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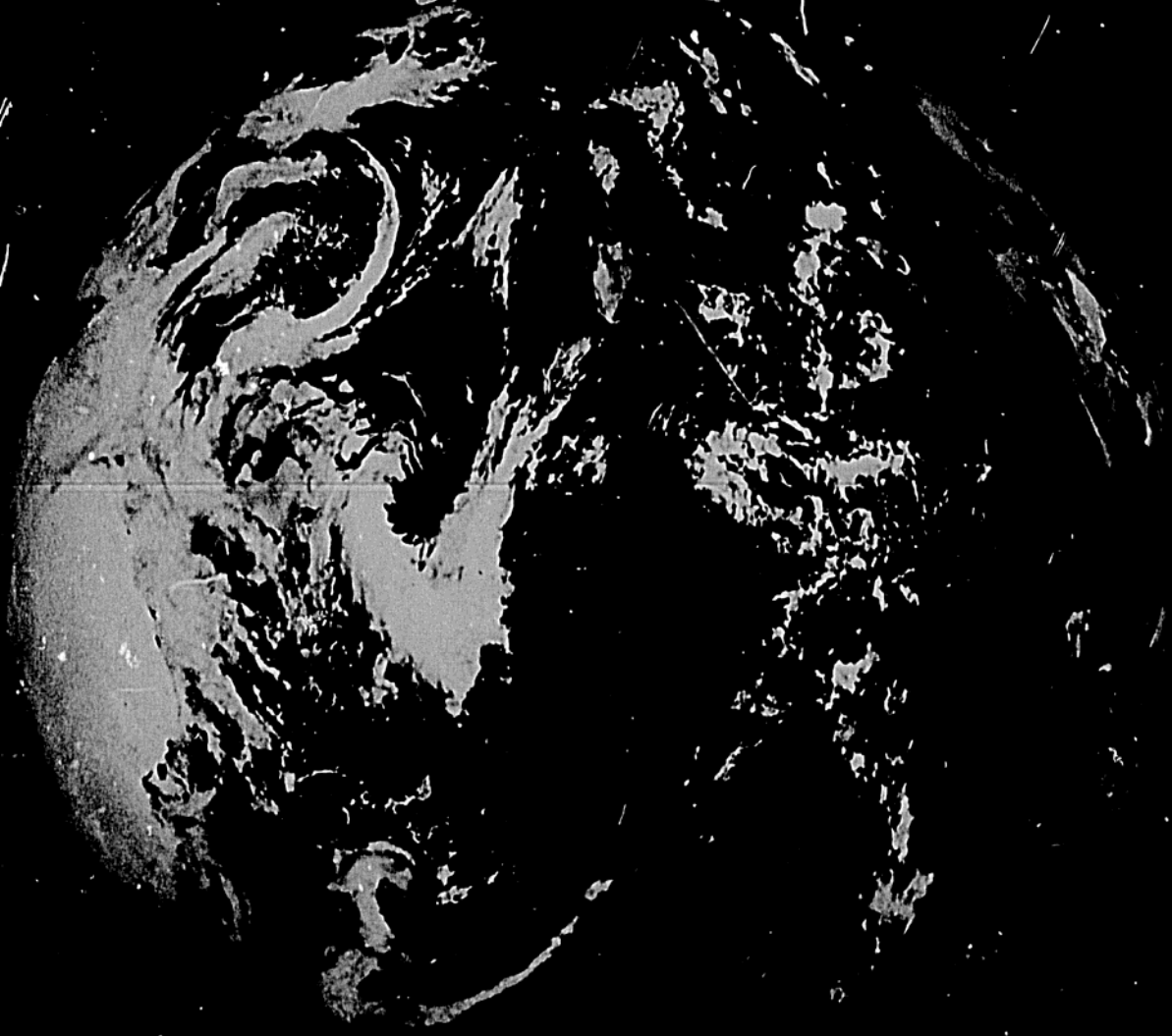
A GLOBAL EXPERIMENT IN AGRICULTURAL DEVELOPMENT



A GLOBAL EXPERIMENT IN AGRICULTURAL DEVELOPMENT

N. C. BRADY

1982

INTERNATIONAL
RICE RESEARCH
INSTITUTE

LOS BAÑOS, LAGUNA, PHILIPPINES
P.O. BOX 933, MANILA, PHILIPPINES

The International Rice Research Institute (IRRI) receives support from a number of donors, including the Asian Development Bank, the European Economic Community, the Ford Foundation, the International Fund for Agricultural Development, the OPEC Special Fund, the Rockefeller Foundation, the United Nations Development Programme, and the international aid agencies of the following governments: Australia, Belgium, Brazil, Canada, Denmark, Federal Republic of Germany, India, Japan, Mexico, Netherlands, New Zealand, Philippines, Spain, Sweden, Switzerland, United Kingdom, United States.

The responsibility for this publication rests with the International Rice Research Insitute.

Foreword

The International Rice Research Institute dedicated a modern laboratory for the conservation, storage, and utilization of seeds of rice, the world's most important food crop, to Dr. N. C. Brady, former IRRI director general, in ceremonies on 24 October 1981.

The IRRI Board of Trustees named the *N. C. Brady Laboratory* in recognition of Dr. Brady's contributions to the improvement of the lives of hundreds of millions of the world's poorest farmers and urban dwellers.

Dr. Brady served as IRRI director general from 1973 to 1981. In June 1981 he joined the U. S. Agency for International Development as senior assistant administrator, Bureau of Science and Technology.

During the ceremonies Dr. Brady shared his perceptions of the establishment, accomplishments, and future challenges of a bold new concept in agricultural development — the worldwide network of International Agricultural Research Centers. The IRRI Board of Trustees considered Dr. Brady's statement to be of interest to all concerned with the development of the improved agricultural technology needed to feed a hungry world. Thus, the Board recommended that IRRI publish and attribute *A global experiment in agricultural development.*

Present at the ceremonies were Dr. Robert F. Chandler, IRRI's first director general; Dr. Clarence C. Gray III, chairman of the IRRI Board and deputy director, Agricultural Sciences, The Rockefeller Foundation, USA; and the following Board members: Dr. Norman Collins, Ford Foundation, India; Mr. Alban F. Gurnett-Smith, Commonwealth Scientific and Industrial Research Organization, Australia; Mr. Lin Shih-Cheng, Chinese Academy of Agricultural Sciences, People's Republic of China; Mr. Sadikin S. W., Agency for Agricultural Research and Development, Ministry of Agriculture, Indonesia; Dr. Hans W. Scharpenseel, University of Hamburg, Federal Republic of Germany; Dr. Mustafa M. Elgabaly, Egypt; Dr. H. K. Pande, Central Rice Research Institute, India; and Dr. In Hwan Kim, Korean Seed Association, Republic of Korea.

Marcos R. Vega
Acting Director General

Dr. Nyle C. Brady (left) accepts congratulations from Dr. H. K. Pande, director, Central Rice Research Institute, Cuttack, India, at the unveiling of a plaque commemorating the dedication of Brady Laboratory. Right is Sadikin S. W., Ministry of Agriculture, Indonesia. Dr. Brady, now senior assistant administrator, U. S. Agency for International Development, served as IRRI director general from 1973 to 1981.

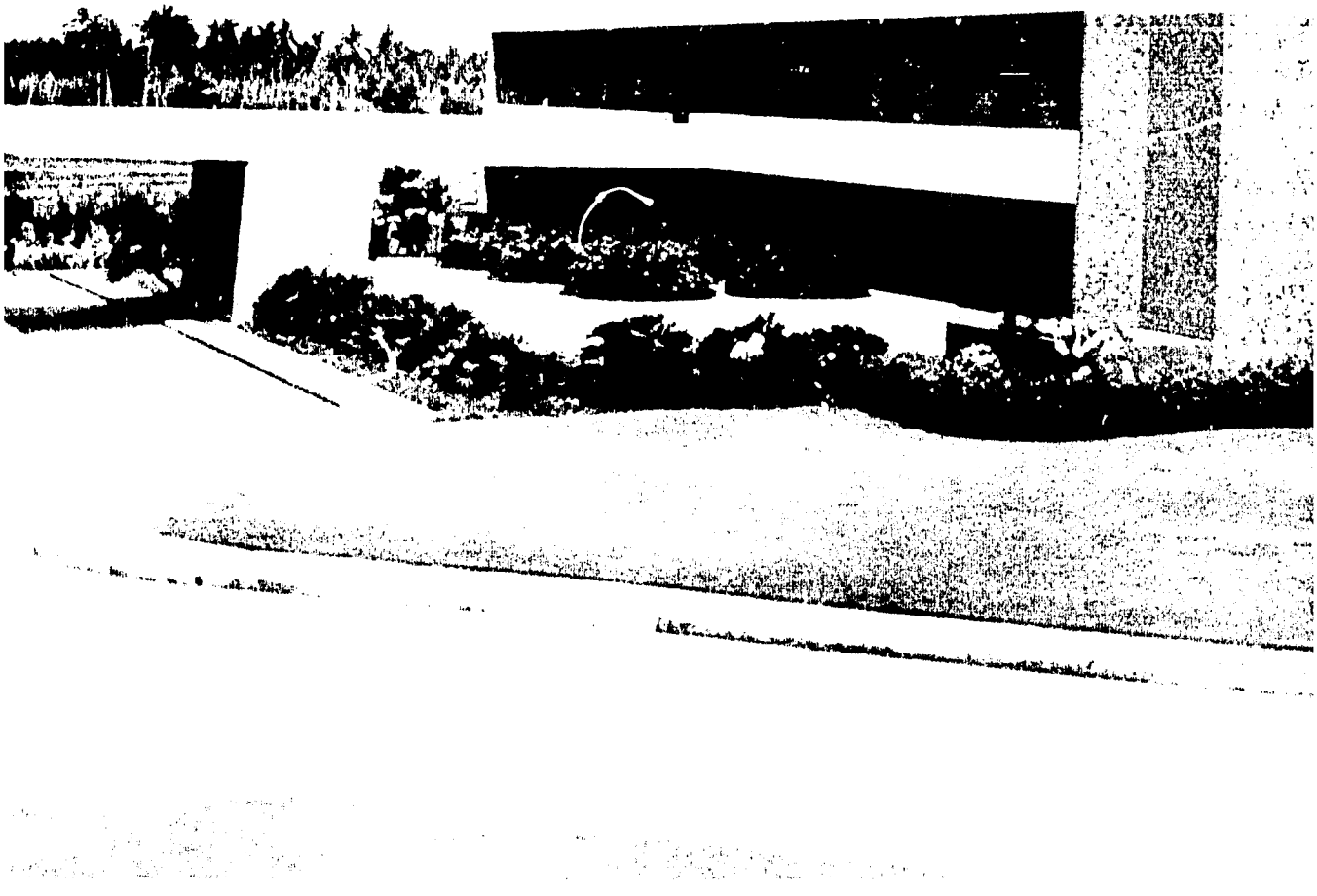
The genetic resources laboratory of the International Rice Research Institute (IRRI) holds the rice world's most precious assets — 60,000 accessions of rice seeds collected from every major rice-growing country. The primary purpose of the laboratory and its germplasm bank is to maintain the world's vast rice genetic resources, thereby arresting the erosion of the genetic base of world's rice crop. This is a working laboratory. The seeds are ready for use not only by IRRI scientists but also by rice researchers across the world.

The rice genetic resources stored in this building are the core of a worldwide Genetic Evaluation and Utilization (GEU) program that has helped revolutionize rice improvement. Interdisciplinary teams of IRRI scientists screen thousands of rice seed accessions for resistance to or tolerance of the major enemies and constraints of the rice plant. Included are organized efforts to evaluate host resistance to major insects such as the brown planthopper, and to diseases such as blast and several viruses that attack the rice plant. Through factory-like processes, scientists evaluate the rices for tolerance for drought, floods, acid and saline soils, nutrient toxicities and deficiencies, and other environmental stresses. First priority is to select rices with high yield potential, short growth duration, and adaptability to various ecological conditions where rice is grown.

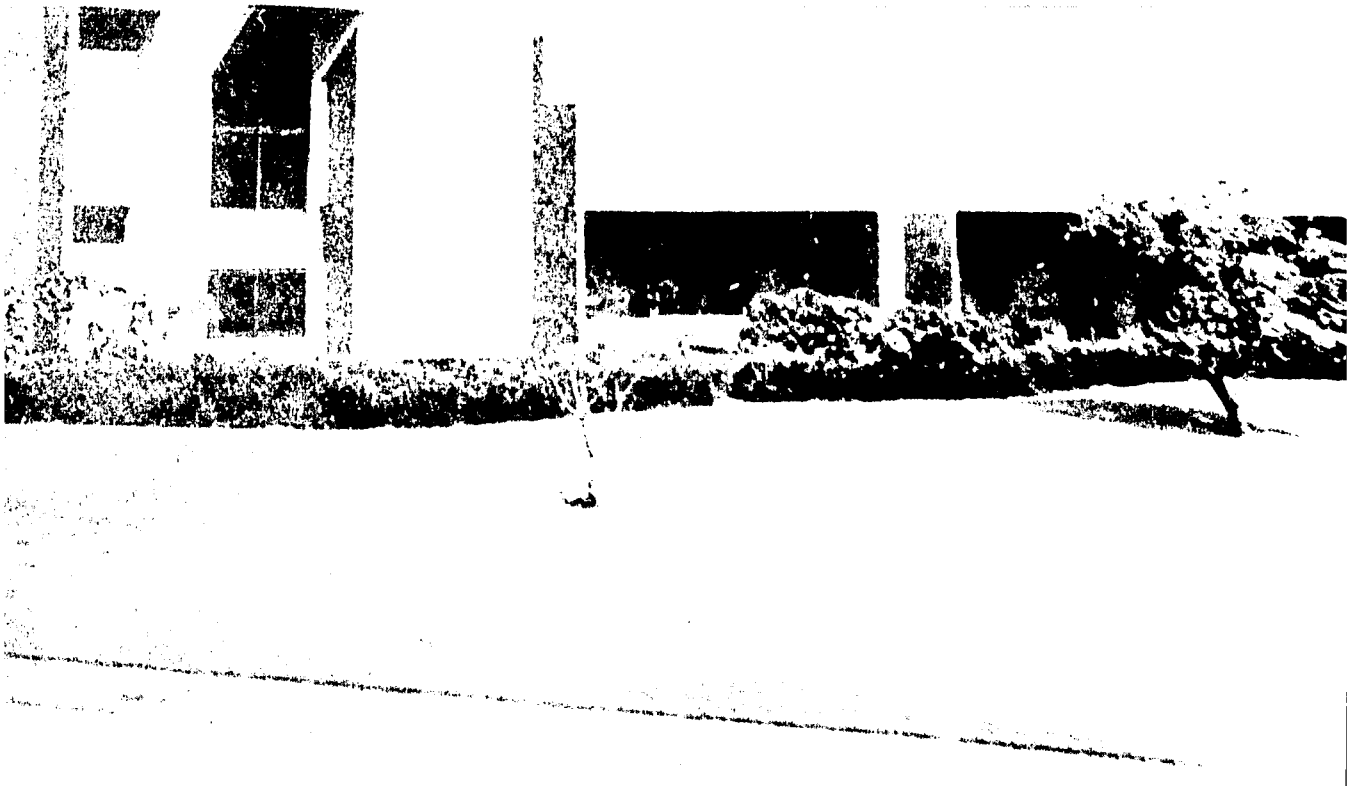
IRRI holds this bank in trust for the scientists and agricultural leaders of the rice-producing countries. It is their rices, collected primarily by them, and sent to IRRI for safekeeping. Scientists everywhere are free to request samples, not only of the rices they deposited in the bank but also of seeds contributed by scientists from other countries. Rices from this facility are thus used in GEU-type rice improvement programs in every major rice-growing country of the tropics.

This building is also the home for another valuable IRRI asset — the scientists and support staff who collect, process, and store the seeds; screen them for usefulness to humankind; and genetically recombine them into new varieties for the world's rice farmers. The new varieties are IRRI's most vital link to the world's rice farmers and their problems.

The institution for which this building was constructed holds a special place in my heart. For 8 years — the most enjoyable of our lives — Mrs. Brady and I were associated with IRRI. As part of a vital institution dedicated to serving most of the world's poor, we worked with international and local staff who gave of themselves to develop new technology for rice production. We worked with equally dedicated scientists at the University of the Philippines at Los Banos and similar institutions in the Philippines and other rice-growing countries. We became friends with the political and scientific leaders of the rice-growing countries as they visited IRRI, and as we visited them. Last, we had pleasant associations with the IRRI Board of Trustees who provided policy and inspirational support, and with repre-



The *N. C. Brady Laboratory* holds the seeds of 50,000 varieties of rice, the world's most important food crop, in cold storage for the use of present and future generations of rice scientists everywhere. The Government of Japan provided funds for the two-story, three-level Laboratory and the Asian Development Bank contributed to its equipment.



sentatives of the private, national, and international donors whose generous funding made IRRI a functioning reality.

Why are great institutions such as IRRI essential to the efforts of low-income countries to feed themselves? Let us review humankind's efforts to feed itself and the events that lead to the establishment of the International Agricultural Research Centers.

THE WORLD FOOD PROBLEM

Mankind's ability to survive is being questioned on many fronts: Does the human race have the political will to construct a framework for lasting peace? Can the earth's natural resource base meet the many conflicting demands on it? Will universal aspirations endure for personal freedom and spiritual growth?

These ancient questions are being raised with greater urgency — and more justification — than ever before. The paramount question, however, is: Can the world produce enough food to feed the human family as it adds another 80 million members each year, and to enable the poorest family members to eat more and better food than their parents and grandparents did?

An unprecedented increase in food demands is inevitable over the coming decades. This increase is due not only to continuing population pressures, but also to a rapid growth in per-capita income within many developing countries, and to political pressures for higher food consumption within centrally planned economies. Simultaneously, the United States — the traditional food supplier of last resort — is reducing the food and feedstocks it has provided the developing nations for the past three decades. The continuing surge in food demand will increase global food prices, placing a disproportionate burden on the poorest nations, and on poor people within all nations. Even if the necessary quantities of food are available on the world market, any increase in the volume of food imports will sorely press the battered economies of the poor nations.

World leaders should examine the unprecedented growth in food production in developing countries in the past two decades as they focus on the stabilization of population growth and on alternative strategies for meeting future food needs. Many interrelated factors contributed to the remarkable increase in world food supplies, but two facets stand out as primary contributors:

- a marked improvement in technologies available to the small farmers who produce most of the food in the developing countries, and
- an improvement in socioeconomic and political environments that permitted farmers to put the improved technologies to work, and to profit from their adoption. Government policies and availability and prices of inputs are prime examples of factors controlling these environments.

IRRI, in cooperation with national scientists and institutions, has contributed greatly to the development of improved technologies for the world's rice farmers, particularly in Asia. IRRI also had less obvious but significant influences on policies and the availability of inputs to help assure technology adoption and profitability on farmers' fields.

A thoughtful examination of IRRI and of its interrelationships with sister institutions, both national and international, might help world leaders identify policies, strategies, and programs to produce more food.

THE INTERNATIONAL AGRICULTURAL RESEARCH SYSTEM: A NEW THRUST IN DEVELOPMENT

IRRI is part of a daring experiment in global research cooperation that began more than 20 years ago . . . an experiment that profoundly influenced worldwide food production and that holds promise of even greater influence in the future. This experiment was initiated in the late 1950s and early 1960s, when a group of foresighted leaders recognized the inadequacy of attempts to transplant existing technologies from the temperate zones to the tropics, or from the rich to the poor nations. Those leaders initiated a bold new approach — to conduct the research necessary to develop improved technology within the developing countries themselves.

From personal experience those leaders had learned that development was not a cut-and-dried phenomenon that could be imported into the developing countries like new automobiles. Although some technological components of the development process could be imported and used with little modification, other components had to be created in the local environments, and all components had to be tested and molded to fit the physical, biological, and socioeconomic environments where they were to be used. Finally, those leaders recognized the essentiality of a synergistic partnership among agricultural scientists and leaders in developing and developed countries to provide the technological bases for increased agricultural production.

Stage I: Formulating the concept

Two separate but related experiences provided the underlying rationale for IRRI's creation. First, in the 1940s the Government of Mexico and the Rockefeller Foundation initiated a joint agricultural program focusing on research on wheat and maize, and on the training of young Mexican scientists for this research. The development and dramatic farmer adoption of semidwarf wheat varieties, first in Mexico then across Latin America and into Asia and the Middle East, emphasized the potential for even greater accomplishments. Leaders such as George Harrar of the Rockefeller Foundation and Mexican counterparts had insisted that on-site research was essential to solve the food problems of the developing countries. Their contentions were borne out.

Modern semidwarf before panicles emerge

Mature semidwarf

Tropical rice plant before panicles emerge

Mature plant "lodged"

Modern semidwarf rices developed at IRRI and in national rice improvement programs have strong, stiff stems that hold the plants upright even with yields of 5 or 6 tons per hectare. Erect leaves intercept more sunshine, increasing photosynthesis. The modern rices put out more tillers of grain, and day length does not affect their growth, so farmers at many latitudes can grow them and at any time of the year. New IRRI varieties such as IR36 and IR54 have been bred to resist half a dozen pests with little or without chemical protection. Semidwarf varieties are now planted on about 30% of the world's rice land.

A few years later, the Indian Government initiated a cooperative extension program with the support of the Ford Foundation. Although its initial success was notable, the comprehensive program was constrained by a paucity of really superior technology. Thus, Indian leaders and other foresighted men such as Forest F. "Frosty" Hill, vice president of the Ford Foundation, recognized the weakness of extension efforts that are based on technologies that are inadequate for the local environment.

These knowing leaders soon concluded that well-financed research of high quality must be conducted in the tropics as a prerequisite for the development of technologies to increase tropical food production. They decided to establish an international agricultural research institute — a research effort in itself — to test this hypothesis. Rice was chosen as the target crop because it is the primary or secondary staple food for 90% of the world's poor people, and because it is grown under a wide variety of agroclimatic and socioeconomic conditions.

The Philippines, and specifically the University of the Philippines at Los Banos, was the site chosen to initiate the first trial in this unfolding experiment, for several reasons. First, active participation in earlier cooperative programs had already demonstrated the commitment of Philippine Government and UPLB leaders. Second, an ideal site would be adjacent to a top-notch university, to assure a dual focus on research and training. Third, English, the international language of science, was the language of instruction in higher education in the Philippines. Fourth, the Philippines provided a variety of agroecologic environments in which to conduct research. And finally, the Philippines, as a small but stable country, was acceptable to other countries as the site for such an institute.

With these factors as a background, the Rockefeller and Ford Foundations and Philippine Government entered into a partnership that in 1960 established the International Rice Research Institute . . . the first formal trial in a global experiment in international agricultural research cooperation.

Traditional rices in the tropics have long, weak stems and wide, droopy leaves. When fertilized, the plants produce heavy panicles, or grain heads. But the stems cannot support the heavy panicles, so the plants "lodge" — they fall over. The grain may dip into the paddy water or be eaten by rodents. The wide leaves at the top limit photosynthesis, thus decreasing grain production, because they prevent sunshine from penetrating the leaf canopy. Traditional rices generally yield 1 or 2 tons per hectare.

Stage II: Expansion of the international center concept to other crops and cropping systems

By the mid-1960s the stiff-strawed, fertilizer-responsive wheats from Mexico were being found productive in other countries, and it was apparent that cooperative research in the Philippines was going to pay off. Among the potential rice varieties being tested on farmers' fields was a line that, was released in late 1966 as IR8, IRRI's first variety.

The success of cooperative research in Mexico and the Philippines encouraged the Rockefeller and Ford Foundations and the Government of Mexico to formally establish in 1966 the International Center for Maize and Wheat Improvement (known as CIMMYT, for its Spanish acronym). By 1967, IR8 was moving rapidly onto the rice fields of tropical Asia. That year, steps were taken to establish comparable centers in other developing nations. Thus, the International Center for Tropical Agriculture (CIAT) was

Dr. Norman Borlaug (left), CIMMYT wheat breeder, inspects a seed multiplication plot of semidwarf wheat in India with Dr. M. S. Swaminathan (right), then the director of the Indian Agricultural Research Institute, and now director general of the International Rice Research Institute; and Mr. Rakesh (center), National Seeds Corporation of India. Wheat farmers in India tripled production from 1966 to 1977, thanks to their rapid adoption of semidwarf varieties developed by CIMMYT and by Indian scientists. In 1970 Dr. Borlaug received the Nobel Peace Prize for his role in the development of the Mexican semidwarfs.

conceived. CIAT was established in Colombia to focus on the lowland tropics of the Western Hemisphere. Similarly the International Institute for Tropical Agriculture (IITA) was initiated in Nigeria to deal with crops and farming systems of the African humid tropics.

As the experiment in international cooperation for agricultural research expanded, there was noted excitement and strong commitment from the leaders of the host countries. The second stage of the experiment was under way.

Stage III: Securing international donor commitment and support

After the validity of the International Agricultural Research Center concept was demonstrated, the foundations invited national and international donor organizations to join in enlarging and financing the network. The next step was the 1971 formation of the Consultative Group on International Agricultural Research (CGIAR), an international consortium of government and private agencies dedicated to the support and improvement of agricultural research in developing nations. The CGIAR was formally cosponsored by the World Bank, the Food and Agriculture Organization (FAO), and the United Nations Development Programme (UNDP).

The CGIAR today is represented by the official aid agencies of most of the world's industrialized countries, as well as the three original sponsors and the Ford and Rockefeller Foundations and other private organizations. An orderly system was established to encourage CGIAR members to share in supporting the four existing Centers, and to jointly help establish additional Centers to respond to priority world food needs.

By 1980 the CGIAR supported 13 International Agricultural Research Centers and organizations concerned with an array of commodities, ecologic conditions, and farming systems (see Appendix I).

The scope of these institutions is broad indeed: 11 International Centers, an international board concerned with the conservation of genetic resources, and an international service to help upgrade national research programs. The number of donor members within the CGIAR has increased from the original 15 to 35, contributing a total budget of $138 million by 1981.

Employed within this far-flung network are about 7,000 persons, which include more than 600 senior scientists from 40 nations. The crops and livestock on which these centers focus provide 75% of the food for developing countries.

CONTRIBUTIONS OF THE CGIAR SYSTEM

Despite their relatively short existence, the International Agricultural Research Centers have made remarkable contributions to world food production. As one would expect, the oldest centers, IRRI and CIMMYT,

have had the strongest and most identifiable economic results.

The impact of CIMMYT's pioneering work is demonstrated by the fact that by 1977, Mexican semidwarf wheats were planted on 30 million hectares — almost half of the wheatland in the developing countries. Wheat production in India tripled from 1966 to 1979, thanks to the rapid adoption of semidwarf varieties developed by CIMMYT and Indian scientists working as part of the CIMMYT network.

Success with rice was equally dramatic. By 1980, about 30% of all riceland in the tropics, and most of the irrigated land, was planted to IRRI varieties or their descendants.

The increased yields from these "miracle" wheat and rice seeds are estimated to feed some 300 million people today, and the economic value of this additional food supply ranges from $3 to $5 billion annually.

The accomplishments of the newer Centers are less well-known, but are making an impact on food production throughout the developing world, and hold even greater potential for the future. For example, new varieties developed by the International Potato Center and its national cooperators are significantly increasing yields of the world's fourth most important food crop. Promising experimental lines of potato are adapted to the hot, humid tropics and a unique tissue culture technique makes possible the transmission of germ-free potato genetic resources.

In Colombia CIAT is working on genetic improvements that can double or triple yields of cassava, now the third most important energy food for some 400 million people in the tropics. CIAT is evaluating the potential of vast areas of unused acid soils in Latin America for food production, and is developing forage varieties that can tolerate such acid soils. The International Laboratory for Research on Animal Diseases, in Kenya, has successfully cultured trypanosome, a disease that inhibits livestock production in vast areas of Africa. Improved lines of edible legumes and innovative soil and crop management systems for Asia and Africa are being developed by the International Crops Research Institute for the Semi-Arid Tropics in India.

The International Centers have not made their research contributions in isolation. Scientists from national institutions cooperated in the setting of priorities for farmers' problems in the regions they serve, and managed the evaluation of the Center varieties and technologies. Center training programs are oriented to the needs of national-program scientists. Their successes — and those of their national cooperators — are determined solely by increases in farmers' yields that result from their research findings.

FACTORS THAT AFFECT THE SUCCESS OF THE INTERNATIONAL CENTERS

The factors that have contributed to the success of the CGIAR system vary for each of the 13 International Centers, but several are common to all.

The international Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Hyderabad, India, works for the improvement of sorghum, pearl millet, pigeonpea, chickpea, and groundnut. Those crops are vital to the lives of 700 million of the world's poorest people. ICRISAT also develops farming systems that maximize use of the erratic rainfall, poor soils, and small farms that characterize the semi-arid tropics.

Independence of political influence

In my judgement the factor that has contributed most to the success of the International Agricultural Research Centers is their relative independence from political influence.

The Centers are autonomous institutions with a minimum of political control and a maximum of independence and flexibility to focus on high-priority research, and to change that focus as priorities change. Thus, the Centers can emphasize priority problem areas and respond quickly to requests for assistance from scientists in cooperating countries. The Centers are governed by self-perpetuating Boards of Trustees, composed of individuals of high scientific and humanitarian integrity, who serve in a personal capacity without pay. Most Board members are from the developing nations that the Centers serve but some are from donor nations.

The scientific staffs of the Centers are also international. Members are chosen by their professional capabilities, without regard for national or political affiliation.

Mission orientation

Sharp, well-defined priorities for each Center are set by the international board and staff, buttressed by continuing inputs from cooperating scientists in both developing and developed countries. Although the Centers undertake quality scientific endeavors, their primary emphasis is on helping poor farmers produce the food their countries need rather than on scientific achievement and recognition in itself. The development of high-yielding varieties of wheat, rice, edible legumes, and root crops that are adapted to specific adverse environments is the best known example of this problem-solving approach.

The Centers place a complementary emphasis on identifying the social, cultural, and economic constraints that impede food production and condition farmers' acceptance of improved technologies. Social and biological scientists work closely at all Centers to develop methodologies to alleviate such constraints.

Blend of international and national research

A unique blending of an *international* research focus with a corresponding commitment to capacity-building at the *national* level is a third attribute of success. The international network concept is one of cooperation rather than competition with national research programs. From the outset it has been clear that as national institutions strengthen their own research, training, and problem-solving capabilities, they increasingly benefit from and contribute to the scientific work being conducted simultaneously at the International Centers. Thus, the system is truly one of symbiosis and partnership.

Continuity of program and staff
The Centers' approach contrasts markedly with the project approach of many other international agricultural development efforts. Such efforts have usually been short-term and staffed with donor-nation researchers whose primary loyalties lie in tenured positions with their home institutions. Therefore, their work invariably suffers from strong pressures to complete individual projects and to publish the results to obtain peer recognition.

But long-term research and training efforts can be pursued at the Centers, using staff members who have dedicated their careers to international agricultural development. Under such circumstances, scientists are motivated by the rewards that accrue from research accomplishment, as well as those from peer recognition.

Training and education
Yearly, hundreds of young researchers and extension specialists participate in special short-term training courses organized by the International Centers, or work as on-the-job trainees in the Center Laboratories and fields. Training programs are combined with degree-oriented courses of study in cooperation with nearby or overseas universities at some Centers such as IITA and IRRI. By 1980 IRRI had offered more than 1,000 science-years of training and adds an additional 200 science-years annually. These training programs strengthen not only the human but also the larger institutional capacities of the developing countries.

Strengthening of ties between developing and developed nations
Programs to strengthen the scientific and institutional ties between developing and developed countries have contributed to Center success. Research opportunities are available for master and doctoral candidates, postdoctoral fellows, and visiting scientists from all countries whose projects are relevant to a Center's primary mission. Such broad educational opportunities facilitate collaborative research among scientists of different disciplines and from many countries. For research that requires expertise beyond their capacity, the International Centers have drawn fruitfully on the scientific talents of the industrialized nations.

Strong international support
National, international, and private donors have given the Centers strong support of two distinct types. Financial support is a crucial and continuing need. The 35 donors have demonstrated their faith in the International Centers not only through contributions to rapidly expanding core programs but also to special projects such as workshops, conferences, and international networks.

But equally important has been the willingness of research programs in the developing countries to help implement cooperative research with the Centers. The national programs provide invaluable site-specific information by the screening and evaluation of new seed varieties, and testing of new farming techniques under a variety of ecological conditions.

This collegial integration of international and national efforts assures high-quality research on common problems, and helps build a cadre of scientists in each cooperating country that can eventually enable it to self-reliantly handle its own problems.

FUTURE CHALLENGES FOR IRRI AND THE CGIAR SYSTEM

Maintenance of autonomy and flexibility

By far the most significant challenge for the future for IRRI is to maintain the autonomy and flexibility that it has enjoyed for the past 20 years. The complexity of the CGIAR systems and the size of the budget required to support it will generate continuing pressures to reduce this flexibility, thus endangering the Centers' traditional autonomy. The Centers should firmly resist these pressures.

The best way to assure IRRI's continuing autonomy and flexibility is to keep its own house in order. A well-organized system must be maintained to set Institute priorities in accordance with the best scientific and policy advice available. This means full cooperation with the CGIAR through its Technical Advisory Committee (TAC). IRRI should also continue its own organized evaluation of programs and setting of priorities, including the involvement of outside experts in annual program reviews. Finally, IRRI's size and complexity dictate that it continue the development of a business-like approach to fiscal management and accountability.

Maintenance of the Institute's autonomy and flexibility forces a sharp definition of the specific roles of the Board of Trustees, the director general and his administrative staff, and the scientific staff. The Board should set policy and, in collaboration with the administration and staff, determine general program directions. The director general and staff should implement policy and program directions, and present to the Board the specific scientific and management background on which they are based.

Continuous evaluation of resource allocation

IRRI's second challenge is to continuously re-evaluate the allocation of its resources and staff among different program areas, including:

1. Problem-solving basic research that produces new biological products;
2. Applied research conducted in the Philippines;
3. Applied research conducted jointly with national programs through international networks and other collaborative mechanisms;
4. Training of scientists, educators, and extension specialists; and

5. Human resource- and institution-building within cooperating countries.

The IRRI staff, through its Long Range Planning Committee and the Board of Trustees, have studied future directions seriously.

IRRI has emphasized that it should focus its future resource allocation on activities in which IRRI has a comparative advantage and in which competition with national programs will be minimal. This means greater long-term emphasis on basic research of a problem-solving nature, on development of research methodology, and on serving as a focal point and catalyst for international agricultural cooperation.

Improvement of relationships with developing countries

The third challenge is to continuously evaluate and improve cooperative relationships with program leaders and scientists in developing countries. When appropriate, IRRI and other International Centers should increasingly utilize the cooperative-network approach to the planning and implementation of research which requires evaluation of its adaptability to a variety of agroecologic and socioeconomic conditions. National scientists must actively participate in decision-making on the research and its site-specific evaluation.

IRRI should focus more sharply on collaborative research with selected scientists in developing countries. Those who administer national research programs must be involved in program formulation, to assure their strong commitment and to ensure financial support. This type of collaboration should be through mininetworks that include scientists in both developed and developing countries.

Improvement of relationships with developed countries

Re-examination and formalization of working relationships between scientists at IRRI and those in the developed countries is the fourth challenge. Dramatic breakthroughs of the future are most likely to come through such collaboration. Bioengineering and other modern research thrusts that require expertise and equipment not available at IRRI are examples. Specific memoranda of understanding should be drawn to clearly identify research areas of mutual interest.

But care must be taken to assure that IRRI is not used merely as a foreign base for training graduate students from the developed countries. The Institute must be aggressive in identifying areas where external assistance is required, and selective of projects for which cooperation is invited.

Re-evaluation of training programs

The fifth challenge is to re-evaluate the nature of IRRI's training programs. Most national programs now have the capacity to conduct their own training programs in rice production, and should be encouraged to do so. IRRI should place greater emphasis on training specialists for collaborative

international networks, on pre- and postdoctoral training, and on providing on-the-job training. To relieve the burden that IRRI now places on the University of the Philippines at Los Banos, cooperative degree-training opportunities should be sought with other institutions.

Increased communication

An increase in communication between IRRI and the diverse groups that share a common interest in its work is the sixth challenge. The priority targets of communication are the scientists and leaders of rice production programs in the developing countries.

The second target is leaders of national and international research and development programs of the developed countries, along with their field support staffs in bilateral programs. IRRI's linkage with this group is particularly weak.

A third target is the political leaders and decision makers in both developing and developed countries. As the ultimate sources of financial and human resource support for IRRI and its cooperators, they must be kept better informed of the institute's activities and contributions.

CONCLUSION

The international agricultural research system has provided the technological base for most of the unprecedented increases in food production during the past two decades. By coupling the talents and expertise of national and international centers, the system has developed research methodologies that have revolutionized international cooperation and, more important, helped increase world food supplies.

The International Agricultural Research Center component of the system is probably needed more critically today than 20 years ago. The problems that remain are even more formidable than those when IRRI was established. Most of the quick and easy achievements are already completed, or their implementation is well under way. The more difficult tasks lie ahead.

The ingenuity that conceived and established IRRI and other International Centers must now be focused on ways to remove the more formidable constraints that remain. The Centers and national institutes must continue to help increase yields in irrigated areas and reduce pest infestations, while simultaneously turning to more difficult jobs such as:

- The removal of constraints in areas with limited resources and where adverse climates, soils, and pests hold down crop and animal production;
- The indentification and evaluation of improved farming systems that focus sharply on the needs of the farm family, as well as on the aggregate food needs and supplies of the national systems;

- The identification of social, economic, and political constraints that curtail the adoption and use of improved technologies. Some of these constraints may interact with new technologies to accentuate the problems of the truly poor.

The International Centers must serve as bridges between scientists from the developed nations and those from the developing nations even more than in the past. Closer interaction with scientists from the developed nations will increase in importance as innovative and sophisticated research techniques permit the development of new biological entities, and the design of new research tools to resolve the problems of resource-poor farmers. Areas in which there will be opportunities for fruitful cooperation include bioengineering; tissue, cell, and embryo culture of plants; embryo culture of animals; and the use of native plants and plant products in pest management.

Mininetworks must be established to coordinate activities of scientist from the developing nations, the Centers, and the developed countries on innovative research areas. Such improved collaboration will enhance training opportunities for scientist from developing countries, and allow the immediate evaluation of new research techniques for adaptability to specific sites.

The most serious task of the future may be to ensure the commitment of both donor and developing countries to the proposition that agricultural research is a vital component of long-term economic development, and that poor countries will probably not be able to feed themselves without it. This commitment should be evident not only during famine and serious food shortages, but as calm and deliberate attempts are made to increase long-term national food production.

Being an optimist, I am convinced that good judgment will prevail and that national and international commitments will be made not only to maintain the momentum of the international agricultural research system, but also to expand and intensify it. IRRI and other International Agricultural Research Centers will continue to play a dual role as developers of new technologies and as critical catalysts to encourage international cooperation to meet food demands of the future.

Appendix 1. Institutions supported by the Consultative Group on International Agricultural Research (CGIAR).

CIAT	Centro Internacional de Agricultura Tropical Apartado Aereo 6713, Cali, Colombia
CIMMYT	Central Internacional de Mejoramiento de Maiz y Trigo Londres 40, Mexico 6, D. F., Mexico
CIP	Centro Internacional de la Papa Apartado 5969, Lima, Peru
IBPGR	International Board for Plant Genetic Resources Food and Agriculture Organization of the United Nations Via delle Terme de Caracalla 00100 Rome, Italy
ICARDA	International Center for Agricultural Research in the Dry Areas P.O. Box 114/5055 Beirut, Lebanon
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics Patancheru P.O. Andhra Pradesh 502 324, India
IFPRI	International Food Policy Research Institute 1776 Massachusetts Avenue, N.W. Washington, D.C. 20036 USA
IITA	International Institute of Tropical Agriculture P.O. Box 5320 Ibadan, Nigeria
ILCA	International Livestock Center for Africa P.O. Box 5689 Addis Ababa, Ethiopia
ILRAD	International Laboratory for Research on Animal Diseases P.O. Box 30709 Nairobi, Kenya
IRRI	International Rice Research Institute P.O. Box 933 Manila, Philippines
ISNAR	International Service for National Agricultural Research P.O. Box 93375 2509 AJ The Hague The Netherlands
WARDA	West Africa Rice Development Association E.J. Roye Memorial Building P.O. Box 1019 Monrovia, Liberia