those scientific areas where opportunities for potential breakthroughs exist. This includes basic, strategic research in which the time lag between the initiation of a project and its eventual payoff is long. A gradual, balanced shift by the CGIAR centres to more fundamental, upstream activities, supported by specialized work in cooperation with advanced laboratories in the developed countries, will bring a new dimension to the global research effort.

A general *modus operandi* was agreed upon. A national programme wishing to expand its role would consult directly with an appropriate centre to plan specific cooperative activities. Further meetings would be held to seek input from, and support of, beneficiary national systems. Joint research proposals, based on collectively established regional priorities, can then be drawn up and submitted, through the TAC, to the CGIAR. The proposals should specify the exact roles of both the centres and the national systems in the execution of the project and reporting of its results. The CGIAR will review the proposals carefully and assist those that have the greatest potential with the necessary financial resources and the required donor support.

Joint programmes, however, do not have to equate with increased financial support. If administered with care, they can be easily incorporated into current activities of the cooperating centres and the national systems. Benefits accrue to the cooperators on several levels. On the one hand the national systems have specialized knowledge to contribute. And on the other, the centres have international stature and broad resources to commit. Of course, the interpersonal relationships formed in such collaborative work environments will yield inestimable future benefits for both the scientists and the research institutes involved.

Several operational questions remained unanswered. For example, how would TAC review the proposals for the internationalized national system activity and evaluate the progress of the programmes, once initiated? Would it be through the 'normal' TAC review procedures for centres, or through an entirely new mechanism? Would donor resources be directed to the projects by way of the centres or go directly to the host national system?

What relationships will the Steering Committees for the new activities establish with the centres' Boards of Directors or Programme Committees?

The participants felt that such details must be worked out a little at a time as the new working strategies evolve, rather than waiting until everything has been agreed upon before starting the projects. The specific blueprints for implementation of the new patterns of partnership will undoubtedly vary with different combinations of activities, regions, national programmes, centres, and donors, but the Rome Conference has laid the foundations for a future of fruitful cooperation in agricultural research.


ARGENTINA
INDIA

ANNEX I

Linkages Between International Institutes and National Programmes in Rice and Wheat Possibilities for Further Collaboration: A Country Report from India

G.S. Dhillon
Minister of Agriculture, India.

I am extremely happy to participate in this Consultation organized to review the role of international agricultural research centres (IARCs) in relation to strengthening of the national agricultural research systems (NARS). India has been a major beneficiary of cooperation with the International Maize and Wheat Improvement Center (CIMMYT) and the International Rice Research Institute (IRRI). The basic high-yielding semi-dwarf varieties that triggered significant production increases in wheat and rice, leading to the Green Revolution in India, came from these institutes. Their assistance in the Green Revolution as well as in developing a body of trained scientists is praiseworthy.

Rice and wheat are the two most important food crops of India, jointly accounting for more than 70% of our total foodgrain production. The contribution of wheat has increased from 13% of the total foodgrain before the wheat revolution began in 1965 to 30% today. During this period the productivity of wheat increased from 827 kg/ha to 2 032 kg/ha and that of rice from 862 to 1 568 kg/ha. During these two decades the compound growth rate in wheat was 5.7% in production and 3.0% in yield per hectare; in rice the growth rate was 2.4% in production and 1.7% in yield. The difference in wheat and rice productivity is mostly because three-fourths of India's wheat land is irrigated while only 42% of the rice is irrigated. Furthermore, rice is more subject to monsoons and pest attacks.

These achievements were made possible through a combination of factors: strong research support and international cooperation, which provided the required technologies; governmental policies, which ensured the availability of the required inputs, including credit and minimum support prices; concerted extension efforts; and above all, the enthusiasm of farmers. The successes in wheat and rice production gave India the confidence to achieve self-sufficiency not only in foodgrains but also in several other crops. Despite India's rapid population growth, from 361 million in 1951 to 751 million in 1985, the per capita availability of cereals over the period increased from 334 to 424 g/day. India has been able to build up a buffer stock that reached more than 28 million tonnes of foodgrain by 1986. Wheat constitutes almost 19 million tonnes of the buffer stock.

AGRICULTURAL RESEARCH AND EDUCATION SYSTEMS

India has a long tradition of agricultural research. The Indian (then Imperial) Agricultural Research Institute was established in 1905 along with five agricultural colleges and research institutes at Pune, Coimbatore, Kanpur, Nagpur, and Lyallpur (now Faisalabad, Pakistan). The state departments of agriculture were also organized during this period.

The Indian Council of Agricultural Research (ICAR) was established in 1929 as a national apex organization for the coordination and management of research and education in agriculture, animal sciences, and fisheries.

ICAR today has a network of 40 Central Institutes, 4 National Bureaux, 4 Project Directorates, 12 National Research Centres, 74 All-India Coordinated Research Projects, 1 National Academy of Agricultural Research Management, and about 600 Agricultural Produce Projects supported by the Cess Fund operating in the ICAR institutes and state agricultural universities. Nearly 6 200 scientists work in the system, directly administered by the Council. In addition, more than 5 000 ICAR scientists support all-India coordinated projects, mostly located in agricul-tural universities. The Council has a plan budget of 4 250 million rupees (equivalent to almost US$340 million) for the Seventh Plan (1985-90) and a similar amount as a non-plan budget.

India has also established 25 state agricultural universities responsible for agricultural education, research, and extension at the regional level. Two of the ICAR institutes are also deemed universities. Nearly 65% of

The keynote address for the Consultation was delivered by His Excellency G.S. Dhillon (right), Minister of Agriculture of India. Other participants are (left to right) Ruy de Villalobos, Under Secretary for Agricultural Economics and Carlos Lopez Saudidet, Board President, Institute of Nutrition and Food Technology, Argentina, and D. Kumar, Joint Secretary, Policy and Planning, Ministry of Agriculture, India.

the ICAR plan budget is used to fund the agricultural universities, which employ almost 19 000 agricultural scientists to carry on regional research and teaching. India's agricultural education system has an intake capacity of 12 500 new undergraduates and 3 600 postgraduate students per year.

When the dwarf wheat and rice genotypes bred at CIMMYT and IRRI became available in the early 1960s, this vast research infrastructure immediately translated their genetic potential into reality.

ORGANIZATION OF WHEAT AND RICE RESEARCH

Research on wheat and rice in India is coordinated at the national level by the ICAR All-India Coordinated Research Projects (AICRPs). The AICRP concept was developed from the successful experience of the All-India Coordinated Maize Improvement Project, which began in 1957. Similar projects were started in rice, wheat, and several other crops in 1965. The rice and wheat projects have been further strengthened, given a wider mandate, and raised to the status of Project Directorates.

The rice project today operates at 52 centres and the wheat project at 28 centres in various agroclimatic zones across India. The centres employ 214 scientists for rice and 162 for wheat. Additional scientists and centres funded through central and state programmes cooperate on a voluntary basis.

Research programmes are organized to solve production problems of each important cultural environment such as irrigated, rainfed, and late-sown conditions in wheat, and irrigated, rainfed upland, lowland, and deep water in rice. To identify location-specific varieties and technologies, the country has been divided into different agroclimatic zones on the basis of similarities in climates (such as temperature, rainfall, and humidity), diseases, soil types, and cropping systems. For example, for wheat alone almost 1 000 coordinated trials are organized yearly to evaluate 1 200 newly bred strains for characters such as yield; reaction to diseases, insects, and drought; grain quality; and performance under early- and late-sown conditions. Almost 3 500 wheat and rice cultivars are evaluated for disease and insect pest tolerance each year.

These two projects have released 270 rice and 120 wheat varieties (including 16 durum types) since 1965. Scientists have developed varieties suited to each cultural environment and specific crop problem together with the crop production and protection technologies that enable them to realize their full yield potentials under various conditions. The success of systematic research in wheat alone can be measured by the fact that India has suffered no serious rust epidemic for the past decade and a half although previous rust epidemics often caused near-famine conditions.

COLLABORATION WITH INTERNATIONAL INSTITUTES

Over the years, the national research networks on rice and wheat have developed very close relationships with counterpart international institutes. The national programmes have cooperated with international centres by providing test sites for multilocational trials and nurseries, supplying various types of germplasm and breeding lines, organizing regional seminars, and sharing experiences to benefit the world community.

These collaborative activities have been mutually beneficial and rewarding at the global level. The success of wheat and rice in India was due to international institutes providing the base genetic materials that Indian scientists had long sought but were not available in local germplasm collections. IRRI and CIMMYT also provided specialized training to young Indian scientists. The impact of such collaboration can be gauged by the large number of scientists in each programme who have visited these centres, and by the many popular rice and wheat varieties with one or more parents from international sources.

Through these collaborative programmes, other countries have released Indian wheat varieties, including Sonalika, HD1981, HD2009, WL711, HD1999, and HD2172. In rice, many Indian sources of grain quality and of resistance to diseases, insects, and other stresses are being used internationally. Indian varieties have been released in Burkina Faso, Mali, Nepal, Pakistan, Senegal, and the United Republic of Tanzania.

The adoption of Indian rice and wheat varieties and germplasm was made possible only through complementary efforts of national and international programmes.

EMERGING SCENARIO

Although India has made good progress in rice and wheat, there is much more to be achieved. The productivity of both crops is low compared with that in several developed countries, and yields still vary markedly among agricultural ecosystems. Some areas that require more attention, in my opinion, follow:

Rainfed conditions

For both wheat and rice, progress has been significant in irrigated, but not in rainfed, areas. Almost 58% of India's total rice acreage is in rainfed ecosystems (uplands, lowlands, and problem environments). Even marginal yield gains in this complex system of low productivity would add significantly to total production.

The same holds true for wheat; almost 25% of the crop is grown under rainfed conditions in central and peninsular India. Durum (macaroni) wheats, which have not been improved as much as bread wheats, are grown in several of these areas.

Fertilizer use efficiency

The increasing cost of fertilizer poses a threat to further increases in production and productivity. Fertilizer efficiency is low in irrigated rice, but much lower in rainfed ecosystems.

Efficiency in rice, for example, is reported to be from 20 to 25%. Heavy nitrogen losses occur through leaching, denitrification, volatilization, etc. To some extent the problem is similar for wheat. Hence, research to increase nitrogen use efficiency is vital.

Weeds

The extent of loss due to weeds varies greatly but is generally estimated as 10 to 15%. Losses are much higher in upland or rainfed rice. In wheat, grassy weeds such as Phalaris minor and wild oats have become a major problem in parts of northern India. Effective alternatives to costly chemical weed killers must be found.

Problem soils

Alkaline, saline, and acid soils are fairly widespread in India. Micronutrient deficiencies are becoming more prevalent in intensively farmed soils. Increasing productivity from these soils requires a combination of varietal and soil-amendment solutions.

Cropping systems approach

So far we have worked to improve individual crops in our research programmes. But farmers with limited land resources must raise several crops to meet their families' requirements. In this context, cropping as well as farming systems assume considerable importance.

Cropping systems, by their very nature, are area-specific and depend on factors such as water availability, soil types, economic levels of farmers, and local food preferences. Such factors have a direct effect on pest management. Cropping systems research in the future must be multidimensional and include soil health, water management, and pest management problems as well as economic aspects and the well-being of farm families.

Disease and insect management

Achievements have been considerable in disease and insect pest management in both crops, but in rice new races and biotypes have emerged and chemical control measures have sometimes broken down. Frequent chemical use also pollutes the environment.

Karnal bunt and foliar blights have gained importance in wheat. Even for rusts, as new, more devastating races evolve, the continuous location of strong, stable sources of resistances requires sustained and concerted efforts. Better multilines are needed, as well as appropriate programmes for multiplication of their seeds.

Grain quality

The greater self-sufficiency and higher economic levels of the population have increased the sophistication of eating habits. Rice and wheat with superior grain are more in demand. An increasing diversity in the wheat consumption pattern necessitates more emphasis on bread and other bakery-product qualities. Durum wheats must retain traditional chapati qualities, but must also be used for semolina, macaroni, noodles, and similar products. Finer and more aromatic types of rice are also in demand.

INTERNATIONAL COLLABORATION IN THE FUTURE

The emerging scenario raises questions of great importance. A generalized approach is slowly yielding to specific considerations in several situations. However, individual solutions to specific problems can only be temporary answers. A coordinated approach is called for in which international institutes and national systems must play complementary roles.

The international centres will have to continue the activities already in progress, which have greatly benefited the national systems, specifically in the identification of stable sources of resistance to various diseases and insects. Cultivars can only be exposed to a wide range of stresses and biotypes of current and future importance through international testing programmes.

The international testing programmes have enabled rapid progress by providing valuable breeding materials, segregating as well as fixed, with generalized resistances and adaptability. The generation of breeding materials is less important for countries with strong national programmes, but weaker programmes will continue to need such materials.

Centres must continue to play a primary role in developing varieties closely adapted to a multitude of specific locations. This requires close cooperation with national programmes in breeding efforts to utilize the full production potential of local environments. The programmes may assist in identified breeding programmes and can assume responsibilities beyond their political frontiers provided they are fully funded in all aspects. However, each national programme must identify the necessary preconditions before assuming the expanded role.

In the future, I see the centres playing a major role by conducting relevant research whose financial demands are beyond the reach of many national programmes. Therefore, centre activities must be strengthened so that they can continue their substantial contributions to the global research effort. India has always been a firm believer in stronger international cooperation. We will certainly support and participate in programmes of increased cooperation in specific areas of wheat and rice research and training.


FAO
ICARDA
PAKISTAN
MEXIC

ANNEX II

Wheat and Rice Research Within the Global Priorities and Strategies of International Agricultural Research: Issues and Options

Guy Camus

***Chairman, Technical** Advisory Committee/CGIAR.*

The presence of agricultural leaders from strong national programmes and international centres at this Consultation clearly indicates the importance of the subject and of collaboration to further our common goal of providing sufficient food for the developing countries.

It is hoped that this Consultation will help increase the efficiency of the global research system through increased partnership and a wider sharing of responsibilities.

Wheat and rice, the most important crops for the developing countries, were the first studied by the CGIAR centres. The vision of the Ford and Rockefeller Foundations in setting up IRRI and then CIMMYT in the early 1960s was a major factor in turning the tide against hunger.

These two centres built on a large consolidated research and information base, strongly focusing on two specific crops and using enthusiastic, dedicated, and well-trained scientists from many countries. In a remarkably short time, they developed the semi-dwarf varieties and associated production technologies that have made many countries self-sufficient in wheat and rice. Many have become net exporters.

CIMMYT and IRRI did not, of course, do all this on their own. Once the first high-yielding varieties became available, scientific and political inputs of partner countries were essential components of the success story.

Besides research, IRRI and CIMMYT undertook massive training programmes that have contributed substantially to developing the scientific capabilities of national agricultural research systems. Now, at least in the case of the strongest national programmes, their scientists can meet their peers in the centres and in developed countries on an equal footing. Both the 1985 CGIAR Impact Study and the 1984 TAC Study of Training in the CGIAR System document these facts.

The successes both in research and at the farm level have been welcome news to IRRI, CIMMYT, donors, and partners alike. Strong national systems are routinely addressing most of the wheat and rice problems that the centres were originally set up to solve. They breed finished varieties and develop agronomic recommendations and specific technologies geared to specific national, social, and agroecological needs. The strongest national programmes are requesting less assistance than before, but are much more specific in the requests they do make. For example, they want characterized germplasm, or parental materials with specific genetic characteristics. Other requests are for information, backstopping, and facilitation of collaborative research networks, and for specific types of training. Some national systems are also increasing their efforts in strategic research.

Perfect! But, what about the weaker systems?

Many countries, despite intensive efforts, are still far from being able to be full partners in the global research effort.

The present worldwide situation for rice and wheat can be considered satisfactory, but some countries still have critical shortages, and many other commodities remain scarce. Furthermore, there is no room for complacency when one considers the projected demands that explosive population growth will create for the mid- and long-term future. Constructive steps are urgently needed.

These considerations, along with the growing achievements of the stronger national programmes, raise a number of issues and options regarding the future direction of the CGIAR and its partners. The issues cut across all commodities and research activities supported by the CGIAR system. But they are particularly well illustrated by the evolution of cooperation between IRRI and CIMMYT and national systems. The organizers of this Consultation have already identified many of these issues; indeed they form its objectives.

THE EVOLVING PARTNERSHIP BETWEEN IARCs AND NARS

The past success of the CGIAR centres has been mainly based on collaboration with partner countries. As described in the *TAC Review of CGIAR Priorities and Future Strategies,* all partners must cooperate closely to meet future challenges.

Among the participants from strong national agricultural research systems were (left to right) Amir Mohammed, Director General, Pakistan Agricultural Research Council; M. Ashraf, Rice Coordinator, PARC; and Arturo Hernandez, Research Official, Wheat Programme, Mexico.

This global research system includes national programmes, multilateral and bilateral agencies, UN specialized agencies, and a number of international foundations, universities, and other institutions of basic research in developing and developed countries, as well as the CGIAR centres.

CGIAR is, by size, a small partner within this group, spending only about 5% of the total resources currently directed to agricultural research in developing countries. But it catalyzes the efforts of many groups and fosters cooperation among interested partners.

Closer collaboration implies a rational division of labour, so that each component of the global system can concentrate on its areas of greatest comparative advantage.

In the CGIAR system as a whole, the national programmes have been mainly on the receiving end. Many may continue to play a passive role, at least in the immediate future. But the hope is that, after this Consultation, the stronger national systems will assume increasing leadership in both applied and adaptive research. Location-specific research is best handled at the national level. Centres should focus on well-defined problems common to many partners so that the solutions will have a greater multiplier effect.

The national systems represented at this Consultation have demonstrated their capacity to generate technology geared for national needs. Their presence indicates their willingness to work in partnership with CGIAR and other institutions, and to share their knowledge and expertise with other countries.

In its review of CGIAR priorities, TAC has already considered operational mechanisms to strengthen partners' links. Networks are one good example. CGIAR centres lead some networks, but national systems are leading a growing number, with a CGIAR centre as a partner, or sometimes a backstop, in the venture.

Even the weakest national programmes have some areas of special expertise, so the networks prevent unnecessary duplication of research and bring greater international recognition to the participating scientists and national programmes. They also encourage the national systems to establish collective priorities by region or subregion.

Collectively established regional priorities usually have considerable influence on how bilateral donors allocate their funds and may also influence the priorities of individual centres. Moreover, they identify the specific services the centres will provide, and pave the way for participants to take on responsibilities that centres may originally have handled. TAC encourages such initiatives and the donor community is increasingly supporting them with bilateral resources.

Beyond the results obtained, networks also speed up the process of strengthening national systems through active participation of all partners in selected research areas. They also offer the greatest multiplier effect.

Other types of partnerships include joint research. More work can be carried out on clearly identified problems by joint planning, execution, and reporting between a national programme and a centre. Joint programmes may often be integrated into the ongoing activities of the partners. In special cases, one partner or a bilateral donor may provide extra funding. Both parties gain from such joint ventures: the national programme contributes valuable specialized knowledge, while the centre brings in broader resources and enhanced prestige. This type of cooperation is best suited to applied and strategic research, rather than to adaptive research, which could be conducted by the national programme alone.

For the future, increased exchange or outposting of scientists between centres and national systems could reinforce collaboration and partnership.

Training is a major ingredient for strengthening national capabilities. So far most of the specialized training

has been at the centres, but TAC supports the trend toward decentralization. The problem is complex, because several levels of training are needed and the partner countries' roles are not yet clearly defined. The Consultation will discuss the issue, and examine the types of training and possibilities for cooperation among centres, universities, and national programmes to meet the vast needs.

Only through vigorous exploration of all possibilities can we meet the challenges of the year 2000, when, for instance, rice production will have to be 60% greater to meet demand. Despite their admirable dedication and efficiency, the centres cannot do everything. The centres and the CGIAR system cannot expand indefinitely, yet the demands keep piling up. All partners must participate in the common endeavor.

THE FUTURE ROLE OF THE CGIAR CENTRES

The CGIAR system's role is evolving toward a service function as more national systems attain the capacity for applied and adaptive research. Any strategy to enhance cooperation between the CGIAR centres and national systems should take three considerations into account.

The first is the diversity of research capacities among national systems, compounded by the specificity and diversity of demands from the stronger ones. Each centre will have to define its priorities and strategy to strike a balance between the needs of the weaker national programmes and the demands of the stronger ones.

The second consideration is the need for a gradual, balanced shift by the CGIAR centres to more strategic and basic research. This would be possible if the stronger national systems decide to take on increased responsibilities for breeding, testing, and adapting technologies to specific environments as well as their share of maintenance research. Such a move would also require concerted efforts to assist weak programmes in solving their current adaptive research problems while helping them increase their research capacity.

Third is the need for balance between opportunities and needs. Centres must continue to focus on those areas where opportunities for potential breakthroughs exist, without discounting the time lag between the initiation of a research effort and its eventual payoff. The time lag may be long for activities with a short research history or where the knowledge base is limited.

A common strategy for all centres would serve no useful purpose; each should develop its own strategy for collaboration in consultation with its major national system partners.

Ways to give greater coherence to the various efforts in the global research system must now be considered, along with the attitudes, mechanisms, and scientific levels of collaboration. It is time to shift gears and increase the momentum. The work to be done is far beyond the scope of CGIAR alone and requires more concerted efforts. Through collaboration and sharing of responsibilities among the partners, CGIAR will be able to progress toward its stated goal: Through international agricultural research and related activities, to contribute to increasing sustainable food production in developing countries in such a way that the nutritional level and general economic well-being of low-income people are improved.


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ANNEX III

Strengthening National Agricultural Research Systems to Assume an International Role in Specific Areas of Rice Research and Training

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Visiting Scientist and Director General, IRRI.

Three main types of institutions contribute to the global agricultural research system that works on problems of the tropics and subtropics:

- National agricultural research systems (NARS), almost all in Third World countries;
- Thirteen international agricultural research centres (IARCs) supported by the Consultative Group on International Agricultural Research (CGIAR); and
- National research systems in industrialized countries.

These groups are interactive, complementary, and symbiotic.

AGRICULTURAL RESEARCH IN DEVELOPING COUNTRIES

In the 1960s, Third World countries faced increasing food deficits, severe foreign exchange imbalances, and employment problems. Concern about the persistent lag in growth of agricultural production led to efforts to extend superior technology to farmers and to encourage its adoption. But many available varieties and production technologies were inappropriate for Third World agriculture. Specific technology had to be developed for the tropics and subtropics.

Special attention was directed to the newly established International Rice Research Institute (IRRI) as the source of new technology for rice production, and to the International Wheat and Maize Improvement Center (CIMMYT), which provided the Mexican wheats. These centres demonstrated the potential for the renovation and growth of agriculture in Asia. The yield increases were the result of new combinations of inputs, based on management-responsive varieties from IRRI and CIMMYT.

Planners and development administrators in the developing countries emphasized research as the catalyst to agricultural growth. That emphasis was fully justified by the success of internationally supported research at IRRI and CIMMYT.

It was recognized that, in addition to these specialized international research centres, the continuous infusion of new technology to meet the future needs of the developing world required strengthening national capabilities in agricultural research. Many country- and location-specific production problems are tied to the social, soil, and climatic environments of monsoon Asia.

The emphasis on agricultural development was backed by the political will of many governments, resulting in increased investments in agricultural research. A 1981 joint study by the International Food Policy Research Institute (IFPRI) and the International Service for National Agricultural Research (ISNAR) found that the aggregate expenditures of 67 developing countries increased from US$394 million in 1970 to about US$1 060 million in 1980. During the same period, the scientific staffs of these developing countries increased from 18 731 persons holding a B.Sc. or higher degrees in 1970 to nearly 34 000 in 1980. Measured in terms of expenditure and scientific staff strength, growth in the national agricultural research systems has been high (ISNAR, 1984).

A paper presented to the Consultative Group on International Agricultural Research (CGIAR) in May 1982 stated: 'Thus both national agricultural research expenditures and scientific staff are now ahead of internationally accepted indicative planning targets. This represents substantial progress on the part of the Third World countries' (Oram, 1982).

Expenditure and numbers of scientific professionals are not the only indicators. A number of countries have numerically strong, well-organized and coordinated, and increasingly well-trained national research systems.

However, growth has not been uniform in all countries. The 1981 IFPRI-ISNAR study found that over 60% of all expenditures were concentrated in only five countries: Argentina, Brazil, India, Mexico, and Nigeria. The distribution of scientific personnel is likewise unbalanced.

Three key participants representing the CGIAR cetres were (left to right) Guy Camus, Chairman, Technical Advisory Committee; M.S. Swaminathan, Director General, International Rice Research Institute; and Donald L. Winkelman, Director General of the International Center for Maize and Wheat Improvement

Scientists observed the performance of their own rices grown in Nepal through an International Rice Testing Program monitoring tour coordinated by IRRI.

The growth in expenditures and scientific staff created allied constraints in a number of countries: insufficient training and experience in research management, inadequate opportunities for young professionals to develop analytical and experimental rigour, and mid-career development blocks for promising scientists in the national systems despite expansion.

These problems notwithstanding, many national programmes now have more scientific staff, holding higher qualifications, than before. With the achievement of a critical mass of scientists in the system, and with growing accomplishments in collaborative programmes with international centres, such programmes are poised to undertake broader and larger responsibilities. Such opportunities would also mitigate some of the constraints felt by many national programme scientists.

THE CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH (CGIAR)

The CGIAR is an association of public- and private-sector donors that funds a worldwide network of 13 international agricultural research centres. Its cosponsors are the United Nations Development Programme (UNDP), the Food and Agriculture Organization (FAO), and the World Bank.

A lucid analytical account of the genesis, evolution, growth, and contribution of the CGIAR is available in *Partners Against Hunger* by Warren C. Baum (1986).

For perspective, the main objectives of CGIAR and its current priorities are:

- to examine developing countries' needs for special agricultural research at the international or regional levels on critical subjects not adequately covered by existing research facilities and to consider how to meet these needs;
- to ensure that international and regional agricultural research complement national activities, and to encourage full exchange of information;
- to consider the financial and other requirements of high-priority international and regional research activities;
- to review priorities for agricultural research in the developing countries on a continuing basis; and
- to consider ways of assessing the feasibility of specific proposals.

Establishing priorities for centre research is a main, continuing function of CGIAR. The Technical Advisory Committee (TAC) has been its principal instrument in articulating research priorities.

GOAL STRUCTURE AND PROGRAMME STRATEGY

The CGIAR system's long-term goal has evolved over time. In a recent document (TAC Secretariat, 1985) TAC adopted this goal statement: 'Through international agricultural research and research-related activities, to contribute to increasing sustainable food production in developing countries in such a way that the nutritional level and general economic well-being of low income people are improved.'

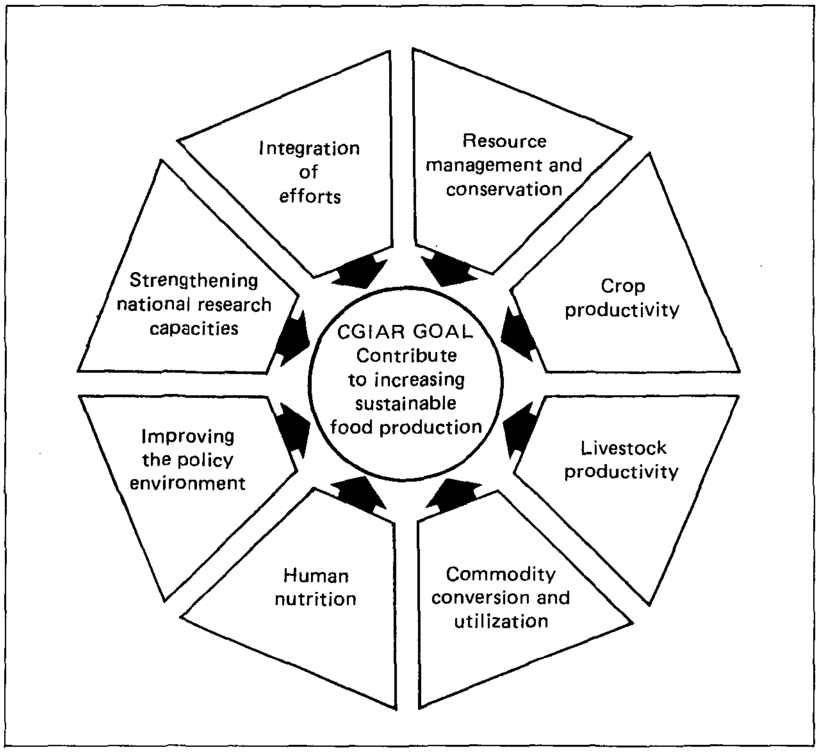
It further states that the central goal can be divided into a set of eight interrelated objectives. One objective is to strengthen national agricultural research capacities in developing countries to accelerate the indigenous generation, adaptation, and effective utilization of enhanced technologies (Fig. 1).

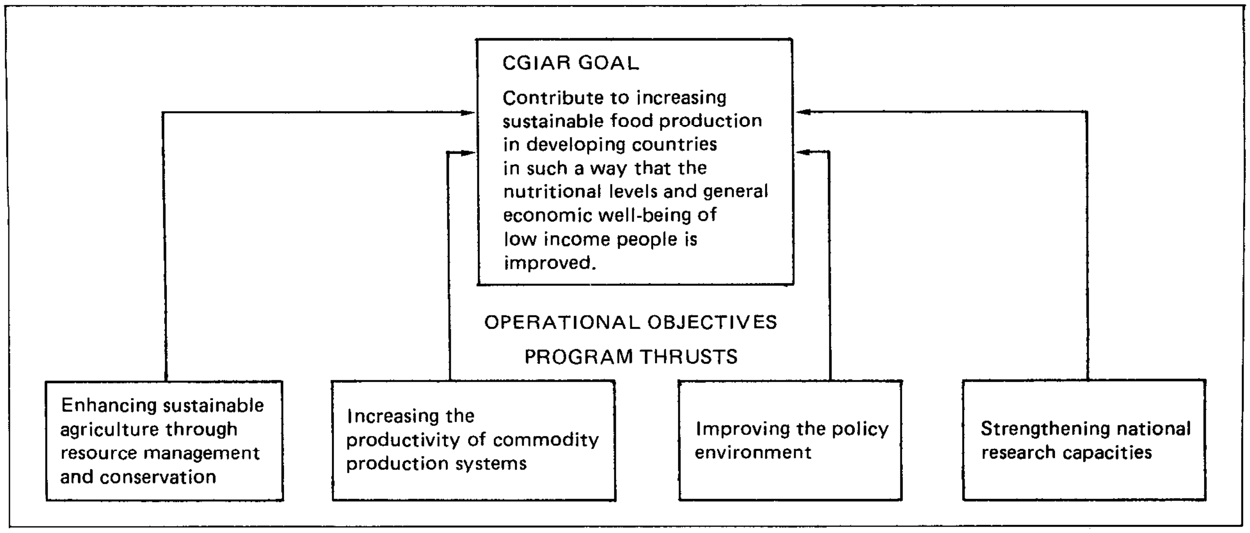
In its operational programme, TAC identified four major programme thrusts, including strengthening national research capacities (Fig. 2).

SHARES IN PUBLIC SECTOR SPENDING ON AGRICULTURE

Since its establishment in 1971, CGIAR has grown to include donors representing 25 countries and more

1. The goal structure of the CGIAR.





2. The problem structure of the CGIAR.

than a dozen foundations and international organizations. Total CGIAR contributions in 1972 were US$20.75 million but had increased to US$173 million by 1984. That growth was paralleled by additional centres with individual mandates (Fig. 3).

Yet in terms of global public sector spending on agriculture, the share received by CGIAR is a modest 1.6%; in relation to developing country efforts, its share is about 5% (1980 figures).

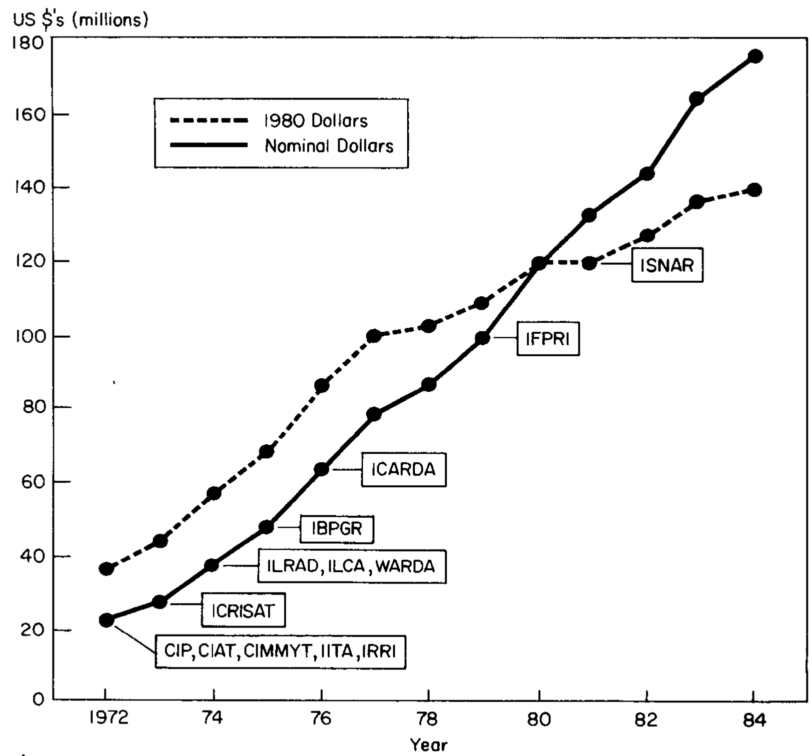
At the same time, the catalytic effect of international centres on national programmes is immense. National systems must act increasingly as equal partners in joint planning of collaborative research ventures. The gradual takeover by national systems of essential applied and adaptive research functions would enable the CGIAR system to concentrate a larger share of its resources on research directed toward developing the bases for future breakthroughs. This would help the centres tailor their cooperative programmes to match the needs and potentials of their clients.

INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)

The Rockefeller and Ford Foundations formally established IRRI in 1960, in collaboration with the Government of the Philippines. IRRI's mission, as mandated in its Articles of Incorporation, is to 'ursue any, or all, of the following objectives:

- to conduct research on the rice plant, and on all phases of rice production, management, distribution, and utilization with the objective of improving the nutritive and economic advantage or benefit of the people of Asia and other major rice-growing areas of the world through improvement of quality and quantity of rice;

3. CGIAR funding to the International Agricultural Research Centers, 1972-84. Reproduced from budgeting, financial management, and reporting in the CGIAR, March 1986.



- to publish and disseminate research findings and recommendations of the Institute;
- to distribute improved plant materials to regional and international research centres where they might be of significant value to use in breeding or improvement programmes;
- to develop and educate promising young scientists from Asia and other major rice-growing areas of the world along lines connected with or relating to rice production, distribution, and utilization, through resident and joint training programmes under the guidance of well-trained and distinguished scientists;
- to establish, maintain, and operate an information centre and library that will provide a collection of the world's literature on rice for interested scientists and scholars everywhere;
- to maintain and operate a rice genetic resources laboratory which will make available to scientists and institutions all over the world a global collection of rice germplasm; and
- to organize or hold periodic conferences, forums, and seminars, whether international, regional, national, or otherwise, for the purpose of discussing current problems.'

Clearly, the Institute's objectives were broadly stated to permit wide latitude for IRRI to develop its programme. This mandate has changed little over the years, during which IRRI has liberally interpreted the broad enabling provisions to sustain its dynamic and responsive growth in the accomplishment of the tasks emerging from its charter of responsibilities.

From the beginning, IRRI recognized that its success depends on the dedication of its scientists to the purposes of the national rice programmes with which they work. IRRI's relationships with national systems have evolved during the past 25 years. The stress on technical assistance in the 1960s shifted toward cooperative programmes with some national systems in the 1970s. The emerging scenario in the 1980s is one of collaborative research, wherein some national systems and IRRI jointly design programmes, each accepting responsibilities where it has a comparative advantage.

Currently, IRRI has cooperative programmes with 18 countries, which account for more than 85% of the world's rice production and hectarage. In addition, IRRI collaborates with the International Center for Tropical Agriculture (CIAT), the International Institute of Tropical Agriculture (IITA), and the West Africa Rice Development Association (WARDA) in Latin America and the Caribbean and in Africa. The five global research services at IRRI — the International Rice Testing Program, International Rice Germplasm Center, Rice Farming Systems Program, Communication and Publications Department, and Training and Technology Transfer Department — provide an effective mechanism for collaboration in rice research, training, and information transfer among countries as well as between IRRI and countries.

IRRI today is the meeting ground for developed and developing national systems and an effective scientific bridge between North and South. Table 1 shows its pathways of cooperation.

IRRI's contributions to science, training, and rice production are documented in IRRI Annual Reports, two TAC Quinquennial Reviews, and recently in an impact study by CGIAR and IRRI at the time of its 25th Anniversary (IRRI, 1985). An analysis of emergent concerns generated by IRRI's contribution to the spread of the Green Revolution and its dynamic institutional response is presented in the last chapter of *25 Years of Partnership,* 'Looking Ahead.' Our attempt here is to highlight the introspective capacity of IRRI's scientific community with its ability to respond to emerging issues, challenges, and concerns and its commitment to

Table 1. Pathways of cooperation between IRRI and national research systems and institutions.

Pathway	Examples[a]
Research services	IRGC, Azolla germplasm IRTP, INSFFER, AFSRN
Country programmes	Resident scientists Scientist-scientist
Cooperative research	Hot-spot screening Shuttle breeding Farm machinery
University and advanced institutions	Organizations (USAID, CIRAD, GTZ, ODA of UK., ACIAR, etc.) Universities and institutions International centres (IITA, WARDA, ICIPE, etc.) RF Network on genetic engineering Individal scientists
Training and technology transfer	Los Baños In-country Joint
Knowledge sharing	Seminars, monitoring tours Bibliographic services Publications

[a]IRGC = International Rice Germplasm Center, IRTP = International Rice Testing Program, INSFFER = International Network on Soil Fertility and Fertilizer Evaluation for Rice, AFSRN = Asian Farming Systems Research Network, ICIPE = International Centre of Insect Physiology and Ecology.

strengthening national programmes through shared perceptions and responsibilities. We present a few concrete examples of activities for consideration in furtherance of the objectives of this Consultation.

STRATEGIC PLANNING COMMITTEE OF IRRI

In 1986, IRRI's Board of Trustees recommended the establishment of an internal Strategic Planning Committee (SPC) to develop a discussion paper on IRRI's future strategy. Board members invited the Institute to focus on seven points in planning its future strategy. One of the seven is collaborating with national programmes in the context of their changing needs and strengths.

The IRRI SPC has approached its task with the fullest awareness of the opportunities to intensify collaboration with national systems, including assisting the strong systems to assume regional and global responsibilities for certain aspects of research and training.

The Committee's deliberations and recommendations on this important topic clearly state that one of the six chief factors influencing the Institute's plans is 'the substantial increase in the research capacity of many Asian, Latin American, and African national rice programmes.'

Each of IRRI's programme areas is striving to respond to the Institute's goals by keeping its own objectives and programmes dynamic. Thus IRRI will continue to adjust its research in the light of changing needs of national rice programmes, perceived problems and opportunities, and IRRI's comparative advantages as a partner in international agricultural research.

The SPC's suggestions also focus on poorer producers and on environmental analysis of rice-producing areas.

Focus on the poorer producers

An important shift in the goals of CGIAR, and of IRRI, is increased emphasis on improving the 'nutritional level and general economic well-being of low income (rice-dependent) people.' That is, equity issues, such as increasing the livelihood security of the poor, are as important as efficiency issues related to increasing total output *per se*.

Environmental analysis and extrapolation domain

IRRI's draft strategy outline on environmental analysis states:

The determination of research priorities on the basis of better knowledge of the importance of the respective environments is particularly critical to determining IRRI's future research thrusts. More work will be needed to map and estimate the areas of the various classes and sub-classes of rainfed rice.

Extrapolation domains for many of IRRI's rice technologies need to be determined. Environmental analysis will assist in establishing the prospective ecological and spatial extent of Azolla, Sesbania, and other green manures (IRRI, 1986).

IRRI AND RESPONSIBILITY-SHARING WITH NARS

IRRI and the national systems, as well as universities in developing and developed countries, have forged many symbiotic links illustrating the power of 26 years of purposeful cooperation. In addition to direct partnerships with national programmes, IRRI serves as a conduit for channeling 'forward-edge' technologies. An excellent example is the 1986 organization of a network supported by The Rockefeller Foundation to apply the expertise of molecular biologists and genetic engineers around the world to practical field problems.

IRRI assists strong national programmes in assuming regional and international responsibilities. The Hunan Hybrid Rice Research Centre in China and IRRI are collaborating in organizing training programmes for NARS. Similarly, IRRI and the National Azolla Research Centre of the Fujian Academy of Agricultural Sciences are organizing training programmes on biofertilizers, particularly Azolla.

As IRRI redirects its priorities toward the more unfavourable environments, much of the work will have to be done in collaboration with appropriate national programmes. Two examples illustrate this new pattern:

- Rainfed upland rice: A coordinated research programme establishing a regional centre in Indonesia would accelerate progress in increasing and stabilizing upland rice yields in Asia.
- Problem soils: A coordinated grid of research centres — in Indonesia for organic peat soils, Viet Nam for acid sulphate soils, and India and Pakistan for saline/sodic soils — would help develop improved varieties and technologies for problem soil areas.

STRENGTHENING COLLABORATION

The future of rice research lies in strengthening collaborative efforts and in sharing responsibilities with national systems. Some IRRI research programmes conceivably might be transferred where appropriate conditions have been established.

In line with IRRI's commitment to more responsive collaboration and responsibility-sharing with national systems, and the priority CGIAR has accorded to strengthening national research capabilities, five areas have been identified as initial activities to strengthen national programme capabilities to assume international roles in rice, with support from IRRI.

The Hunan Hybrid Rice Research Centre, Changsha, Hunan, China

China developed hybrid rice technology and has successfully used it for 15 years to increase productivity beyond the yield ceilings of improved semi-dwarf varieties. The technology exploits heterosis, or hybrid vigour, and involves growing hybrid seed commercially. About 8.5 million of a total 32 million ha of rice in China are planted to hybrids, which yield about 20% higher than the best conventionally bred varieties. The Hunan Academy of Agricultural Sciences played a pivotal role in the development and spread of this technology. In 1984 the Hunan Provincial Government established the Hunan Hybrid Rice Research Centre.

In 1979, IRRI also stepped up its research on hybrid rice. IRRI imported cytoplasmic male sterile (CMS) lines from China to use in developing CMS lines for tropical environments. In turn, IRRI contributed a large number of elite breeding lines to China's effort to identify restorer lines.

Through training programmes and by supplying information and hybrid rice genetic materials, IRRI and China are working collaboratively to help national programmes in India, Indonesia, Malaysia, Republic of Korea, Thailand, and Viet Nam that have initiated hybrid rice research.

About 220 delegates from 17 countries and IRRI attended the first International Symposium on Hybrid Rice, organized by China and IRRI, and held in Hunan in 1986. Symposium participants recommended target environments, future research directions, and mechanisms for collaborative research.

The Hunan Hybrid Rice Research Centre could be strengthened, in collaboration with IRRI, to undertake international responsibilities including:

- identifying new CMS sources and sharing them with national systems;
- investigating the development of new CMS sources through protoplast fusion;
- developing techniques for predicting heterosis;
- identifying gametocides;
- refining techniques for more economical hybrid seed production;
- conducting training programmes on hybrid rice technology and seed production; and
- providing opportunities for visiting scientists from national programmes to participate in the centre's research.

IRRI can provide backup scientific and logistic support for all these tasks. More important, IRRI can be the conduit for channeling innovations in forward-edge science, such as biotechnology, to China.

The National Azolla Research Centre, Fujian Academy of Agricultural Sciences, China

Azolla, an aquatic blue-green alga that fixes nitrogen from the air and converts it to a form that crops can use, has been used as a green manure by Chinese farmers for thousands of years. The China National Azolla Research Centre has recently found that Azolla can also enrich low potassium concentrations in irrigation water.

China began systematic applied research on Azolla after 1949. IRRI has also organized international cooperation in basic and applied research and training in Azolla. But further study is needed on problems in traditional Azolla cultivation and utilization, such as those associated with temperature, phosphorus management, and pest control.

Basic researchers must study the classification of Azolla and its symbionts, the synchronization of fern and algae in the Azolla life cycle, sporocarp induction and its utilization, nitrogen fixation and hydrogen release, and the development of new Azolla strains through biological engineering.

The first International Workshop on Azolla Use, cosponsored by the Fujian Academy of Agricultural Sciences and IRRI, was held in Fuzhou in 1985.

The National Azolla Research Centre could be strengthened to undertake international responsibilities in collaboration with IRRI. The centre could promote understanding of this ancient and beneficial nitrogen-fixing biological association and accelerate its use, not only in crop production, but also in animal husbandry.

The centre and IRRI have already agreed to develop and strengthen this centre to assume international responsibilities.

Selected NARS with regional responsibilities on adverse soils

Past efforts to breed for tolerance for adverse soils were limited by poor

understanding of environmental interactions, lack of screening techniques to isolate tolerant varieties, and inadequate knowledge of the genetics and mechanisms of tolerance.

To speed research in these areas, IRRI has conducted basic research on drought resistance, flood tolerance, adverse soil tolerance, and fertilizer efficiency under undependable soil and climatic conditions. Most studies are now complete and have resulted in:

- a better understanding of the soil and climatic constraints of adverse environments;
- the development of laboratory, greenhouse, and field techniques for screening varieties against soil and climatic stresses;
- the construction of special facilities to accelerate breeding work for adverse environments; and
- the initiation of breeding programmes to combine adaptability with such economic traits as yield, insect and disease resistance, and grain quality.

In most adverse environments, the major factors depressing production are in the soil. Developing tolerant varieties is the first step to increasing production capability on adverse soils. Ideally, all research activities should be carried out in target environments. Climatic constraints, though they rarely exclude the use of land for rice, are an additional hazard.

An international project is underway to utilize basic IRRI research in developing improved varieties for Asian ricelands affected by adverse soils. In the process, the project will also improve the professional capabilities of national scientists.

Representatives from Bangladesh, India, Indonesia, Pakistan, Philippines, Sri Lanka, Thailand, and Viet Nam identified institutions and countries to host and share in such a research programme during a 1986 project design workshop (Table 2).

Although IRRI will have responsibility for basic work, national programmes will obviously play a major role in this strategy. Because the national programmes are more interested in developing commercial varieties, it seems advisable for IRRI to strengthen selected programmes' basic research. Conducting prebreeding research and varietal improvement concurrently will save time and increase interest in the problems.

A Regional Research and Training Programme for Upland Rice-Based Farming Systems at Sukarami, Sumatra, Indonesia

Upland rice is planted on about 20 million ha, or 15% of the world's rice area. Upland rice is grown on 11.5 million ha in the northern foothills of Bangladesh, Democratic Kampuchea, the northern Gangetic Plains and eastern India, Indonesia, Laos, the Philippines, Thailand, and Viet Nam. In Latin America 6 million ha, or 72% of the total rice area is planted to upland rice, mostly in Brazil. West Africa has 2 million ha of upland rice.

Yields are low and prospects for major improvement are less than in irrigated and rainfed lowland rice. But millions of the poorest of the poor depend on upland rice for sustenance; so in terms of equity, upland rice deserves attention. The problems of land degradation and the low sustainability of upland rice systems must also be considered.

More than 50 million impoverished people grow upland rice in South and Southeast Asia.

In a recent 41-country survey, upland rice breeders identified drought, weeds, blast and brown spot, acid soils, and phosphorus management as the most critical researchable constraints to increasing upland rice productivity. Scientists involved in upland rice research need sites that typify such physical (climate and soil) and biological (diseases and insects) environments.

A well-equipped research centre, with adequate human resources and equipment, located in a zone representative of areas where upland rice is already grown, is essential for the improvement of upland rice farming. Research alone cannot change traditional practices, so such a centre must also be devoted to manpower training, including extension workers and farmers so that they learn to use new technologies.

A project proposal was prepared to establish a Regional Research and Training Programme for Upland Rice-Based Farming Systems of Sukarami Agricultural Research Institute for Food Crops in Sumatra, as part of the Indonesian national system, after discussions at the 1985 International Upland Rice Conference in Indonesia.

Table 2. Centres proposed to take primary responsibility for developing rices tolerant of adverse soils.

Soil type	Host NARS[a]	Participating NARS
Coastal saline	CSSRI, Port Canning, India	Bangladesh, Burma Philippines, Republic of Korea, Sri Lanka
Sodic	CSSRI, Karnal, India	Egypt, Pakistan
Saline/sodic	PARC, Faisalabad, Pakistan	Egypt, India
Acid sulphate (flood-prone)	Cantho University, Viet Nam	Bangladesh, India, Indonesia Philippines, Thailand
Acid sulphate (drought-prone)	DOA, Thailand	Indonesia, Philippines
Peat	BARIF, Kalimantan, Indonesia	Burma, India, Malaysia Philippines, Sri Lanka, Thailand, Viet Nam
Iron toxic	DOA, Sri Lanka	India, Malaysia

[a]CSSRI — Central Soil Salinity Research Institute, PARC = Pakistan Agricultural Research Council, DOA = Department of Agriculture, BARIF = Banjarmasin Agricultural Research Institute for Food Crops.

This activity could be internationalized with Indonesia as host and coparticipants such as Bangladesh, India, Laos, Thailand, and Viet Nam.

Regional hot-spot screening facilities within the International Rice Testing Program (IRTP)

IRTP is a cooperative network for worldwide evaluation of elite rice cultivars over a wide spectrum of environments and stresses. Through IRTP, nurseries for yield, observation, disease, insect, problem soils, low temperature, and other stresses are composed, disseminated, and evaluated.

The strength of IRTP lies in the active participation of cooperating national systems in the systematic evaluation of elite germplasm.

At least 111 varieties in 46 countries have been released through IRTP. The network should be modified and expanded to reflect the increasing emphasis on adverse environments and the progress of national programmes. Screening sites of the stronger national programmes can be upgraded to collaborative regional research centres to establish regional nurseries and to take responsibility for some hot-spot screening. This could generate a higher volume of quality material and facilitate the distribution of genetic material among national systems in regions of the same ecology.

IRTP has already developed regional programmes in East Africa with the help of Tanzania, and in the Caribbean region with the Dominican Republic. Similar regional nurseries could be developed in Asia. Intensive screening at hot spots could identify genetic sources of resistance to major insects, diseases, and soil problems. Table 3 suggests test locations and key national programmes for screening on the basis of soil classification, temperature, and rainfall pattern.

More important, establishment of regional hot-spot facilities would contribute to the professional growth and development of young national scientists.

Table 3. Potential sites for "hot-spot" screening for resistance to selected stresses.

Soil type	Host NARS	Participating NARS
Inland salinity	Pakistan	Afghanistan, Egypt, Iran, India
Coastal salinity	India	Bangladesh, Burma, Indonesia, Philippines, Thailand
Alkalinity	India	India, Pakistan
Acid sulphate	Thailand	Burma, Indonesia, Philippines, Viet Nam
Iron toxicity	Sri Lanka	Burma, India, Indonesia, Thailand
Acid upland	Brazil	Colombia, Cote d'Ivoire, Mexico, Nigeria
Peat soils	Indonesia	Malaysia, Thailand, Viet Nam
Blast	Philippines	China, India, Indonesia, Malaysia, Pakistan, Republic of Korea, Thailand, Viet Nam
Bacterial blight	India	Bangladesh, Burma, China, Nepal, Republic of Korea, Thailand
Tungro virus	Philippines	Bangladesh, India, Indonesia, Malaysia, Thailand
Brown planthopper	China	Bangladesh, Burma, India, Indonesia Philippines, Republic of Korea, Sri Lanka, Thailand

IRRI's main contribution would be assistance in the mid-career development of participating national scientists and the channeling of 'forward-edge' technologies through the regional centres.

These programmes would also provide opportunities for some young and mid-career professionals from developed countries to work with national programmes, helping them to grow professionally together with scientists in the tropics and subtropics.

Positions would have to be created at each host national programmes in which visiting scientists from participating national systems could work for specified periods on clearly identified programmes. Visiting scientists might draw salaries and benefits equivalent to those drawn by their respective foreign service officers in the national programmes of host countries. A larger number of visiting national system scientists might work at international centres for mid-career development under similar terms.

Regionalization of research programmes would give fuller use of complementary national resources of participating national programmes. Fundamental studies and basic research needed to back up regionalized research programmes would be suggested through detailed work plans prepared at technical meetings and workshops. Most of this long-term and highly specialized research support would be conducted at IRRI. The greatest contributions of the national system scientists to the basic research would be their unique capacities to identify and state problems. This strategy would further focus IRRI research and improve the pursuit of excellence and analytical and experimental rigour in problem-solving among participating national programmes.

Other benefits would be the new links for technical cooperation among national programmes, and the enhanced cooperation between such programmes and donor agencies.

National systems do not work only on rice. A sound model of collaboration in rice would encourage further collaboration, including assumption of responsibility in other areas, with the following benefits:

- Scarce staff resources would be augmented.
- Information could be exchanged more freely.
- Increased intercountry research coordination would reduce the

duplication of research among participating national programmes.

- The 'institutional voice' of IRRI could articulate the problems, especially financial, of the national programmes, and lobby for solutions.

A basis for research linkages between private and public sectors would be established. Agricultural research is essentially a public-sector activity in developing countries, but the private sector conducts an increasing amount of agricultural research in developed countries.

Preconditions for regional research responsibility

Following are some preconditions necessary for the implementation of national programme responsibilities for global programmes:

- Acceptance of the fact that sustained growth in agriculture depends on a broadbased research and educational system that is responsive to the needs of farmers and rural society.
- Availability of a critical mass of trained researchers and an operational environment that encourages individual initiative, interdisciplinary teamwork, intellectual discipline, and responsiveness to society's needs.
- Broad interdisciplinary development among the physical, biological, economic, and social sciences, and among agricultural institutions that plan programmes within national systems.
- Accordance of priority to research programmes on major problems whose solutions have great immediate, as well as long-term, value.
- Improved infrastructure facilities that can adapt technologies from other national programmes and international centres to achieve intermediate-stage production increases.
- Acceptance of English as an international language to be used in research and training programmes. Use of other languages would be based on consultation and consensus among participating national programmes.

Most important, a national programme must successfully discharge its responsibilities to its own country if it is to assume the responsibility of hosting a regional programme. The national programme must also be committed to the international sharing of its domestic facilities, strengths, and perceptions.

Operationally, each participating national programme must explicitly commit itself:

- To organize research by agro-ecological conditions so it will be most accessible to other countries with similar environments;
- To approach agricultural research problems on a multidisciplinary basis within the entire ecological area;
- To develop joint research projects with the other participating national systems;
- To cooperate with universities and research institutions in developed and developing countries by engaging their scientists for joint projects, and by organizing meetings and seminars;
- To exchange research information and scientific staff with participating national programmes throughout the zone, allowing researchers to become better acquainted and thus share their knowledge and experience;
- To allocate resources to key topics of regional priority, speeding solutions through pooled resources; and
- To strengthen existing national research institutions to build a network within the ecological zone, and to avoid unnecessary duplication and unhealthy competition in research.

Additionally, a host national programme should have experience in collaborative research and a record of harmonious working relationships with other institutions. The designated station in a host national programme must be reasonably accessible, and travel regulations of the host country must allow hospitable entry and exit for visiting and participating scientists, trainees, and scientific materials.

A Model for NARS and IRRI Collaboration

The concept and some procedures of the United Nations University System (UNU) might be an appropriate modality for expanded cooperation among centres. The UNU recognizes certain institutions as its associates, developing and supporting them as partners in international programmes.

Under such a scheme, each national programme station designated to undertake regional or international responsibilities could be developed as an associate of IRRI; this would essentially transform IRRI itself from an 'institute' to an 'institution', and strengthen the present network programme with a network of associate institutes.

An important preliminary step would be an intense interinstitutional, intergovernmental, and interorganizational consultation, resulting in the projection of proposals and preparation of detailed project reports.

Consultation and debate among senior scientists within the national programmes is a must. Implementation of the proposals must rest on a solid foundation of shared perceptions, knowledge, and determination to pursue excellence among both administrators and scientists in the participating national programmes.

Identification and evaluation criteria would have to be formulated to ensure both scientific rigour and compliance with national policies.

This scenario of steps might be necessary to implement such a programme:

- Appoint a steering group at the CGIAR level to guide and support accomplishment of the tasks.
- Designate an executing agency to work under the Steering Group's guidance.

- Constitute a 'Small Norms and Accreditation Committee' at the level of the Technical Advisory Committee (TAC) to provide professional judgement on selection criteria for host national programmes; guidelines, scrutiny, and approval of project reports; and related activities. The Norms and Accreditation Committee would set the following standards, and others: 1) stability of the host national programme; 2) funding and budgetary procedures; 3) research environment; 4) programme identification; 5) programme evaluation; 6) financial management; and 7) sharing of the research products and related linkages.
- Establish an appropriate management structure at the national level to enable the national programmes to accept international responsibilities.

Funding the Activities

Three mutually complementary sources of financial support are possible:

- CGIAR donors would contribute through multilateral and bilateral aid programmes.
- This could be supplemented and strengthened by an adaptation of the 'Transfer of Knowledge Through Expatriate Nationals' (TOKTEN) programme of the United Nations Development Programme (UNDP).

  TOKTEN began in Turkey as a country programme. It provides dual support in funding and provision of scarce professionals, and has recently assumed a regional dimension. For example, in 1985, UNDP's Regional Bureau for Africa approved a project with the Organization of African Unity which capitalizes on linguistic and cultural affinities among African people. In this project, expatriates will help an African intergovernmental organization rather than assist their countries of origin. An analogous form of TOKTEN-like support could be formulated for a regional consortium of national research systems.
- Developing countries, under their respective technical cooperation programmes, could provide fellowships and other forms of support.

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ANNEX IV

Strengthening National Agricultural Research Systems to Assume an International Role in Specific Area of Wheat and Rice Research and Training: an International Consultation

D. L. Winkelmann and B. C. Curtis
Director General and Wheat Programme Director, CIMMYT.

The success of joint participation in international agricultural research, particularly in wheat and rice improvement, has been remarkable and a tribute to all involved. However, our concern here is with examining opportunities for further enhancing that cooperation. In exploring options that pertain to wheat research, a clear perception of the current roles and activities of CIMMYT and national agricultural research system (NARS) should be kept in mind.

Although international agricultural research centres (IARCs) and national systems both see farmers as the ultimate beneficiaries of their work, the primary clients of the centres are the national programme researchers, while the primary clients of the national programmes are local farmers. International centres concern themselves mainly with developing intermediate products and services for national programmes use. In contrast, national programmes are ultimately concerned with developing finished technologies and production recommendations appropriate to the circumstances of local farmers.

CIMMYT'S PRODUCTS AND SERVICES

Within this general framework, CIMMYT provides five major products and services to national programmes: germplasm, training, research procedures, counsel, and information.

CIMMYT has played an important — and perhaps often underesteemed — liaison role in threading together the work of thousands of researchers worldwide. This role has been effective largely because national systems perceive us as being above politics; they have no reservations about sharing germplasm or information through CIMMYT, nor about our willingness to share with them. This even-handedness has resulted in trust — one of the Center's most valued assets.

NATIONAL PROGRAMME ENHANCEMENT

CIMMYT is engaged in many activities to strengthen national systems' human resources. More than 40% of the total effort of the Wheat Programme, for example, is allocated to such activities, including training, counselling, and information dissemination. In wheat training, CIMMYT focuses on crop improvement (breeding, pathology, cereal economics). CIMMYT offers researchers in-service courses in Mexico, or 'in-country' in collaboration with individual national programmes. Fellowships are provided for national scientists to work at CIMMYT headquarters and to visit other national programmes. More than 2 000 researchers from developing countries are CIMMYT wheat training alumni.

Our counselling activities with national programmes are of two types: 1) exchanges that convey technical information among peers, and 2) discussions of research policy for managers and decision makers. These counselling services are provided by CIMMYT staff and, sometimes, by scientists from other national programmes. Our information programme strives to communicate not only CIMMYT research results but also other information relevant to national systems engaged in maize and wheat research. More than 7 000 individuals and libraries receive CIMMYT publications and scientific information services. We also host international and regional conferences, often in association with national programmes. A major expansion of CIMMYT training, conference, and information facilities is a measure of our concern for these efforts.

SMALL GRAINS IMPROVEMENT

CIMMYT has developed an 'international' breeding strategy for bread wheat, durum wheat, and triticale. Clearly no single enterprise can efficiently fashion varieties for each of the developing world's wheat microenvironments. Nor is it possible to develop one or even a few genotypes that would meet the needs of the entire world. Instead, our wheat research focuses on a limited number of large agroecological zones, termed 'mega-environments,' each of which is found in several countries and comprises more than 1 million ha. The mega-environments are based on the main varietal characteristics needed by local farmers; they are relatively uniform in moisture, soil type, temperature regime, biotic stresses, etc.

Each breeding programme emphasizes broad adaptation within these mega-environments.

Our breeding strategy for small grains has several interrelated features: large numbers of crosses, shuttle breeding, selection for resistance to multiple diseases, and international multilocational testing.

International testing programme

Among the most important features of the germplasm improvement process is the global network of cooperating researchers who participate regularly in the international nurseries programmes for spring bread wheat, durum wheat, and triticale. CIMMYT facilitates the operation of this network first by compiling the nurseries, which comprise materials both from CIMMYT and from participating national programmes, then by distributing them to cooperators in target mega-environments. After harvest, network participants send the performance data to CIMMYT for collation and analysis. This global testing network enables hundreds of experimental lines and varieties to be evaluated simultaneously each year at more than 300 locations worldwide. National programme cooperators are free to release any nursery cultivar as a local variety for farmers, under any name, or to cross it with local varieties to combine the best traits of each. The network provides CIMMYT and participating national pro-grammes with valuable information on the performance of materials under a range of environmental conditions, as well as a mechanism to acquire new sources of genetic diversity.

Spring bread wheat improvement

To illustrate CIMMYT's strategy, consider the practices used in spring bread wheat improvement. In CIMMYT's early days, research concentrated on materials for well-watered areas, which make up about three-fourths of the developing world's area under spring bread wheat. Critical to the strategy was 'shuttle breeding,' or evaluation and selection at two quite different sites within Mexico. The sites are so situated that two cycles can be evaluated each year, halving the time to develop a new variety. Far more important, however, materials selected at both sites have a formidable robustness that buffers them against minor environmental vagaries and helps ensure good performance under a range of growing conditions. Also, a conscious effort was made to ensure durable resistance against leaf, stem, and stripe rust, the most widespread biotic stresses of wheat. The benefits bestowed by the Mexico shuttle have made CIMMYT spring bread wheats strong performers in many environments, and have easily justified making initial selection under such rigourous conditions.

Hundreds of improved wheat cultivars are evaluated yearly at more than 300 locations worldwide through CIMMYT's international wheat testing programmes.

Our approach to meeting national programme needs has evolved since those early days. One reflection is our current focus on wheats for each of several mega-environments. In defining these environments, a first partition is in terms of moisture availability. Temperature is a second important concern: some spring bread wheats require cold tolerance in the early stages and some need heat tolerance during later growth. A third major factor in defining mega-environments is resistance to fusarium head scab, which affects some 12 million ha in six countries and seems to be spreading. As additional information is received and analyzed, still other important biotic and abiotic stresses may be used to delineate mega-environments. Judgements on the relative importance of various stresses are based on information from national systems and CIMMYT staff. Considerations include 1) the extent of the area affected, 2) the number of countries involved, and 3) the probability of success at various cost levels.

We have tentatively identified seven spring bread wheat mega-environments in the developing world. Certain serious problems affect portions of some of these mega-environments. Examples are *Septoria tritici,* which affects about 3 million ha, and acid soils, which limit production on more than 1 million ha. How we treat problems affecting mega-environments depends on the circumstances of the research system involved. For *S. tritici,* we have developed resistant materials through the global network. For acid soils, which are confined essentially to Brazil and the East African highlands, we are working directly with Brazilian institutions, providing materials for relevant mega-environments and working with them to add acid soil tolerance. CIMMYT also studies many other stresses that affect spring bread wheat, working alone or with national systems.

Each mega-environment also requires wheats with a range of maturities.

We should also note that other considerations, such as tan spot disease, may become more important in the future. National and CIMMYT staff must therefore stay abreast of changes in disease spectra and virulence.

Even after factoring in differing maturities, each mega-environment (indeed each macro-environment) still has significant heterogeneity. Most materials emerging from the Mexico shuttle, however, have the yield stability and general fitness to perform throughout the relevant environment.

The enormous range of germplasm that CIMMYT has assembled is a ready source of genes for virtually any varietal problems confronted by national programmes.

CURRENT RESEARCH PARTNERSHIPS

Let's explore some of CIMMYT's current research partnerships, and opportunities for new collaboration with greater involvement of advanced national programmes. The 13-year-old collaboration with Brazilian institutions to develop high-yielding wheats with improved acid-soil tolerance involves shuttle breeding between sites in Brazil and Mexico. Lines are screened for agronomic type and rust resistance in Mexico and for aluminium tolerance and resistance to other diseases in Brazil. Wheats developed through this partnership yield more than twice as much on acid soils as the wheats of 10 years ago. Even so, we still need better disease resistance, especially for *Helminthosporium sativum*, fusarium head scab, and the two septorias.

We also collaborate with selected national programmes for disease screening in 'hot spot' areas: for example, stem rust resistance in durum wheat and septoria resistance in bread wheat (Ethiopia), stripe rust resistance in bread wheat (Ecuador, Kenya), and multiple disease resistance for highland areas (Mexico). These collaborative efforts benefit the cooperating national systems by providing new germplasm and the entire international wheat improvement community by screening, improving disease resistance, and information dissemination. The operational dimensions of some of these cooperative projects are best carried out through the current organization, but other projects might benefit from more formalized cooperative research networks.

Various national programmes cooperate in formal networks coordinated by CIMMYT. For example, activities of the Barley Yellow Dwarf Virus International Research Network range from research on the virus and its resistance mechanisms to germplasm evaluation and breeding. Several donors provide funds to facilitate network participation. This network is particularly appealing because of the wide range of scientific competencies involved, the way that results are transmitted and processed, and the participation of researchers from developing and developed countries — each contributing according to its particular advantage.

EXPANDING NARS INVOLVEMENT IN INTERNATIONAL ACTIVITIES

Expanded national systems' participation can be envisioned for certain international activities, especially among the advanced programmes represented at the Rome Consultation. Three models for expanded national programme involvement in international research ventures will be considered.

The first involves the internationali-

zation of national research systems. The structure for some of these activities need not be highly formal; for example, the shuttle breeding projects between CIMMYT and selected national programmes are informal but effective. Networks for these activities could be formed to plan joint research with responsibilities for specific problems allocated according to competencies, share analyses and data, and ensure the professional and technical quality of the research itself.

More formal NARS-IARC networks need not be restricted to germplasm development. Properly organized networks of scientists concerned with crop husbandry could have high payoffs, even though agronomic problems are often diverse and site-specific. One proposal is a network to study crop management for the ever more intensively farmed lands under rice-wheat rotation from Pakistan through Bangladesh. Such problems include weeds, fertility, soil structure and tilth, and salinity, but the focus of such a network would go beyond agronomy and technology generation; it would apply science to the underlying relationships on which sustainable yields must be based.

Training courses for procedures in crop management research and in specialized research topics are prime candidates for transfer to selected national programmes. Advanced national systems could serve as regional training centres for research workers from neighboring national systems.

As an example, the Turkish National Wheat Programme has a wealth of experience in dryland production agronomy that it might share with other national programmes through in-service training. CIMMYT might help develop course curricula, contribute training materials, and provide other support to the teaching staff. Sabbatical-like secondments, or visiting fellowships for national scientists to work at other national programmes, could enrich researchers' professional development, especially in research areas where the host national programme has noted expertise.

PRECONDITIONS FOR INCREASED NARS INVOLVEMENT

In our view, a national system that assumes a full-fledged international research or training function should have:

- a comparative advantage to undertake the activity based on 1) ecological factors, 2) human resource capacities, and 3) physical research infrastructure and facilities;
- a funding and organizational structure that will assure continuity of both human and physical resources engaged in the activity;
- a political structure that will ensure that the international activity will be above politics and that the needs of other national programmes will be met in an evenhanded way; and
- circumstances within the country that ensure easy communication and exchange of germplasm and research information with other countries.

CONCLUSION

We should keep in mind the very different institutional mandates of national systems and international centres when exploring ways to strengthen national systems to assume an increased international role in wheat and rice research. CIMMYT's central programme is focused on those germplasm development problems that are applicable to the largest areas and the greatest number of countries. CIMMYT's success proves that an international organization can mount an effective breeding strategy and that research results can be shared in an evenhanded and sustained way. Several research and training areas were identified in which, through new organizational forms, the global scientific community could more fully utilize national scientific capacities. Some national systems have long made significant contributions to international agricultural research. Even so, the potential for expanded national systems' involvement is great and should be strengthened and more fully recognized.

ANNEX V

The Development of the Global System of Agricultural Research and Future Challenges for Cooperation

T. R. Hargrove

Editor and Head, Communication and Publications Department, IRRI

The Third World food situation was desperate in the late 1950s and early 1960s. Concerned organizations such as the Club of Rome predicted a 'time of famines,' particularly in Asia, by the mid-1970s.

Efforts to increase agricultural production by transferring technology from the industrialized nations had largely failed because of the vast differences in environments, labour use, markets, and social conditions in developing countries. Agricultural experts realized that technologies for Third World farmers must be developed and adapted in the areas where they will be used — a task that requires cooperative efforts at many levels.

The first cooperative programme of agricultural research began in 1943 when The Rockefeller Foundation sent a team of four scientists to work with wheat and maize scientists in Mexico. From that programme came, first, disease-resistant strains of wheat that were quickly adopted by Mexican farmers. The incorporation of dwarf germplasm from Japan led to the famous Mexican wheats, semi-dwarf varieties that yielded bountifully without lodging. A Rockefeller Foundation-Mexico programme of 'shuttle breeding' — testing alternate generations at two different locations in northern and southern Mexico — gave the Mexican semi-dwarfs insensitivity to photoperiod or daylength, thus opening the path for their adoption across Latin America. Although Mexico had imported half of its wheat in the 1940s, the nation was self-sufficient by 1956. By 1963 the semi-dwarfs covered 95% of Mexico's wheat land.

National systems in South Asia were among the first to recognize the potential of the new semi-dwarfs. As a result, the new varieties soon spread across the Asian subcontinent and into northern Africa.

Meanwhile, in 1960 the International Rice Research Institute (IRRI) was established by the Ford and Rockefeller Foundations in cooperation with the Government of the Philippines. IRRI's land and facilities were built on the campus of the University of the Philippines at Los Baños. IRRI began operations as the first formal international agricultural research centre in 1962 with the objective of increasing the production of rice — the basic food of a third of the earth's population — and of food production from rice-based farming systems.

By late 1966 IRRI had released IR8, the first semi-dwarf rice variety to spread widely across the tropics. Like the Mexican wheats, IR8 was resistant to lodging and insensitive to photoperiod. Within a few years IR8 was grown on 25% of the world's tropical riceland, particularly the irrigated areas. By the late 1960s, newer insect- and disease-resistant varieties such as IR20, then IR26 began to replace IR8.

Meanwhile in the mid-1960s the Rockefeller-Mexico wheat programme was formally organized under Mexican law as the International Center for Maize and Wheat Improvement, or CIMMYT. This second international centre was to work with national systems worldwide to increase the production of wheat and maize.

The development of human resources in national systems was an integral component of the new centres' programmes from their inception. Centre educational opportunities include short-term training courses in crop production or research methodologies, guidance in M. Sc. and Ph. D. programmes, and cooperative research through post-doctoral or visiting scientist positions. Today, more than 7 000 rice and wheat workers are IRRI and CIMMYT alumni.

The early 1970s saw new trend in global crop improvement — a range of locally developed semi-dwarf rice and wheat varieties was being released by national agricultural research systems. A joint research project to analyze this trend in rice was initiated in 1975 by IRRI, The Rockefeller Foundation, and 27 national systems in 10 Asian countries. About 70% of the new rice varieties were semi-dwarfs; 85% were bred and selected by scientists within the national programmes (the remainder were IRRI lines). But IRRI varieties provided 'genetic building blocks' for the new semi-dwarfs — 96% were progeny of crosses of IRRI and local germplasm. The pattern in wheat was similar. A study of the same type on the development of non-genetic technologies would undoubtedly show the same trend — strengthened national systems assuming a greater role in cooperation with the centres.

The Third World has never known a wave of agricultural innovation equal to that popularly termed the 'Green Revolution.' Today, farmers grow modern varieties from national programmes and centres on at least 115 million ha — half the total land planted to wheat and rice in the developing world. The new varieties typically outyield the old varieties by 400 to 500 kg/ha. Worldwide, they annually provide more than 50 million tonnes of additional grain — enough to feed half a billion people.

The achievements of CIMMYT and IRRI in cooperative work led to the establishment of two new centres in the late 1960s: the International Center for Tropical Agriculture (CIAT) in Colombia, focusing on phaseolus beans, cassava, tropical pastures, and rice for Latin America; and the International Institute of Tropical Agriculture (IITA) in Nigeria, for cowpea, yam, sweet potato, as well as rice, maize, cassava, and soybean for Africa and farming systems for the humid and subhumid African tropics.

Agricultural development agencies in the industrialized countries recognized the potential of the global research system and joined the Rockefeller and Ford Foundations as donors. More centres were planned.

In 1971, the Consultative Group on International Agricultural Research (CGIAR) was established to collectively support the research and training activities of the centres. There are now 40 donor members from industrialized countries, major foundations, international development agencies, and developing countries that the centres are mandated to serve. The CGIAR is cosponsored by the U. N. Food and Agriculture Organization, the U. N. Development Programme, and the World Bank. Collectively, those agencies appoint a Technical Advisory Committee to evaluate and guide centre research.

The combined budgets of the four centres totalled US$18 million in 1971; by 1985 the CGIAR budget was almost US$180 million, supporting a network of 13 centres (Table 1). Although the

Table 1. The 13 International Agricultural Research Centres sponsored by the CGIAR.

Centro Internacional de Agricultura Tropical (CIAT)
Apartado Aereo 6713
Cali, Colombia

Centro Internacional Mejoramiento de Maiz y Trigo (CIMMYT)
Londres 40, Apdo. Postal 6-641
Mexico 06600

Centro Internacional de la Papa (CIP)
Apartado 5969
Lima, Peru

International Board for Plant Genetic Resources (IBPGR)
Crop Ecology and Genetic Resources Unit
Food and Agriculture Organization of the United Nations
Via delle Terme de Caracalla
00100 Rome, Italy

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

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

International Food Policy Research Institute (IFPRI)
1776 Massachusetts Avenue, N.W.
Washington, D.C. 20036
U.S.A.

International Institute for Tropical Agriculture (IITA)
P.O. Box 5320
Ibadan, Nigeria

International Livestock Centre for Africa (ILCA)
P.O. Box 5689 Addis Ababa
Ethiopia

International Laboratory for Research on Animal Diseases (ILRAD)
P.O. Box 30709
Nairobi, Kenya

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

International Service for National Agricultural Research (ISNAR)
P.O. Box 93375
2509 Aj The Hague
The Netherlands

West Africa Rice Development Association (WARDA)
E.I. Roye Memorial Building
P.O. Box 1019
Monrovia, Liberia

system has grown tenfold, the total budget is very modest in terms of global expenditures. The CGIAR budget is about what a large state in the USA spends annually on agricultural research and extension; individual centre expenditures are considerably less than the cost of a single modern fighter plane.

The success of the Green Revolution also helped convince Third World governments and other agencies that national agricultural research is a powerful instrument for increasing food production, with a high rate of return, particularly in Asia and Latin America where land scarcity made it difficult to increase cropping area.

National research systems have grown rapidly during the past 25 years; today, national expenditures account for 95% of the total investment in Third World agricultural research. The greatest change has been in Asia, where almost every country has increased its real expenditures in national research.

The number of agricultural scientists in developing countries rose from 14 700 in 1959 to 63 000 in 1980. More than 16 000 had participated in centre educational programmes. About 12 000 had attended formal training courses. Centre scientists supervised the research of 800 M.Sc. and 400 Ph. D. students during that period.

Today, the world's most acute food crisis is in Africa. Although Africa met its own food requirements 20 years ago, per capita food production began to decline in the 1960s, dropping 15% in the 1970s alone. Meanwhile, population is increasing at 3% to 4% per year. Africa now receives half of the world's cereal aid versus 5% or 6% in the early 1970s, according to the UN World Food Council. Tanzania, for example, imported 129 000 tonnes of maize, 50 000 tonnes of wheat, and 37 000 tonnes of rice in 1983.

Millions in Africa face a continued state of undernourishment. Famine is not only a threat, it is reality across large areas.

Members of the CGIAR system recognize the crisis in Africa. Four of the 13 centres are based there. Collectively, the centres and donors are increasing their emphasis on strengthening African research systems and developing new farm technologies for African staples such as maize, sorghum, millet, cassava, wheat, rice, potato, beans, and livestock.

Many feel that the challenge of helping Africa rapidly increase food production must be addressed on an emergency basis, somewhat like the early centre efforts in Latin America and Asia of two decades ago.

At the same time, even countries that are now self-sufficient in food production are hosts to millions of hungry — particularly in regions still untouched by the Green Revolution because of harsh environmental conditions. For example, in many non-irrigated areas, farmers must depend on the fickle rains to water their crops; they are still bound to hardy but low-yielding traditional varieties. Areas with saline soils still suffer, as do mountainous regions, where cold temperatures stunt the growth of the improved varieties now available.

The development, adaptation, and extension of improved agricultural technology to farmers in these underprivileged areas are an even more difficult challenge than that faced by the centres 25 years ago. This challenge demands far greater human and financial resources than the centres alone can provide. Meeting the challenge will require a truly pragmatic and coordinated joint effort of scientists in strong national agricultural research systems their partners in the international centres, and donors — in short, the global agricultural research community.

ANNEX VI

Report of the Rice Working Group

Rapporteur: Sir Ralph Riley

1. It was decided to first address the identification of the pre-conditions essential for a NARS to assume an international role; opportunities and constraints; and funding implications.
2. It was agreed that the first and most important pre-condition for the assumption of an international role by a NARS is the presence of political will. This political will should take two forms. First, in the nation that is to assume international responsibility, there should be a willingness to use, altruistically, its resources of scientists, facilities, plant materials and ideas for the benefit of people beyond its frontiers. Second, for nations that are to be the beneficiaries, and which will receive knowledge and techniques generated elsewhere, it may be necessary to designate scientists who could be the first recipients of the new findings and who would liaise with the national scientists of its country with international responsibility.
3. Associated with the political will, it was also agreed that the collaborative activity to be centered on a component of a NARS must be seen to be in equal stewardship by scientists of all nations participating in the programme, whether members of the host nation or of the cooperating nations.
4. Other issues discussed concerned the requirement that the host nation should be able to distribute freely, and perhaps more widely, plant material to the cooperating nations. Second, there should be complete freedom of movement of scientists between the host country and all participating nations; the duty-free entry of equipment and supplies to the host nations will be necessary. The issue of funding was discussed. It was accepted that a required element for the success of such cooperation was the participation of the relevant international centre. Particular emphasis was placed on language and the need for a common language was regarded as paramount to any inter-country collaborative programme and must be agreed upon before its inception.
5. Presentations were made by nations concerning the contribution that they considered their system could make to international agricultural research. India indicated that it would like to work with other nations with similar agro-ecological environments and that it had an elaborate and well-developed system of agricultural R&D, backed by well-trained scientists and effective nationally coordinated programmes for commodities. Indonesia has a considerable core of agricultural scientists, very effective research systems, and international training programmes in operation; it is accessible and has already made national finances available. Mexico, which has good human resources, has already made considerable international commitments to wheat research. Mexico believed that every country has special expertise and special ecological conditions that should be placed at the disposal of the international community. China has already developed international centres for hybrid rice and Azolla studies, and hopes to develop new centres on rice disease and insect hazards, rice training, poor soils in mountainous conditions, rice ecology and the use of by-products.
6. It was pointed out that China's national centre for hybrid rice had stimulated the imminent release of hybrid rice varieties in Indonesia and Korea and that India had demonstrated substantial yield benefit from hybrid rice but was deterred from the release of a variety after economic evaluation.
7. In considering what specific responsibilities might be assumed by NARS, it was agreed that international testing programmes had provided enormous benefits in the past and would continue to do so. It was agreed with the utmost emphasis that the exchange of germplasm must continue as an essential element in the genetic advance of rice. There were some reservations as to the effectiveness of the International Rice Testing Program (IRTP) in Africa and, to a lesser extent, in Central America.
8. In the IRTP, great prominence was placed in its organization such that each participating nation

funded the cost of its own participation. This was regarded as the key to success in Asia. Different procedures were used in Africa. Generally, the procedures have changed in the IRTP so that yield trials no longer figure to any significant extent and the emphasis is on nurseries. Germplasm exchange was regarded as pivotal to international agricultural research.

9. There was a mixed reaction to the use of 'hot spot' screening. Many felt that this was the most effective way of isolating material resistant to physical, chemical or biotic hazards. Others felt that there was an element of regional specificity in such screening. While CIAT had undertaken quantitative evaluation of the improvement in the efficiency of selection for disease resistance provided by hot spot exposure, the results were 15% better than the general environment and 30% better when the disease incidence was increased by the use of spreaders. Finally, in relation to international testing, it was agreed that countries benefitted from working together provided that there was an International Steering Committee and that the arrangements were controlled by the participating countries to their mutual benefit.
10. In discussing IRRI research outside the Philippines, it was acknowledged that there are many specific ecologies that occur in a number of developing Philippines. Technologies appropriate to those ecologies need to be devised and, in so far as there is an international need, the work must be undertaken in an international context. This context the will bring together a particular national programme (suitably placed ecologically), other collaborating national programmes and IRRI. Such activities should only be developed when high priority is given to the objectives and the host nation makes a significant commitment. Examples of such developed activities are work on upland and deepwater rice. It was emphasized that cropping systems research should figure prominently in these and other examples.
11. Training activities aimed at exploiting special country expertise and ecology were already underway or planned in relation to hybrid rice — Azolla in China, problem soils in India, saline soils in Pakistan, and irrigation in arid conditions in Egypt. IRRI is well aware of the opportunities to dispense training, and nations are responsive. The group was very much encouraged to learn that some countries such as India and China are already supporting international training from their own financial resources. Anxiety was expressed about the organization and funding of training in Africa and it was hoped that this could be drawn to the attention of donors. Language is a component of the problem in Africa.
12. The view was taken that 'upstream' research in such fields as biotechnology, computer modelling, soil physics and soil chemistry was best done by those anywhere in the world who could do it most efficiently. However, it was felt that developing countries should have competence in advanced science and some countries, such as China, India and Indonesia, had already created or were planning national capabilities. It was pointed out that so far as plant breeding is concerned, there is a long lead time between the recognition of a new opportunity and its delivery to farmers.
13. The group considered that in the modalities for collaboration between IARCs and NARS, the notion of a division of responsibilities and leadership was inappropriate. Where national capabilities are at a reasonable state of development, its essence should be partnership. Where adequate national capability had yet to be developed, it was unlikely that the country would take a significant role in international activities, and it should concentrate on its internal problems.
14. There was no strong opinion expressed for or against the notion of 'associated centres,' although it was accepted that they might be useful in some circumstances. While recognizing that a measure of formality would be necessary in arriving at a memorandum of understanding between IARCs and NARS centers, the general plea was to keep the system as simple as possible. Bureaucracy must be avoided at all cost.
15. When IRRI needed to work outside the Philippines, it could initiate a joint venture with a country programme. While, in a way, this is like IRRI contracting out its research requirements, it is more than research procurement because of the importance of partnership. Nevertheless, work that cannot be done in the Philippines but for which IRRI is responsible to the international community will be done elsewhere when a reasonable share of its costs are borne by the host nation. The national programme will be responsible for the internal management of local funded staff and resources; IRRI will be responsible for the outposted member of its staff located in the host country. Generally, the host country or IRRI will inform the Advisory Committee about the international programme. But it was accepted that the precise arrangement must be programme-specific to acknowledge the variation in circumstances and the need to accommodate to the administrative arrangement in the host country.
16. Most programmes of this kind will address agro-ecological problems of international significance

that occur in countries that may be far apart geographically. The group felt that a special effort should be made to enable donors to appreciate the magnitude and importance of such problems and that an adaptation of the more normal patterns of funding may be necessary. However, money could come to such activities at present through three channels. First, through the internal budget of the host nation, whether or not generated from its own revenue. Second, from bilateral special funds to the host nation. Third, through the core or special core budget of IRRI, after due examination by its usual CGIAR budgeting process. Questions were also asked as to whether donors might wish to examine whether a special support process might be developed for this kind of international agricultural research, which will become increasingly widespread as the excellence of the NARS increases.

17. The group was concerned that procedures that would enable national systems to assist in the solution of international problems should be devised with the utmost urgency.

ANNEX VII

Report of the Wheat Working Group

Chaired by: Dr. A. Mohamed (PARC)
Dr. O. F. Rivaldo (EMBRAPA)
Dr. C. H. Saubidet (INTA)
Rapporteur: H. G. Zandstra

1. *Introduction*

The workshop's objectives were to explore in detail the responsibilities that might be assumed by stronger NARS, with the assistance of CIMMYT, in support of other national systems. The group would explore modalities of collaboration and preconditions essential for NARS to assure such an expanded role.

This report summarizes discussions of three half day sessions, in which a considerable exchange of experiences and new proposals took place. In many cases the importance of on-going NARS collaboration was stressed, but new needs and possible approaches were frequently explored. The discussions on new approaches often reached a consensus supporting experimentation with new modalities, without a detailed understanding of the constraints and funding, administrative or managerial implications. There was, however, a strong feeling that IARCs and NARS should be courageous in their attempts and allow details to be worked out as programmes became formulated and implemented.

The discussions are summarized under the headings used in the agenda of the Consultation.

2. *Breeding programmes, germplasm activities*

It was recognized that CIMMYT's breeding strategy for wheat was now based on adaptation of materials to one or more 'mega-environments', with breeding objectives being derived from clear environmental specification. Broad adaptation is now considered in terms of suitability of materials for more than one mega-environment.

Most participants felt that NARS with strong interest in certain environments could expand their participation by assisting, with the help of CIMMYT regional staff, in the refinement of international crop improvement strategies, the maintenance of regional germplasm working collections and the formulation of appropriate breeding guidelines. This structure for germplasm development readily allows a coordinated contribution of NARS to internationally defined programme needs.

Participation of NARS in shuttle breeding programmes was widely recognized and the group saw a great potential for expansion of this mode of collaboration through training and even the designation of collaborators as 'associate CIMMYT scientists,' in recognition of their contribution.

It was felt that the IARC and NARS should increase germplasm activities. These should include collection — an obvious area for expanded NARS involvement — maintenance and evaluation in regional working collections, and exchange for identified purposes and for long-term conservation in base collections. With the increased potential of wide-cross programmes such collaboration appeared to provide an attractive opportunity to associate new techniques for germplasm utilization with increased emphasis on collection and evaluation.

There was agreement that CIMMYT's collaboration with NARS has already been extraordinarily effective and that the IARC should continue to play a leading role in germplasm development to assure the development of programme modalities which effectively capture the potential for collaboration by stronger NARS while assuring benefits to more recently developed or smaller national programmes.

3. *International testing programmes*

These programmes represent an effective on-going collaboration. Mutual benefits to NARS and IARC are well understood. There is a high level of participation and increasingly NAR lines enter into the nurseries. The emphasis on yield trials is reduced, and it is recognized that continued collaboration can become more effective by improved targetting of trials and more effective sharing of feed back.

The temptation to take on too many nurseries were discussed and methods to assure benefits (feed back and seed) to NARS not planting the nurseries should receive attention.

4. *Hot-spot screening facilities and component technologies for specific ecologies*
CIMMYT expressed a desire for more assistance from NARS in hot-spot screening activities. It was evident that donors felt this type of activity attractive because it deals with a defined constraint and lends itself to specialized contributions by a number of collaborators to aspects such as the development of improved screening procedures, stress monitoring methods, supporting physiological or resistance mechanisms and access to variants in stress conditions.

It was stressed by the group that collaboration should not be confined to germplasm development. It should also be possible to address specific agronomic or stability constraints of important agroecological conditions.

Collaboration among NARS and one or more IARCs in this type of research is particularly suited to the networking approach, such as that applied in the BYDV, Fusarium and rice-wheat research activities.

It was suggested that expansion of such collaborative activities would greatly enhance the contribution of the NARS-IARC system when it includes specialized training at the stress location and participation of NARS with a range of capabilities.

5. *Training programmes*
There was general agreement that NARS could effectively contribute to satisfying the training needs. The demand for wheat production training far exceeds the present capacity. It was felt that this training could be conducted by NARS on a regional basis, with IARC collaboration in methodological aspects and training materials. Several participants stressed that the regional aspect of such training would require special funding support to avoid taxing the already tight NARS budget.

In addition to production training, several NARS involved in collaborative research networks on specific constraints or hot-spot screening expressed their willingness to conduct specialized training developed in the context of these networks. This could be as short courses or as in-service training. It was felt that the training and associated research and staff exchanges should be planned in the context of regional excellence.

Among specialized training needs, training of plant breeders is particularly important for capability building and there is a great difficulty to satisfy the demand. Most NARS leaders stressed that they would be able to train wheat breeders within their programmes and it was generally agreed that this would greatly assist in the development of the international wheat programme.

NARS leaders in the group felt that IARCs should stress specialized training in advanced research techniques. Often this would have to be as in-service training. At times NARS scientists would benefit from short sabbaticals designed to allow collaborating scientists an opportunity for in-depth analyses of data or strategic studies.

6. *Upstream research*
We learned a lot from the discussion of this topic. It became evident that there was little merit in IARCs expanding greatly in basic research. It was agreed that there are numerous, well equipped, highly specialized academic institutions more suited for this work.

In the context of biotechnology, the upstream research expected from IARCs was defined as 'the application of basic or strategic research tools to the solution of practical problems'. Examples given were the use of urease inhibitors, application of genetic probes, improved models of environmental adaptation systems, the use of wide crosses and improved crop forecasting methods. CIMMYT was encouraged to expand its activities in these areas and to train NARS in these techniques.

Several NARS expressed concern about the increased privatization of basic research and foresaw difficulties in future access to results of such research. CIMMYT indicated that while its collaboration with advanced academic institutions helps maintain it in the forefront, it may be equally difficult to obtain results from commercial research organizations.

7. *Preconditions for an international role for NARS*
There was general agreement about preconditions. Important among these were:
   - The activity must have a high priority in the NARS.
   - The political will to contribute internationally to the specific research must exist, as must the desire to ensure that the needs of other NARS will be met in an evenhanded way.
   - The NARS should not suffer from serious internal organizational problems.
   - The NARS should have proven effectiveness in the dissemination of technology and have demonstrated its impact on national agriculture.
   - There should be free exchange of information and germplasm among participants.
   - It should have sufficient well trained manpower and physical facilities for organizing training courses. The creation of regional centres or international centres of excellence for work on specific constraints should

be considered by IARCs and donors.

- The country should be compatible with regional countries, so that visa agreements can be developed and communality in languages be established to serve proposed collaborators.
- There should be additional funding, particularly for international travel and per diems, and where appropriate, for payment of additional staff.
- The NARS should be identified for its contributions to international research by the IARC after extensive consultation with other collaborating and beneficiary countries.

The funding implications were extensively discussed. A case was made for salary supplements to scientists active in international activities at NARS as a means to avoid loss of staff as a result of international exposure. On the other hand concerns were expressed about split allegiances of staff to NARS and IARCs or donors. It was felt that at this time great flexibility in the type of funding arrangement may be required, and that both bilateral and multilateral sources should be explored.

It was pointed out that major multilateral donors often have arrangements for funding of regional activities, and that channeling of funds through IARCs may ease the internal constraints in funding regional or international activities for some donors. In spite of this, it was generally felt that collaborating NARS should be directly funded by donors or the CGIAR should shoulder the additional cost of their international research and training activities.

8. *Modalities of collaboration*
   There exist a wide range of IARC-NARS collaborative arrangements such as international testing, participation in shuttle breeding, hot-spot screening programmes, bilateral collaboration in research on specific environmental constraints and the participation of a group of NARS in regional or international collaborative research networks.

While there appears to be a place for each of these modalities, there was agreement that the benefits from sharing of research tasks among participants in a regional network should receive more attention. The results of the analyses of networks conducted by the SPAAR should be more widely disseminated. They found that successful networks met the following characteristics:

(i) address a clearly defined problem (commodity or constraint);
(ii) presence of a steering committee;
(iii) a capacity for coordination;
(iv) joint fixing of priorities in research and training;
(v) division of labour;
(vi) information and documentation support;
(vii) availability of funds for NARS and coordination; and
(viii) free exchange of information and germplasm.

8. The participants recognized a wide range of networks and felt that NARS and IARCs should be encouraged to evolve collaborative modalities that stress mutual stewardship of the collaboration, equality of roles and IARC input as one of facilitating international roles.

9. *Political, financial and administrative implications*
   The specific arrangement would undoubtedly vary widely and they will at times demand changes in policies or administrative procedures. The group discussed some of these:
   (i) there will be a need to relax constraints to germplasm exchange when it relates to international research activities;
   (ii) new funding and administrative pathways for donors and the CGIAR may be needed; and
   (iii) new methods for recognizing NARS staff, particularly for their contribution to international research activities.

10. *Follow-up*
    The discussion of the follow-up activities was very positive. Several NARS showed a strong desire to enter into increased partnerships with IARCs.

The group expressed the hope for a strong follow-up by donors and the CGIAR which would seek to create the conditions required for greater participation of NARS in international agricultural research activities.

ANNEX VIII
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