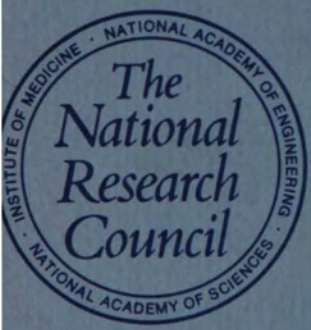
IV

SUPPORTING PAPERS: WORLD FOOD AND NUTRITION STUDY

VOLUME V

Study Team 14

Agricultural Research Organization



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VOLUME V

Study Team 14

Agricultural Research Organization

Commission on International Relations
National Research Council

NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D.C. 1977

NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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This is Volume V of Supporting Papers, World Food and Nutrition Study. The other volumes are:

Volume I

Study Team	1	Crop Productivity
Study Team	2	Animal Productivity
Study Team	3	Aquatic Food Sources

Volume II

Study Team	4	Resources for Agriculture
Study Team	5	Weather and Climate

Volume III

Study Team	6	Food Availability to Consumers
Study Team	7	Rural Institutions, Policies, and Social Science Research
Study Team	8	Information Systems
Study Team	10	Interdependencies

Volume IV

Study Team	9	Nutrition
Study Team	12	New Approaches to the Alleviation of Hunger

PREFACE

Shortly after the World Food Conference held in Rome in 1974, the President of the United States wrote to the President of the National Academy of Sciences asking the Academy to make an assessment of the problem of hunger and malnutrition and "develop specific recommendations on how our research and development capabilities can best be applied to meeting this major challenge."

The study was begun in June 1975 by a Steering Committee appointed by the President of the Academy. It produced two reports for the President: an Interim Report, published by the Academy in November 1975, and a final report, World Food and Nutrition Study: The Potential Contributions of Research, published in June 1977. The Steering Committee was assisted by 14 study teams appointed by the Academy to analyze and make recommendations to the Committee on various portions of the study (Table 1).

This publication is one of five volumes containing the reports of Study Teams 1-10, 12, and 14. Study Team 11's report overlapped the other reports and has been integrated with them. Study Team 13's report of its ranking of research priorities was an integral part of the work of the Steering Committee. Consequently, it is not published here. Study Team 13's work is explained in detail in Appendix B of the Steering Committee's report.

The Steering Committee is deeply grateful to the chairmen and members of the study teams for their dedicated work, undertaken for the most part under heavy pressure of time. This work provided the greater part of the source materials for Chapters 2 and 3 of the Steering Committee's report, dealing respectively with "High Priority Research" and "How to Get the Work Done." The study teams are responsible for the content of their reports, which were reviewed by appropriate members of the Steering Committee.

Study Teams 1-12 were asked to identify areas of research and development that had outstanding prospects for helping to meet world food and nutrition problems

Table 1. Study teams, World Food and Nutrition Study

Study Team	Title
1	Crop Productivity
	Subgroup A Pest Control
2	Animal Productivity
	Subgroup A Animal Health
3	Aquatic Food Sources
4	Resources for Agriculture
	Subgroup A Farming Systems
	B Land and Water
	C Fertilizers
	D Energy and Equipment
5	Weather and Climate
6	Food Availability to Consumers
	Subgroup A Food Losses
	B Food Processing and Preservation
	C Food Marketing and Distribution
7	Rural Institutions, Policies, and Social Science Research
	Subgroup A Policies and Program Planning
	B Research, Education and Training, and Extension
	C Finance, Input Supplies, and Farmers' Organizations
8	Information Systems
9	Nutrition
10	Interdependencies
	Subgroup A Population and Health
	B Energy, Resources, and Environment
	C International Trade Policy and Comity Between Nations
	D National Development Policies
11	New Approaches to Increasing Food Supplies
12	New Approaches to the Alleviation of Hunger
13	Research Priority Assessment
14	Agricultural Research Organization
	Subgroup A Research Organization in the United States
	B Global Agricultural Research Organization
	C Development of Research Personnel

over the next several decades. For each such area, they were asked to respond to three questions:

-- What advances in knowledge will specific areas of research produce, and what is the scientific or technological significance of these advances?
-- If the research produces results, what effect would they likely have on reducing global hunger and malnutrition over the next several decades?
-- What supportive action will be required to conduct research for the accelerated activity recommended (e.g., more resources, policy changes, organizational changes)?

The study teams were asked to base their selection of research areas on their answers to the first two questions. Answers to the first and third questions provided insight on the feasibility of each research area. This information was used by Study Team 13 and the Steering Committee in the selection of research priorities. It also provided raw material for Study Team 14 and the Steering Committee when they considered steps to mobilize and organize resources to implement the proposed research.

Each study team's selection of high priority research areas involved two steps. In the first step, the study teams reviewed research recommendations and possibilities for research provided by existing reports, by the study team members themselves, and by hundreds of other people who were consulted, including many from other countries. From the hundreds of research possibilities, each team selected a limited set that would likely have the greatest global effect on hunger and nutrition. The second step narrowed this set to research areas whose potential was thought to stand out well beyond that of the rest of the group.

The Steering Committee hopes that these study team reports will provide rich source materials for those interested in pursuing the various subject areas in greater depth than could be done in the report of the Steering Committee.

Harrison Brown
CHAIRMAN
Steering Committee
World Food and Nutrition Study

Report of Study Team 14

AGRICULTURAL RESEARCH ORGANIZATION

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OVERVIEW AND RECOMMENDATIONS

OVERVIEW

The Setting

Based upon study of the present and prospective global food and nutrition situation, it is our judgment that:

-- No nation can view food and nutrition matters as if it were operating in a closed economy. Changes on the food front elsewhere in the world transmit shock waves to U.S. producers and consumers almost instantaneously, and vice versa. Thus close U.S. participation in the larger community of international food and nutrition science serves both the self-interests of this country and the cause of strengthening research and development throughout the world.

-- The quantity, quality, and stability of food production and the level of human nutrition in many of the developing, as well as the advanced, countries can be substantially improved. To do so, however, more international collaboration, political will, and a continuous effort will be required.

-- Stepped up, strategically targeted efforts, including the building of a professional and institutional capacity, especially in the developing countries, are necessary if these improvements are to be made.

-- The substantial research, development, and training capacity of the United States can make a more powerful contribution toward meeting world hunger and nutritional needs through further mobilization, strengthening, and some reorganization, particularly if such efforts are integrated with measures to improve the growing international agricultural research networks.

-- This mobilization of U.S. potential requires, among other actions, explicit legislative mandates to and

adequate funding of appropriate departments of the U.S. government, including the Department of Agriculture (USDA), the Agency for International Development (AID), the National Science Foundation (NSF), the Department of Health, Education, and Welfare (HEW), and perhaps others. The significant redirections in research emphasis that are taking place should be continued. Further building of international dimensions into U.S. research and educational programs is essential if we are to increase the value of these programs both to the United States and to the developing countries. We have seen that high quality research produces benefits that span national boundaries. For example, Asia, Africa, Latin America, the United States, and Australia have all increased their wheat production as a result of international research on this crop. Without question, the development and use of Mexican semidwarf wheats have meant worldwide advances.

Key Findings

We analyzed the problems and considered what might be done to strengthen the U.S. contribution to increasing food production and combating malnutrition. These key findings emerged:

-- The rate of increase in the productivity of U.S. agriculture appears to be tapering off. Because our advanced agriculture is so heavily based on modern science and technology, the quality and level of food-related research are closely associated with the ability of U.S. farmers and related businesses to make further gains in productivity.

-- Real U.S. resources going into agricultural research and development, especially investigations of fundamental biological processes and their incorporation into agricultural technology, have been declining. As a result of inflation, fewer personnel and facilities are used. Short-run pressures, including important environmental and regulatory concerns, have diverted scientific talent from more long-term, productive research. Increased student teaching loads have reduced the time some scientists have for research. Thus it is doubtful that new knowledge is being generated fast enough to enable the increases in productivity required for sustained agricultural growth. Multidisciplinary research areas, which lie between agricultural technology and discipline-based

research, are particularly suffering.

-- High quality personnel are critical to U.S. research. Professionals should be encouraged to pursue careers in international as well as domestic food and nutrition research. This calls for sustained research and training funding with appropriate evaluation and monitoring, and for a rewards system in which, through peer reviews and other advancement processes, professional societies, faculties, and administrators adequately recognize the contributions of scientists, especially those working on teams, who are concentrating on world food and nutrition problems.

-- Scientists who are already trained could, with the right incentives, apply their talents to solving food and nutrition problems. However, more good scientists will be needed. The numbers of scientists should be enlarged by increasing the number of training programs in food and nutrition, especially in the developing countries.

-- For the most part, U.S. international agricultural research and development that is supported by public funds is appropriately the financial responsibility of the federal, not the state, government. There are natural complementarities between the federal and state interests, but the prime responsibility for leadership and continuity in support rests with the U.S. government.

-- Private firms contribute to solving important agricultural and nutritional problems. They are major investors in food and nutrition research where they can, through patent protection, for example, retain proprietary interest in their investment. Their capacity to do first-class research and training on a contract basis should be used more often.

-- Important first steps are being taken, by USDA and the state agricultural experiment stations, for example, to redirect the use of presently available funds to today's high priority needs. Greater specialization and division of labor are being encouraged. As a means of redirecting research priorities, questions are being raised about whether certain research funds should continue to be earmarked. Historically, such earmarking was started in an era of agricultural surpluses and concerns about developing new uses and markets for farm products. In providing for more flexible use of appropriated funds, there is an opportunity to improve the relevance, quality, and performance of U.S. food and nutrition research.

-- Historically, the United States has developed a remarkably strong agricultural system. It is

essential that it remain so. By using our extraordinary technical and financial base properly, food and nutrition research can be enhanced with profound gains to the United States and to people everywhere. In the case of public institutions, much of the needed legislative authority exists. With respect to more effective international collaboration, many of the necessary bilateral and multilateral arrangements with which U.S. institutions can work are in place. However, to step up efforts, particularly those of USDA and of the state agricultural experiment stations, increased federal appropriations and authorization to use some of presently available and new funds for international activities are necessary.

-- Important as the U.S. contribution at home may become, better answers to world food problems will require a global effort. In this we see the United States as a receiving and contributing partner working in an international network alongside: (1) research institutes in other high-income nations, (2) international agricultural research centers, and (3) research and training institutions in the developing nations. Important first steps are being taken in this direction. In fact, the key elements of an evolving, productive global network in agriculture, food, and nutrition already exist. Professional associations of scientists and public agencies and institutions can do much to make this network produce and flourish.

-- In spite of the social, economic, and political importance of the world food and nutrition problem, despite the fact that a large number of U.S. agencies influence or interact with that problem here and overseas, and even though new groups such as the U.S. government's Agricultural Policy Committee have been formed, the United States still needs continuously to develop, assess, and maintain its domestic and international food and nutrition strategies, policies, and programs. Means of performing these essential functions are addressed in our recommendations.

Action Needed

Our findings suggest the need for five major types of action by the United States:

-- Redirect part of the presently available resources, and portions of those that may be added, toward research, development, and training that gives higher priority to world needs, placing special

emphasis on long-term problems. For example, it is widely agreed that efforts should be intensified to improve the photosynthetic efficiency of certain crops and their capacity to fix nitrogen. However, in trying to direct resources to high priority uses, we must retain the essential strengths of our present decentralized decision-making processes.

-- Mobilize scientific resources not now tapped for agricultural and nutrition research, especially those within universities.

-- Strengthen the U.S. scientific community's involvement in food and nutrition research and development by improving collaborative relationships with foreign scientists, especially those in the poorer countries where the problems are most acute. Collegial relationships across international boundaries should be strengthened and nurtured; more U.S. scientists, especially those being trained, should be learning from foreign colleagues through direct involvement in research in tropical and subtropical countries.

-- Enlarge the flow of federal funds into agriculture and nutrition research through new and existing channels to further develop existing state and national programs and to develop and sustain an international dimension in this work.

-- Assess, monitor, and evaluate continuously the U.S. research and development effort in food and nutrition in the context of the changing domestic and world situation. Because the scope and nature of food and nutrition needs are constantly changing in dimension, close surveillance, insistence upon high quality work, and the integration of the total effort within a larger coherent policy framework are central to the public interest.

RECOMMENDATIONS

- We recommend that the United States substantially increase the resources devoted to food and nutrition research, development, and training to elevate the relevance, quality, and productivity of the U.S. and global research system.

We propose increasing the present base of federal funding for agricultural and nutrition research (estimated at more than $600 million) 20 percent in the first year. One-half of this increase would be distributed through a new competitive grants program for high priority research with an equal amount allocated through more traditional USDA-Cooperative

State Research Service (CSRS) formula funding channels. It also is recommended that, subject to review, total federal funding for agricultural and nutrition research be increased 10 percent annually (in real terms) in each of the four succeeding years. In addition, a five-year USDA federal matching funds program for the construction of research facilities would be established. An estimated $50 million annually is required by USDA and land-grant institutions alone. Thus when the needs of other institutions also are taken into account, $100 million or more per year would be required.

We also recommend continued and expanded funding for development assistance aimed primarily at improving food production in the developing countries. Funds would be provided largely through Title XII of the Foreign Food Assistance Act of 1961, as amended. Singled out for special consideration are: (1) ongoing core budget support for the international agricultural research centers and institutes, (2) support for the agricultural and policy research services and programs within the developing countries, and (3) funding of partnership relationships between institutions in the developing countries and U.S. universities and associated research organizations along the lines mandated in the Title XII legislation. These are critical overseas elements in the global agricultural research and training network.

The U.S. policy of supporting up to 25 percent of the core budgets of the international centers is critically important to this initiative. In urging that this policy be continued, we estimate that the cost to the United States will rise from the present levels of around $20 million for 1977 to perhaps $30 million by 1980. Estimates of U.S. allocations (grant and loan funds) for national research systems, training, and related special projects are more difficult to make as are the funding requirements of the Title XII-type working partnerships between developing country and U.S. institutions. Especially for the latter, substantial increases in longer term grant (in contrast to loan) funds are likely to be required.

- <u>We recommend bolstering the U.S. capacity for analysis, evaluation, administration, and management of food and nutrition research and policy matters</u>.

Means of performing planning, analysis, and management functions should be carefully examined to use more effectively available resources for food and nutrition research and to administer substantially

increased funds. Functional needs are more apparent than is the appropriate administrative structure. Thus our recommendations allow several alternatives. For clarity we start with the central analytical and policy analysis functions and then discuss administration of the more traditional and the newly recommended programs.

Establish and fund a food and nutrition council. Functionally, a food and nutrition council would deal with domestic and international issues and their relationship to a broad array of national concerns including food sufficiency, health, trade, aid, energy, economic stabilization and growth, and environment. Administratively, the council would be in the Executive Office of the President with close links to the Office of Science and Technology Policy (OSTP).

The council would: (1) provide an interdepartmental forum; (2) continuously monitor and assess the world food situation; (3) establish policy objectives; and (4) design, evaluate, and integrate the mix of policies and programs to reach established goals.

We recommend that a subgroup within the council monitor and evaluate the magnitude and mix of national and international food and nutrition research. This group would pay special attention to human nutrition research. Work in animal nutrition differs sharply from human nutrition research in historical emphasis and mode of development. The field of animal nutrition is well developed in USDA and state agricultural experiment stations in contrast to much of the work in human nutrition.

The council should be staffed with career government professionals. Some of this talent probably would be drawn from established agencies to further liaisons with the several existing agencies and departments intimately concerned with the proposed council's deliberations.

Because of the increasing importance of world food and nutrition considerations to USDA's operations, USDA probably will strengthen its policy assessment and analysis capacity at the secretarial level.

Implement the new competitive grants program through USDA. This new program should be administered in USDA by a new agency under the Assistant Secretary for Research and Education. Projects should be selected on the basis of a critical peer review system, and grants should be available to all researchers whether in the federal, state, or private sector. A portion of the grant funds should be transferred to other federal granting agencies such as NSF and the National Institutes of Health (NIH) when consistent with high priority research needs. The proposed open

competitive system should be designed to attract and mobilize scientific personnel in all sectors including parts of the university community and private industry not traditionally involved. Accountability for this program would rest with the Assistant Secretary.

Provide an infrastructure for an international dimension in U.S. research and educational institutions. Continuous funding is required for U.S. research and educational institutions to develop and maintain an international dimension in ongoing programs. Institutions with a commitment to international research and training should have some means of funding required staff, facilities, and related infrastructure. Without these the U.S. training and research potential will probably be underutilized.

Activate the federal matching funds program for research facilities. This newly funded program also would be administered by USDA, and would make monies available for approved construction and facilities projects on a 50/50 matching basis. This arrangement would enable universities and experiment stations to modernize and expand facilities required for high priority research. Thus the allocation of matching funds for facilities should be closely coordinated with overall research programming.

Create training study and coordination groups. Appropriate training is essential to develop effective research personnel. In both the domestic and development assistance programs, expanded funding is recommended for graduate and postgraduate fellowship research and training opportunities. Such enlarged programs would go some distance in developing new generations of scientists and in promoting collaboration in research education. There is also a need, particularly in the developing countries, to train less experienced research workers so that they can help implement food and nutrition research programs. The developing countries are attempting to strengthen undergraduate and postgraduate degree programs in their colleges and universities, often against formidable obstacles. Yet the important connection between educational institutions and research capability is often not being forged. In short, there is a continuing need for increased assistance for institutional development in the developing countries.

To examine training needs and the means of meeting them more systematically we recommend that consideration be given to forming a joint committee on international training within the Title XII program. This committee would: (1) work with the developing countries and multinational organizations to assess

personnel requirements for the food and nutrition field; (2) work with appropriate U.S. groups such as USDA's International Scientific and Educational Council and the National Association of State Universities and Land Grant Colleges to monitor and assess U.S. training programs both domestically and abroad; and (3) provide counsel on the planning and execution of U.S. training efforts.

Consideration also should be given to establishing an international committee to assess and monitor the personnel requirements of food and nutrition research worldwide, giving special emphasis to the needs of the developing countries. Such a committee might be established by a multinational body such as the Consultative Group on International Agricultural Research (CGIAR). This committee might identify acute shortage areas and work with donor agencies, national research programs, and training institutions to help mobilize the resources required to help overcome serious personnel deficiencies.

Authorize an international dimension in domestic research programs. USDA, particularly the Agricultural Research Service (ARS) and the Economic Research Service (ERS), and the state agricultural experiment stations should be encouraged to use a portion of their presently available as well as enlarged flow of federal funds for high priority international research. The decision as to how much to allocate to this specific use would, if possible, be left to the administrators of the USDA agencies and state experiment stations in order to capitalize on special competences and interests. In some cases, however, as in ARS, it may prove helpful to provide more specific guidelines to give some protection against short-run domestic pressures.

The goal of this recommendation is to develop and sustain an international dimension in domestic research programs in order to strengthen these programs and their value to the United States and other countries. At the same time, we have recommended that the United States, together with other countries, strengthen its development assistance work focused on food and nutrition research, training, and competence building abroad. We feel that the domestic (USDA, state agricultural experiment stations, U.S. universities and laboratories) and development assistance efforts are complementary and require coordination.

Scientists receiving federal funds should be encouraged to collaborate with scientists abroad. This probably would require international travel and collaborative research within the developing countries, and in some cases bringing foreign scientists to the United States.

It is broadly accepted that international participation is required to further development in the poorer countries. But it is less understood that international participation also is required for effectively operating domestic research programs. The United States is but a part of the larger world community of scientists, agriculturalists, and nutritionists. Another nation's problem today may be of prime concern in the United States tomorrow. Solutions, like the problems themselves, may be generated in laboratories and on farms almost anywhere in the world.

Today no country is insulated from changes in the global levels of food production, needs, trade, and prices. Thus it is our judgment that full U.S. participation in the larger world community of international food and nutrition science serves both self-interests and the larger goal of improving human welfare.

Report of Subgroup A, Study Team 14

RESEARCH ORGANIZATION IN THE UNITED STATES

INTRODUCTION

Our ability to help solve the problem of producing enough food for an ever-expanding world population will depend on how the U.S. research effort is organized. The United States has shown its ability to produce, process, and distribute food in excess of its own needs. Technology developed in both public and private research laboratories has contributed significantly to this ability.

The U.S. research system is a combination of public and private initiative and is a joint federal-state undertaking with both national and international components. It is a system that combines research from the discovery of the most basic scientific relationships through the intermediate chain of developmental research and operational application of those relationships.

This report concentrates on the research component, but it should be recognized that the extension of research results through public institutions has and continues to play a vital role in facilitating both the design and application of technology to produce large quantities of nutritious food products. Recommendations made in this report should not detract from the importance of this delivery and communication system.

One hesitates to recommend changes in a system that has demonstrated the ability to perform so well. Yet improvements can and must be made. The challenges for the future are even greater: Can a research strategy be developed that will continue to solve problems at home while strengthening the ability of all nations to solve their food and nutrition problems? That is the major challenge facing the U.S. food research system.

Our recommendations are not intended to suggest that what is being done today in terms of basic research is unimportant, or that our research system should be completely restructured. They are, instead, designed to build on what we have so as to improve the

system's capability of meeting both domestic and international food needs--today and tomorrow.

THE PRESENT U.S. FOOD AND NUTRITION RESEARCH SYSTEM

Food research, as used in this report, is a broad term covering basic or applied research that directly or indirectly influences the quantity or quality of the food supply. So defined, it encompasses: agricultural and aquatic food production research; market research, including food processing and distribution; and nutrition research designed to improve diets, prevent nutrition-related diseases, or develop cures for such diseases.

Food research strategy is part of a broader set of policies and programs that affect the conditions under which food is produced and consumed. Food research strategy and food policy programs should be mutually consistent and supportive. One possible inconsistency is cutting or holding constant in real terms the budget to support food research while expressing concern about the world's long-term ability to feed an ever-expanding population. Another inconsistency is encouraging economic development in other countries according to the principles of comparative advantage, and then closing our doors to the import of such products.

Food is broader than just agriculture. Food research is, therefore, broader than agricultural research. Research concerned with the production of food is but one component of the food system and is not wholly contained within the system. Research having no direct ties to food can, over time, lead to results that have significant long-term effects on the ability to feed a growing world population.

The interaction of a food and nutrition research strategy with a broader set of food policies and problems serves to emphasize the importance of consistent policies and programs that encourage progress in increasing both present and future levels of food production in the United States and around the world. It makes one aware of the large number of external factors directly and indirectly affecting food production and therefore food research and development strategies.

Our description of the existing U.S. food and nutrition research system concentrates on an analysis of how research funds flow within the system and the comparative advantages of each research institution.

Two main groups comprise the U.S. food research system from a flow-of-funds perspective, those who supply funds and those who receive funds to perform research (Figure 1).

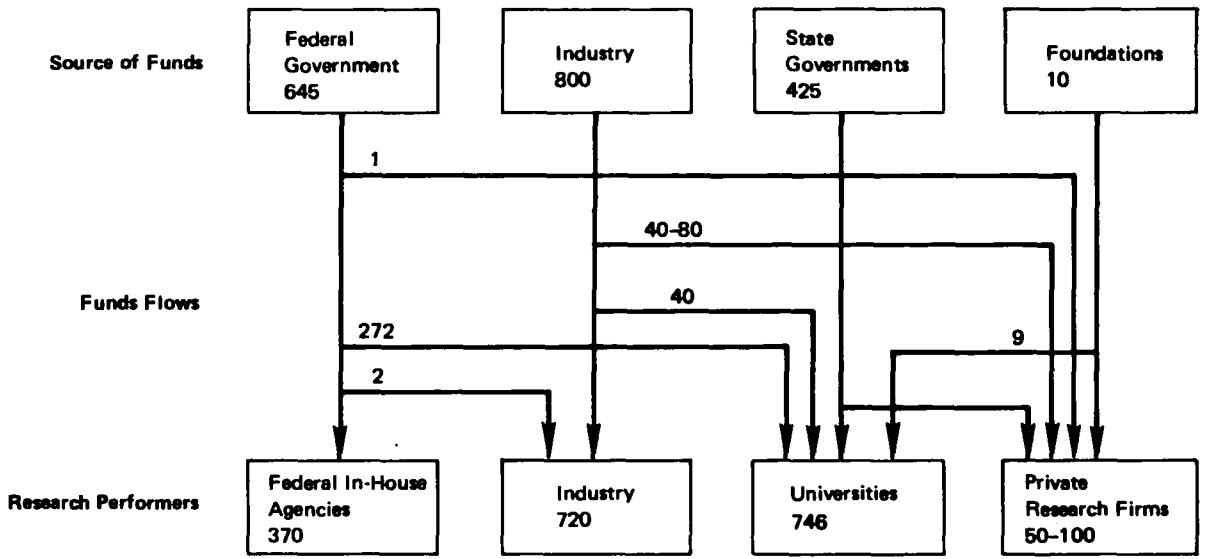


FIGURE 1 Research and development funds for the U.S. food research systems, 1976 ($ millions).

Sources of Funds

The four main sources of funds are the federal government, private industry, state governments, and foundations. Incomplete data suggest that these sources provided approximately $1.9 billion for food research in 1976, about half of which came from federal and state sources. Since 1970, increases in total food research appropriations have only kept pace with inflation allowing for no increase in scientific personnel.

Approximately 85 percent of the total federal food research appropriations (about $560 million) goes to the Department of Agriculture. The remainder is distributed among agencies such as NSF, NIH, AID, and the Departments of Commerce, Interior, and Defense. These agencies spend approximately $85 million on food-related research. Much of this money goes to university researchers in the form of extramural research grants.

State governments supply about $425 million in operating funds for food research by its universities. The bulk of this goes to the state agricultural experiment stations. However, a small amount goes to universities other than land-grant and nonagricultural departments within land-grant universities for carrying on more basic, food-related research.

The present magnitude of private industry funding for food research is uncertain. In 1965, private industry spent approximately $500 million. It was projected that it would be spending $800 million in 1975. Private industry funds include expenditures by agribusiness firms and the research component of producer checkoff programs. Such checkoff programs are provided for by law largely on a voluntary basis. While most programs currently are used for advertising, they provide a potential long-term source of funds for producer-oriented research.

Private foundations such as Ford and Rockefeller supply approximately $10 million for food research within the United States. Such foundations have reduced research expenditures because of inflation and a depressed stock market.

Research Institutions and Agencies

Those who perform research can be divided into four categories: federal in-house agencies, private industry, universities, and private research firms. Each of these institutions has a comparative advantage in performing certain types of research. Each also has unique motivations for research based on its sources of

funds, accountability factors, and purposes.

Federal In-house Agencies

Included under these agencies is research performed by scientists as employees of the federal government. In 1976, federal in-house research expenditures were about $370 million. The largest federal in-house agency is the Agricultural Research Service in the Department of Agriculture with in-house research expenditures of $285 million in 1976.

The comparative advantage of federal in-house agencies in performing food research lies in their ability: (1) to concentrate large amounts of resources on problems of national importance (no other food research performer has a comparable ability), (2) to direct research to areas where the need is the greatest, and (3) to assemble multidisciplinary teams of scientists when a diversity of talents and expertise is needed.

Private Industry

Private industry spends about $720 million a year on research and development. The primary motivation for such research lies in the potential for patentable ideas or discoveries that could mean a consumer franchise. Most industry research is designed to develop input items that are purchased by producers or to develop new food products. Private industry's comparative advantage therefore lies in its ability to: (1) administer research with the power to stop or start based on profit potential (industry research does not depend on the time-consuming and often delayed government appropriation process); (2) to conduct developmental research when a profit potential is evident; (3) to conduct multidisciplinary research; and (4) to conduct marketing research including consumer testing, evaluation, and product modification to meet marketing requirements.

Universities and Agricultural Experiment Stations

These institutions spend approximately $746 million on research. About 60 percent of this funding or $425 million comes from state governments; $272 million from federal sources, including the Cooperative State Research Service, and competitive grants from other federal agencies; $40 million from private industry; and $9 million from foundations.

State agricultural experiment stations were established to serve the states' agricultural needs. They are a component of, with very few exceptions, each state's land-grant university.

The comparative advantage of university and experiment station research lies in their ability: (1) to perform both basic and applied research and relate the two; (2) to put established scientists in contact with the new generation of scientists; (3) to take advantage of a delivery and feedback system through interaction with extension specialists; (4) to maintain frequent contact with clientele to ensure relevant research results--this contact encourages rapid initiation of developmental research by private industry and implementation by producers; (5) to explore the unknown and engage in higher risk basic research; and (6) to provide new information through a large number of scientific and applied publications.

About 90 percent of the dollar value of university food research is performed in the agricultural experiment stations of land-grant universities. There are opportunities for better integrating and coordinating research done in the land-grant system with that conducted by nonagricultural departments in land-grant universities and that done in universities other than land-grant.

Private Research Firms

Such firms assemble scientists for the primary purpose of conducting client-oriented research. Private research firms spend about $75 million a year on food research. Much of this money is spent to obtain answers to specific questions for clients within a relatively short period of time. Although private firms have their own research staffs, they also draw on university expertise through consultancy arrangements. The comparative advantage of private firms lies in their ability: (1) to conduct research requiring relatively quick answers, (2) to assemble interdisciplinary teams of researchers, (3) to address individual situations or questions of clients, and (4) to seek answers worldwide if necessary.

CRITERIA FOR DEVELOPING A RESEARCH STRATEGY

A food research system designed to help solve world food problems should satisfy the following criteria:

-- Provide a mechanism for continuously assessing, reviewing, and adjusting established food policy

and programs, including food research strategy, in light of the evolving world food situation.

-- Establish short-term and long-term research objectives and plans consistent with the comparative advantage of research institutions within the United States as well as the inputs of other nations.
-- Provide the resource support needed for basic, intermediate, and applied research to solve both present and future food problems.
-- Mobilize and attract the right quantity and mix of qualified research talent.
-- Coordinate research for a balance of research input and output that takes advantage of the strengths of the various research components while satisfying the expectations of those supporting the research effort.
-- Develop a communication system that informs interested scientists, research administrators, and policymakers about research being conducted.

APPLICATION OF CRITERIA TO THE U.S. RESEARCH SYSTEM

How well does the existing U.S. research organization satisfy the criteria specified for a food research strategy?

Mechanism for Assessing the World Food Situation

During the 1970s, the U.S. food system has become more concerned about the world food situation. USDA and other government agencies have begun to look at the adequacy of intelligence on world food production and consumption. The need for internationally held food reserves has been discussed. The adequacy of support for the food research system has been questioned. In addition to the World Food Conference, within the United States the Agricultural Research Policy Advisory Committee (ARPAC) held a working conference to assess research to meet U.S. and world food needs.

In 1975, Congress enacted groundbreaking legislation for more effective use of land-grant and similar agricultural colleges and universities to meet the need of increasing world food supplies. Title XII of the Foreign Assistance Act of 1961, as amended, provides federal funding so that colleges and universities can promote agricultural institutions and programs in poor countries. Title XII strengthens the ties between the universities and the international food research system by providing a basis for expanded international activity at the state level. Strong

university leadership will be required to make the system work. There is a danger that new funds will be used only to augment existing projects or that federal agencies will stifle rather than stimulate new initiatives contemplated by the act. New, imaginative projects must come forth if the university research system is to warrant the trust provided it by this innovative legislation. Federal agencies must recognize that Congress has given the universities the initiative.

We are gradually adjusting our research strategy to contemporary food and nutrition problems, but much remains to be done in terms of developing the proper mix of research effort, determining the appropriate level of support, and improving the quantity and quality of output. However, the food and nutrition problem is broader than research strategy, and it has two requirements: development of an overall food strategy that recognizes both the domestic and international aspects of the food problem, and development of a long-term research strategy that is consistent with the magnitude of the problem.

Some may consider the development of an overall food strategy beyond the scope of this study. As indicated previously, a food research and development strategy is, in fact, an integral part of our overall food strategy--domestic and international. Thus while awareness of the world food problem has increased, overall research strategy efforts to date have been rather ad hoc, with no basis for continuous evaluation. Such an ad hoc response by the United States to one food crisis after another is not sufficient. It has resulted in food policy decisions that seem highly fragmented.

The problem of satisfying world food needs begins with policy and organizational decisions that are much broader and more complex than food research policy. Who in the federal government, for example, is responsible for assessing the world food situation? Who in the executive and legislative branches is responsible for assessing the domestic and international policy implications of changes in the world food situation? What are our goals as they relate to world food needs? Who is responsible for seeing that these goals are reached? What responsibility does the Secretary of Agriculture have for policy decisions affecting food supply and demand internationally? Regarding international food policy, where does the responsibility of the Secretary of Agriculture end and that of the Secretary of State begin? How are policy alternatives such as a domestic, market-oriented agricultural policy, export controls, import controls, population controls, and various

levels and types of food diplomacy, international food aid, and technical assistance best rationalized within and among the various government agencies?

These are questions that every administration and Congress must address. Today these questions are even more critical because of the pressing effect of increased foreign demand on domestic policy decisions, because of the need for an open international system, and because of the increased importance of food internationally. Therefore, the federal government needs a central goal for decisions affecting our domestic and international food policy. This goal would have three functions:

-- providing a continuous assessment and analysis of the world food situation, problems, and policies affecting its resolution;
-- establishing objectives and goals in terms of where we want to go, when we want to get there, and how we want to get there;
-- designing, evaluating, and rationalizing the mix of policies and programs to reach established goals with a minimum of conflict.

There are alternative means of accomplishing this complex task involving government agencies in both the executive and legislative branches.

Broadening the Role of the Secretary of Agriculture

The Department of Agriculture could be restructured to give the Secretary of Agriculture a substantially broadened role and constituency in relating to domestic and international food policy. Food policy decisions presently are distributed among some 26 federal agencies. The responsibility for food research is distributed among at least eight federal agencies. This alternative would reassert the role of the Secretary of Agriculture and of USDA in food policy and food research decisions.

Traditionally USDA has viewed the U.S. producer, agribusiness suppliers, and marketing firms as its primary clientele. However, new, powerful consumer and international interests are developing that also affect food policy decisions (for example, food stamp programs and international trade negotiations, respectively). These sometimes conflicting interests must be resolved. One can forcefully argue that the place to do this is within a single agency with a broadly defined mission and clientele. For USDA the change would be substantial, however. It would require that congressional, producer-oriented committees accept this

broader role in their legislative, oversight, and appropriations actions.

Continuing the Cabinet-level Agricultural Policy Committee

The Ford Administration attempted to solve the problem of developing a cohesive, consistent food policy by forming the Agricultural Policy Committee which is still in existence. This committee is composed of the Secretaries of Agriculture, State, Treasury, and Commerce; the Director of the Office of Management and Budget; and various presidential staff and economic advisers. This committee system preserves much of the line responsibility in the cabinet officer system and it has direct access to budget operation processes.

The success of such a committee with diverse interests is largely a function of the type of leadership that exists and the commitment to make it work. The danger with such a committee is that results frequently can be related directly to the strongest, most influential person on the committee, and such results may not be in the public interest. This concept would be substantially strengthened if this committee had its own staff and if its name were changed to the Food and Nutrition Policy Committee.

Creating a Food and Nutrition Council

Our institutionalized presidency has numerous staff offices which, in varying degrees, perform advisory and coordinating functions. For example, the Council of Economic Advisers (CEA) was created by Congress to provide the President with continuous assessment and advice on economic matters. It reports annually to Congress in the "Economic Report of the President."

A similar council could be created with responsibility for assembling, coordinating, and advising the President on domestic and international interdepartmental issues affecting food policy. Such a council should have sufficient staff to continuously review and assess the world food situation and policies affecting it. It could work with related agencies to develop an overall food and nutrition strategy with an understanding of how the pieces fit together. One responsibility of the council would include developing the role of domestic and international food research as a component of overall food and nutrition policy. The council should be required to make annual and interim reports to Congress, which are necessary for effective

communication and implementation. If such a food council were created, it might tend to erode the Secretary of Agriculture's influence on food and nutrition policy.

Creating a Permanent Joint Commission on Food and Nutrition Policy

Temporary joint executive-congressional committees have been used extensively to perform periodic studies of food policies. Recent examples include the National Commission on Food Marketing and the Food and Fiber Commission. The problem with which we are dealing is more permanent in nature. It could be addressed by establishing a permanent commission on food and nutrition policy. The advantage of such a commission would be its ability to serve the needs of both the executive and legislative branches. The principal question lies in its workability on a permanent basis, particularly when different political parties hold congressional majority and hold the office of president.

Expanding the Role of the Office of Science and Technology Policy

The Office of Science and Technology Policy is the focal point for research policy in the Executive Office of the President. OSTP should play a central role in developing a food and nutrition research capability and strategy that is consistent with overall science policy. It is unfitting, however, that OSTP be charged with performing broader food strategy assessments and with formulation functions.

* * * * *

The Department of Agriculture should be the lead agency in the development of a food and nutrition strategy within the federal government. Research policy is a vital component of this overall strategy. USDA's role as a leader in food nutrition strategy should be strengthened. This could be accomplished by: (1) reestablishing within USDA a food policy assessment and analysis group reporting at the secretarial level, (2) establishing an assistant secretary whose sole responsibility would be agricultural research and education (details follow in a later section), and (3) establishing as a matter of policy the broad role of the Department of Agriculture as a lead agency in food and nutrition policy decisions.

Food and nutrition policy decisions that have major effects on the United States and the world will continue to be made in other departments and agencies including NSF, HEW, the State Department, the Treasury Department, the Commerce Department, CEA, OSTP, the Energy Research and Development Administration (ERDA), the Defense Department, the Labor Department, the Transportation Department, and agencies of the Executive Office of the President. As a result, the problem of developing a consistent, coherent food and nutrition policy will remain even if the recommended changes in USDA are made.

The two attractive alternatives for dealing with the problem of overall development and coordination of a food and nutrition strategy and policy are the Food and Nutrition Policy Committee (now known as the Agricultural Policy Committee) chaired by the Secretary of Agriculture and the Food and Nutrition Council. A particular president may prefer one over the other for equally valid reasons. In either case, the committee or council should be charged with the development and coordination of food and nutrition strategy, policies, and programs across government agencies. The activities of the committee or council should be structured along major policy or problem areas with related agencies involved as working subgroups. Subgroups would be concerned with research, foreign economic development, food aid, import and export policy, environmental policy, and domestic agricultural policies. All of these policies directly affect this nation's ability to contribute to a long-term solution of the problems of food supply and demand.

The food committee or council research subgroup would be responsible for coordinating food and nutrition research policy among government agencies. As in the case of food and nutrition policy, USDA would be a lead agency in food and nutrition research.

This recommended machinery for a food research strategy must perform within the overall framework of federal science policy. OSTP assists in determining and articulating that policy, but it cannot function effectively unless it works with the science leadership within the government. For this reason, we suggest that proper liaison and representation be established in OSTP for food and nutrition research. We recommend that efforts be made to have one of the associate directors of OSTP trained in the areas of agricultural, food, or nutrition research; or familiar with the field; or at least assigned the responsibility of representing agricultural, food, and nutrition research issues in OSTP's deliberations. This individual should call together committees of leading scientists and research administrators to evaluate the research

programs of government departments, universities, private research firms, and industry. And he or she should have enough knowledge and clout to pull together effectively representatives of different departments of government to develop recommendations on appropriate divisions of labor in research and development activities.

Obviously food policy cannot and should not solely determine policies in each of these areas. Yet food policy interrelationships must be recognized and considered in making decisions if we are really concerned about solving food supply problems. The framework for explicit recognition and consideration of an overall food strategy must exist somewhere in the federal government to serve the needs of Congress and the executive branch. The process of evaluation must be continuous as economic, scientific, and even political considerations and problems evolve.

Research Objectives and the Decision-making Process

The process by which research decisions are made directly affects the ultimate research product. We need an efficient research process with a minimum of conflicts, a balance of scientific and policy input, and an allocation of responsibility according to the comparative advantages of each institution that performs research.

Reports evaluating the food research system take different perspectives on improving the research planning decision process. The Pound Report (NRC 1972), for example, suggests a need for greater involvement of individual scientists in the research decision process, and administrative leadership that is more sensitive to the needs of science. It also is critical of the direction Congress has given research by earmarking research funds for particular problem areas.

Improving the process by which food research decisions are made must recognize that institutions, both within and outside government, have a key role in decisions in food research which range from policy decisions to funding, program, and project decisions.

The research decision process has different levels. It begins at the highest levels of federal and state government with the establishment of a <u>policy</u> toward research and related <u>funding</u> decisions. Each agency charged with carrying out research has a <u>mission</u>. <u>Goals</u> are established consistent with the mission. <u>Objectives</u> for meeting goals are established. <u>Programs</u> of research are developed to meet objectives. <u>Projects</u>

are developed.

The problem is to determine appropriate divisions of labor in decision making for different decisions at different levels. What type of policy guidance should be provided? Who should provide it? What resources should be provided? What specific research should be done? Who should do it? How should it be done?

Different people are involved in making different types of decisions. Policy decisions are made largely by Congress, the President, state legislators, governors, and related institutions such as OSTP, the proposed food and nutrition committee or council, and the Secretary of Agriculture. Policy decisions involve interaction with interest groups, including industry, universities, producers, and consumers, and consideration of other aspects of domestic policy, budget limits, and, increasingly, foreign policy. These decisions are political decisions.

Policy direction and influence flow from the top downward in the research decision process. They are felt all the way down to the project and scientist level, but in lessening degrees. On the other hand, scientists have the comparative advantage in decisions at the project level. They are involved with research administrators in developing research programs.

The Pound Report points out that a problem exists in seeing that there is an appropriate mix of policy and scientific components at each decision level. This only can be done if there is consultation vertically through the various levels. Developing the appropriate environment for such vertical consultation is difficult. Every research administrator bears this responsibility when participating in the development of a research program as well as when participating in research policy meetings such as ARPAC.

At the national level ARPAC was established, at least in part, to help define research objectives for the USDA experiment station portion of the food research system. ARPAC members include all research and extension agency heads of USDA, research administrators from the universities and agricultural experiment stations, a representative of the Agricultural Research Institute, and a state extension service administrator. ARPAC was set up primarily as a communication, coordination, and planning device within the agricultural research system.

With more aggressive USDA and experiment station initiative and leadership through organizations such as ARPAC, overall research objectives could be readily specified. The framework and impetus for such increased initiative is provided for by certain provisions of the omnibus agricultural bill currently before Congress, the reestablishment of the Office of

Science and Technology Policy in the Executive Office of the President, and the machinery suggested in this report for developing an overall food and nutrition research strategy.

A vital link in the research organization and planning process is the establishment of a focal point within USDA for research activities. As currently organized, the Assistant Secretary having line authority for the Agricultural Research Service and Cooperative State Research Service also has authority over the Forest Service, Soil Conservation Service, Extension Service (ES), and National Agricultural Library (NAL). We recommend that an Assistant Secretary within USDA have exclusive line authority for ARS, CSRS, and NAL. Extension Service functions also should come under the new assistant secretary since its activities are an essential link in applying research results. The new assistant secretary should be a highly qualified research administrator who is familiar with the food research system and who has the respect of the scientific community. He or she would have access to such advisory groups as were necessary to carry out his or her functions and would be in a lead position with regard to interagency food research policy and coordination activities. Many of these basic requirements are formalized in the omnibus agricultural bill.

Research Support

Over the years state, federal, and private sources have invested substantially in food research. The technology resulting from this research, including mechanization, hybridization, fertilization, and pest and weed control has been responsible for most of our production increases in this century. In recent years, however, the public's willingness to provide real increases in research expenditures has come into question. The number of scientific personnel devoted to food research essentially has been held constant while the urgency of food supply problems has increased. In the meantime, a 1975 study by the National Academy of Sciences (NRC 1975a) has concluded that the rate of increase in the productivity of U.S. agriculture appears to be tapering off.

In the future, increases in food production will be constrained by the following factors: (1) a general slippage in research capacity over the past 10 years largely due to inflation; (2) constantly higher dollar costs in researching increasingly complex problems; (3) new and greater responsibilities to maintain and improve the environment; (4) increasing demand to

ensure food safety; (5) requirements that we look more closely at the nutritional value of new and existing food products; (6) increasingly regressive pressures placed on high yielding plants and animals by the environment, insects, and disease; (7) new technology demands caused by high energy prices, use of marginal lands, consumer demands, and the ability to use certain existing technology; (8) persistent and formidable yield barriers; and (9) erosion of technology reserves. Reversing current trends and overcoming significant roadblocks to increased productivity will require an increased level, concentration, and continuity of research support.

We urge substantially increased food and nutrition research support in terms of increased base support of existing federal funding under the Hatch Act to land-grant colleges and USDA in-house research programs including ARS and ERS, and a substantially expanded competitive grants program. We recommend that federal support for USDA food and nutrition research be immediately increased 20 percent ($120 million) over present levels in the first year and cumulatively increased at the rate of 10 percent per year in real terms for five years. These increases would be divided equally between USDA in-house research and Hatch Act formula allocations and a new competitive grants program. Over a five-year period this increased federal funding will raise USDA research support from the current level of $560 million to nearly $1 billion in real terms from the present base. Such new funds should be available for use to support <u>both</u> high priority domestic and international research. As a result of this expanded international scope and funding, USDA will become a global leader in food and nutrition research. In addition, federal matching funds should be provided at a level of $40 million per year for five years for the construction of new food and nutrition research facilities at agricultural experiment stations.

Base Support

The trend toward constant or declining real food and nutrition research appropriation at the federal level must be reversed. This is particularly a problem for USDA and the related land-grant university system. USDA budgets have not kept pace with either inflation or costs brought on by the increased complexity of research. The universities' problems have been compounded by tight state budgets. Increased student enrollments have drained away research talent, funds, and space.

We must replenish resources that have been drained away both in USDA and our universities. This requires a substantial initial injection of new funds with cumulative sustained increases over a period of at least five years. The proposed increases in base funding would provide about $56 million in real terms the first year and cumulative increases of 5 percent in real terms thereafter for five years. Emphasis in the use of these monies should be placed on high priority research as identified in this study and on training new scientists needed to carry out an accelerated food research program. Increased funding should be available for use in both domestic and international programs in such high priority areas. While a substantial portion of the added funds should be used for purposes with direct international implications, the advantages of flexibility in the use of these funds suggest that they not be earmarked for this purpose. In fact, as suggested in the Pound Report (NRC 1972), all existing intentions for using the funds should be carefully reviewed to allow flexibility in allocating funds to the areas of greatest need.

Competitive Grants

A substantial increase in mission-oriented competitive grants is needed. This represents a radical departure from the USDA tradition of distributing funds to universities on a formula basis. Since the 1960s, USDA extramural grants by ARS have decreased from $10 million to $2 million. Similar declines have occurred in CSRS competitive grants.

This proposal would establish a competitive grants program in USDA emphasizing high priority basic discliplinary and multidisciplinary research. The initial funding would be approximately $50 million (10 percent of the current USDA agricultural research budget). Cumulative real increases of 5 percent of the agricultural research budget are recommended for four additional years. At the end of the five-year period competitive grants would total nearly $190 million annually in real terms.

This competitive grants program should be viewed by USDA, the universities, and the scientific community as the focal point for highest priority food and nutrition research. Grants should be tailored to the size, complexity, and term of research, from basic to applied, needed for maximum productivity. To establish this image and maintain overall research quality the following administrative recommendations are made:

-- Grants should be administered by a new agency within USDA operating under the Assistant Secretary for Research and Education.
-- The agency should have a highly qualified, broad-based, predominantly non-USDA advisory committee of scientists inside or outside of the food and nutrition research community.
-- Priority macroallocations for the distribution of grants should be made after consultation with other major food and nutrition research granting agencies such as NSF, NIH, ERDA, and AID as well as with leading scientists.
-- Specific projects should be selected on the basis of a rigorous peer review system. Both large multiyear institutional grants and small individual investigator multiyear grants should be made available. Large grants should emphasize, at least initially, complex team research of an interdisciplinary, multidisciplinary, interdepartmental, or even interinstitutional nature. Many of the highest priority projects identified in this study are of this nature.
-- The program should emphasize capable management of priority research, accountability, and productivity in continuing support for particular projects.
-- Grants should be open to all researchers and research establishments whether they be land-grant universities or those other than land-grant, private industry, or private research firms.
-- Grants should be open to research having either a domestic or international thrust according to the priorities and the merits of particular proposals.
-- The granting agency should have the flexibility to make institutional grants of a longer term nature to support the development of international research components in the United States. Precedent for this exists in the NIH granting system.
-- Grants should include provision for support of predoctoral research associates as an aid to attracting and training new scientists.

Research Facilities

Certain research problems could be so large and complex that they cannot be dealt with by our present research institutions. In such instances new, mission-oriented research centers should be established in proximity to existing leading research institutions to overcome barriers to increased productivity. Where such research centers are considered necessary we recommend that they be established by a coordinating

facility matching fund and longer term competitive grant or by ARS with appropriated increases in funds.

Research Talent

The talents of the scientists we now have could be used better if they were given more research support, and scientists could be attracted from related disciplines if ample resources were available. But the bulk of scientists must be those newly trained who have been attracted to food and nutrition research. To attract such scientists we need: (1) long-term support, (2) adequate personnel training support in research grants, and (3) the conviction that food and nutrition research having both domestic and international dimensions is important. Food and nutrition research must once again be able to compete for research talent that has been attracted to other areas that offer greater financial and nonfinancial rewards. This applies to domestic and international programs. For years the United States has trained international students, but U.S. scientists have not had equal opportunities to get international experience. This has been particularly true in the case of predoctoral and postdoctoral research assistants and young scientists.

The United States is continuously in need of trained personnel who have actual knowledge of activities in all areas beyond the continental boundaries. This need for an understanding of other people--their objectives, problems, and approaches to their solutions--will grow in importance in the years ahead as the world population grows and nations become more interdependent. Our understanding of other peoples' situations will in large measure determine how effectively our food and nutrition research programs can attack present and future food and nutrition problems.

It has been characteristic of food research that the greatest rewards result from disciplinary, domestic-oriented research. Researchers who participate in international programs, which are often interdisciplinary, should be assured of comparable rewards. Many of our scientific disciplinary associations could benefit from becoming more involved in international programs. It may be necessary for a foundation to develop programs to encourage this.

More concrete steps can be taken to remedy the rewards problem in the international area by: (1) establishing an award for excellence in international research as part of award programs sponsored by U.S. professional societies; (2) establishing within a

foundation or the National Academy of Sciences a focal point for fostering an international dimension in the disciplinary societies; and (3) establishing new international journals in which international research results would be published.

Coordination and Division of Labor

Those who fund food and nutrition research have a mission associated with their support, such as advancing science, increasing food production, solving agricultural problems, fulfilling rural needs, reducing diseases through improving nutrition, or increasing profit. Similarly, those who perform research have a comparative advantage in certain lines of research. Often these missions and roles overlap. The duplication should be eliminated.

U.S. Department of Agriculture and the National Science Foundation

There may be a temptation to switch NSF and NIH support of food and nutrition research to USDA because of its increased competitive grants funding. This would be a mistake. NSF's strength lies in its involvement with the more basic disciplinary research. Over the years NSF has developed a working relationship with leading scientists who frequently have been outside the mainstream of USDA research funding. The competitive grants program is intended to strengthen basic research supported by USDA, but the context of the USDA program will be more mission or goal oriented--to develop more productive plant and animal systems, for example. Both programs are needed.

Similar analogies can be made about the NIH program, which is distinguishable from USDA's nutrition program as it has a disease-related thrust and is more basic research oriented.

Agricultural Experiment Stations

The land-grant university system should seriously consider optimum patterns of specialization among the agricultural experiment stations. Not every state can maintain a land-grant university with expertise in all food research disciplines. In some instances, it would be more productive for universities to specialize in certain disciplines and to develop cooperative arrangements with other states to exchange scientific knowledge and talent in related areas. This

specialization is already developing in certain food research disciplines in areas such as the northeastern United States. In this area it has developed as a matter of necessity, resulting from the economics of specialization, tight budgets, and the inability to attract highly qualified research talent in each discipline in each state. Specifics of operational patterns of specialization are too complex to be developed in a study of this type. ARPAC should take the lead in designing and implementing increased interstate specialization and exchange of talent.

Progress has been made through the market system; however, more is needed. The Illinois experiment station has become a leader in soybean research and the Texas experiment station in sorghum research. The competitive grants program will help, but more direct initiatives are possible through agreements among states and regions. There is a danger in drawing definitive lines of specialization that subsequently become barriers to free scientific endeavor and interchange. Competition in the research community is as important as it is in the business community. No university, government agency, or private research entity has a monopoly on scientific talent, nor should it have. A balance must be struck. Having too many research organizations or too few inflexible organizations with virtual monopoly power are equally undesirable.

Regional Planning and Joint Review

Improved funding, coordination, and planning are possible among states through regional planning councils and joint review of research by ARS, CSRS, ERS, and the new competitive grants agency. Regional planning and joint review not only improve coordination but could spawn high priority team research projects among states that would be eligible for competitive grant support. In addition, regional research funding needs serious review with an eye toward dispersing funds on a competitive basis and thereby tying funds directly into the budget process. CSRS should take the leadership in accomplishing such a review and making appropriate changes.

Agency for International Development

AID's prime responsibility in international research should be that of establishing research capability in the developing countries. USDA should be responsible for support for domestic and international

research needs in the U.S. food and nutrition research system.

Communication and Information Systems

Effective research communication systems are vital to the institutional recommendations set forth in this report. Good communication systems minimize duplication, increase research additivity, facilitate scientific exploration, and stimulate thought processes through scientific interchange. Study Team 8's report on information systems offers recommendations that complement our own.

A FINAL WORD OF CAUTION

Many of our recommendations could potentially bog down the research decision process in so much bureaucracy that it not only would become self-defeating, but would make the system less responsive to needs. In many respects the success of the agricultural experiment station system in contributing to the productivity of American agriculture has been a result of its grass roots orientation and support. Reorienting the research system to obtain a greater international thrust and to overcome major roadblocks to increased productivity undoubtedly will require greater direction. Yet the system that is developed should be designed to maintain the grass roots scientific initiative in the present system.

Report of Subgroup B, Study Team 14

GLOBAL AGRICULTURAL RESEARCH ORGANIZATION

INTRODUCTION[1]

> ...the first step in an agricultural development program should be initiation of a substantial, highly integrated research program, directly connected to farm problems at one end and to basic research and foreign efforts at the other (Mellor 1968:364).

There is, for the first time in history, an emerging global agricultural research system concerned with increasing food production for domestic use in the developing countries. This system, which is far from fully organized and established, is composed of five major components: (1) research organizations in the developing countries, (2) regional or intercountry research programs in the developing countries, (3) international agricultural research institutes principally located in the developing countries, (4) research organizations in the high-income countries, and (5) cross-country research networks generally concerned with specific commodities.

This report describes this emerging system, notes its major strengths and weaknesses, outlines improvements that might be made, discusses past and current contributions by the United States, and reviews ways in which the United States might provide more substantial contributions in the future.

THE CURRENT GLOBAL AGRICULTURAL RESEARCH ORGANIZATION

The current global agricultural research system is extremely diverse. No one model or description can easily represent all of the components and countless institutional structures. We will only outline some of the general characteristics, note the main institutional components, and show how they sometimes intertwine in research networks.

General Characteristics

Despite their diversity, most agricultural research organizations share some of the same functions and components. These will be noted in this section, along with an indication of the magnitude of funding provided to the main elements of the system.

Functions

The chief aim of any research organization, as the Food and Agriculture Organization of the United Nations (FAO 1968:101) stated nearly 10 years ago, "...should be to ensure that the main problems of agricultural development are identified and defined, and then resolved as quickly and cheaply as possible." Moreover, research findings should be capable of being translated into technologies that can be applied to different farm sizes, particularly by the smaller and/or poorer farmers.

Carrying out this task involves a series of formal and informal steps. Among these are: (1) problem identification; (2) a plan of research; (3) scientific research in the natural, physical, or social sciences; (4) mission-oriented, problem-solving research, based on diagnostic studies, which has implications for action; (5) actual testing of tentative solutions to real problems at the conceptual, laboratory, and field levels; and (6) dissemination of field test results, implementation of their use, and continuous evaluation of performance.

Viewed a little differently, it might be said that three kinds of effort are required: (1) a constant search for scientific breakthroughs that push back the biological or physical limits to improvements in technology; (2) continuous development of improved technologies (including maintenance research) within the limits of available scientific knowledge; and (3) realization of the full potential of technologies actually used in or available to each country, including research to adapt the appropriate technology to local needs (NRC 1975d:13).

Numerous categorizations of the research effort are possible. But in order to carry them out, certain common institutional components are usually thought necessary.

Key Institutional Components

Technology is generated in both informal and formal settings. Farmers, local blacksmith shops, and

backyard inventors are the sources of many forms of technology, especially mechanical.[2] More scientifically-based technologies, particularly those that are biological and chemical, generally flow from more formalized research organizations, both private and public.

Within the formal public research system, experience suggests (Moseman 1970:55-56) that three organizational components are desirable at the national level:

-- a strong nationwide system including such regional and local research centers as may be required for diversity of the agricultural environments;
-- the association of teaching and training programs at selected research centers with the research and educational linkage designed to furnish the training necessary for specific agricultural specialists;
-- a close connection between the research centers and extension and other activities responsible for helping farmers to use new technology.

The same components are also desirable at the regional and international levels, although perhaps to varying degrees. The desirability of the second and third components has not always been recognized in the United States (Waggoner 1976).[3]

Funding of Formal Agricultural Research

The importance of different forms of formal research may be judged from data for 1971 and 1974 which have recently been compiled by Boyce and Evenson (1975:1-49) for groups of countries of various income levels.[4] They are summarized in three tables that follow.

Table 1 indicates that about $3.7 billion was spent globally on agricultural research in 1974. There was a high concentration of agricultural research in countries with higher income levels. In both 1971 and 1974, more than half of the expenditures were in the highest income group and over 80 percent were in the top two income groups. The other three income groups represented less than 20 percent of the total expenditures.

Table 2 normalizes the expenditures in terms of the value of agricultural production. Nations with the highest income spent three times more in terms of total funds. When the comparison was limited to public funding (deducting private research), the difference narrowed.

Table 1. Annual total world expenditure on agricultural research by income group, 1971 and 1974*

Group	Per capita income (U.S. dollars)	1971 (millions of 1971 U.S. dollars [percent])		1974	
I	>1,750	1,768	(51.9)	1,900	(51.6)
II	1,001-1,750	1,090	(32.0)	1,155	(31.4)
III	401-1,000	250	(7.3)	272	(7.4)
IV	150-400	181	(5.3)	232	(6.3)
V	<150	118	(3.5)	123	(3.3)
TOTAL		3,407	(100.0)	3,682	(100.0)

*Excludes People's Republic of China.

Source: Data provided by R. E. Evenson, Agricultural Development Council, Los Banos, Laguna, Philippines, 1976.

Table 2. Relation of world expenditures on agricultural research to the value of agricultural product, by income group

Group	Per capita income (U.S. dollars)	Percentage of total and public research expenditures to value of agricultural product* 1971 total	(public)**	1974 total	(public)**
I	> 1,750	2.48	(1.44)	2.55	(1.48)
II	1,001-1,750	2.34	(1.76)	2.34	(1.83)
III	401-1,000	1.13	(0.86)	1.16	(0.92)
IV	150-400	0.84	(0.71)	1.01	(0.84)
V	< 150	0.70	(0.65)	0.67	(0.62)

*Total expenditures include: (1) national public agriculture, (2) national public agriculture related, (3) industry, and (4) international. Excludes People's Republic of China.
**National public agriculture (national public agriculture related is not included).

Source: Boyce and Evenson (1975). Additional data provided by Evenson for public proportion for Group V.

Table 3 breaks the total expenditures down into three categories: national public, industry, and international public. The national public figure is broken down into two categories: agriculture (traditional agricultural research stations and programs) and agriculture related (related work carried out in more general research organizations). The lesser role of national public research in the highest income group was due to the greater role of industrial research in the highest income group (particularly in North America and Oceania). Within the national public category, the role of agriculture-related research activities was greater in the higher income countries (particularly Western Europe and Asia) and considerably less in the lower income countries. The international centers were an emerging category for the lower income countries, but still only a small portion of the total research expenditures for those areas.

Clearly, on the basis of funding, public agricultural research within traditional institutions is the primary source of agricultural research in the poorer nations.

Research Investment by Commodity

Public research investment may be examined in commodity as well as income terms. Preliminary estimates of national expenditure by commodity have been made by Evenson (Table 4). They suggest that in the developing countries the largest amounts have been spent on cotton, followed by cattle, wheat, rice, and sugar cane. In terms of research investment as proportion of product value, the largest investment was for cotton, followed by cattle and several grains. The smallest expenditures were for deepwater rice, coconuts, cassava, and sweet potatoes. The international centers worked on 13 of the 20 leading commodities. A subsequent tabulation of total expenditures reveals rather sharp regional variations in expenditures within commodity groups, but notes the consistently low position of root crops, pulses, oil crops (except cotton), and fruits (R. Evenson 1976, unpublished data, World Food and Nutrition Study).

A somewhat different approach by Cummings (1976:4-7, 80-81) has attempted to classify research done on major food crops of economic importance by the relative adequacy and inadequacy of research in four major developing country geographic regions. Adequacy was judged in terms of crop technology, yield levels, and the capability of institutional services. In most cases the level of research was rated as seriously to critically inadequate. The major exceptions, rating

Table 3. Percent of total world expenditures on agricultural research by sector and by income group, 1971

Group	Per capita income (U.S. dollars)	National public		Industry	International public	Total
		Agriculture	Agriculture related			
I	>1,750	51.3	24.7	24.0		100
II	1,001-1,750	66.2	26.8	7.0		100
III	401-1,000	70.9	18.9	7.4	2.8	100
IV	150-400	86.1	8.1	2.8	3.0	100
V	<150	80.7	9.5	5.2	4.6	100

Source: Boyce and Evenson (1975). Additional data provided by Evenson.

Table 4. Preliminary estimates of international and national research investment by major commodities (1971 constant dollars)

Commodity in order of value of production	Value of commodity in all developing nations (1972) ($ billions)	Estimated research investment: International centers (1976)[a] ($ millions)	National centers (1971)[b] ($ millions)	National investment as proportion of product value (percent)
1. Rice	Over 13	7.9	34.7	0.26[d]
2. Wheat	5 to 6	3.8	35.9	0.65
3. Sugarcane	5 to 6	none	30.2	0.50
4. Cassava	5 to 6	1.9	4.0	0.07
5. Cattle	5 to 6	7.9	54.8	0.88
6. Maize	3 to 4	4.1	29.6	0.75
7. Coconuts	3 to 4	none	2.0	0.06
8. Sweet potatoes	3 to 4	0.6[c]	3.4	0.09
9. Coffee	2	none	8.5	0.40
10. Grapes	2	none	6.9	0.35
11. Sorghum	1+1/2	1.2	12.2	0.77
12. Barley	1-1/2	0.5	9.4	0.62
13. Groundnuts	1-1/2	0.5	4.0	0.13
14. Cotton	1-1/2	none	60.1	3.50
15. Dry beans	1-1/2	1.5	4.0	0.25
16. Chick peas	1-1/2	1.2	3.0	0.18
17. Chillies and spices	1-1/2	none	4.0	0.25
18. Olives	1-1/2	none	5.0	0.33
19. Grain legumes[e]	1	1.6	(25.3)	(2.00)
20. Potatoes (white)	1	2.0[c]	8.2	0.68

[a]Centers and programs sponsored by the Consultative Group on International Agricultural Research.

[b]Rough estimate derived by allocating total research expenditures by country according to the proportion of standardized publications. Standardized publications are converted into constant scientist-years.

[c]Additional funds also were spent on these crops at the Asian Vegetable and Research Development Center.

[d]The proportion varied sharply by type of rice: shallow water, .40; upland rainfed, .16; intermediate, .16; and deep water, .05. The international center investment was principally in the first two types.

[e]Pulses; excludes soybeans. The estimate of national research expenditure appears high and is not consistent with other estimates.

Source: Summarized from: Evenson, R. E. (1975) Notes on Agricultural Research in the Developing Nations. Unpublished, Agricultural Development Council, New York, N. Y., pages 10-11, table 3. Evenson wishes to emphasize that the data are only crude approximations; he would like to recalculate them (letter, June 7, 1976).

adequate or inadequate, were irrigated wheat, rice, and corn (and even for these crops there were some regional exceptions). Sorghum, millet, and food legumes (pulses) ranked particularly low.

Once one moves beyond the identification of gross imbalances, however, the fine tuning of resource allocation among commodities may become a complex matter, involving national goals and a wide range of technical, social, and economic factors.[5]

Chief Institutional Components

There are many components in the global agricultural research system, both within individual nations and at the regional and international levels. The major components are outlined in Figure 2. A more comprehensive framework of the flow of resources is presented in Figure 3. Most of the linkages in Figure 3 are vertical, but horizontal linkages between countries may be expected to develop.

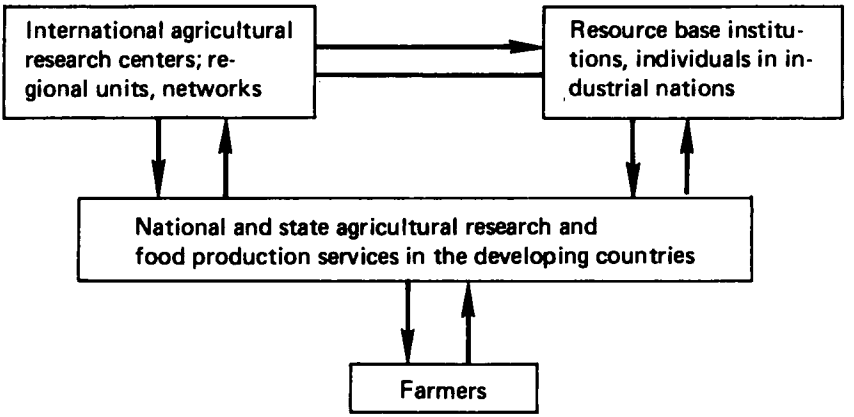
Within the Developing Countries

As Table 3 indicates, most of the funding for agricultural research in the developing countries is at the public level and is for agricultural rather than agriculturally related groups. In most cases, public agricultural research is carried out by or under the auspices of the ministry or department of agriculture. In certain cases, research on some crops, generally for export, has been and is done by specialized and largely autonomous specialized research institutes. Only a limited amount of research normally has been done at the colleges of agriculture.

The export commodity research institutes have long been found in former colonies. Moseman (1970:57-59) notes that this was particularly true of the former British colonies:

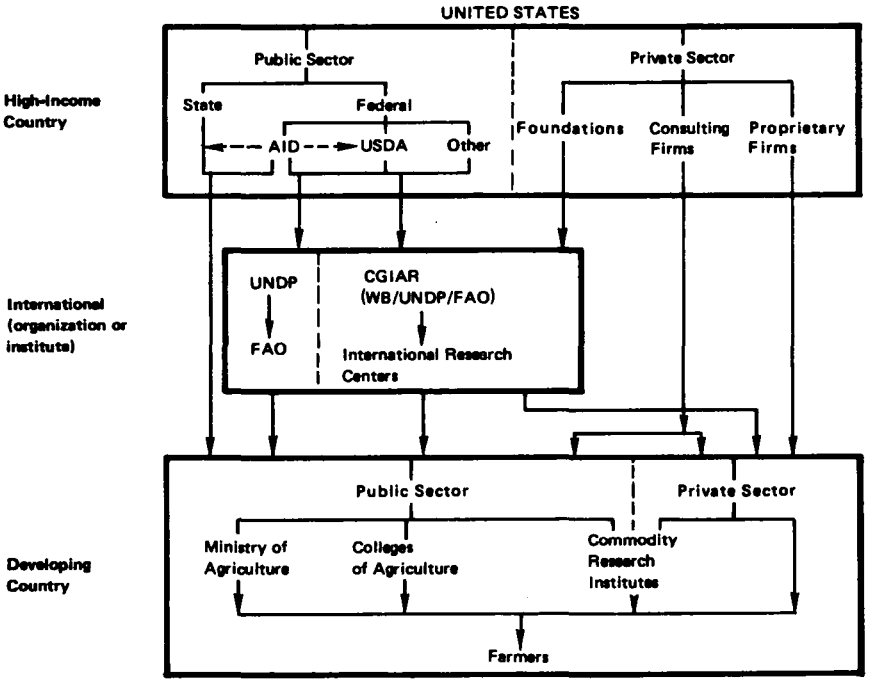
> This pattern prevailed in pre-independent India and Pakistan with their central research institutes for jute, cotton, sugarcane, and other crops, and in Africa where research institutes were set up to serve the broader regional areas of West Africa concerned with rubber, cocoa, and oil palm.

Due to this commodity orientation, as Moseman puts it, "only limited attention has been given to the broad-scale adaptive research essential for agricultural diversification and modernization (Moseman



Source: Adapted from a diagram prepared by Lowell Hardin.

FIGURE 2 Generalized structure of international agricultural research for developing nations.



Note: Dotted lines indicate flow of funding.

FIGURE 3 Detailed structure of international agricultural research for developing nations.

1970:57)."[5] Over time, the single crop focus has lessened somewhat. More emphasis has been given to a range of food commodities. And in some cases increased attention has been given to cropping and farming systems.

As more general agricultural research on domestic food commodities began to receive attention, it was generally taken on by ministries or departments of agriculture and supported by public funds. Often, however, the research was carried out by several different agencies within each ministry or department. Mosher notes that as of 1970:

> ...research is conducted by 10 different bureaus in Ceylon, by 15 separate institutes managed by 5 different directorates within the Ministry of Agriculture in Indonesia, and by 9 different agencies within the Department of Agriculture and Natural Resources of the Philippines (Mosher 1971).

Some attempts have been made to regroup and coordinate these "multiform" research programs; these will be discussed later.

While the above developments were taking place, agricultural colleges and universities were established in increasing numbers. In many cases, they have more personnel with postgraduate research training than do the research institutes in their respective countries (Mosher 1971:260). Yet the colleges are usually under the administration of the ministry or department of education;[6] they have few if any funds for agricultural research.

Bangladesh is a case in point. AID helped the Ministry of Education establish the Bangladesh Agricultural University (BAU). It is a magnificent facility with more than 70 Ph.D.s on its staff and about 150 graduate students. BAU has a 600-acre field station and associated laboratories. Yet in fiscal year 1973, only about 5 percent of the university's budget was allocated for research, mainly in support of master of science theses. The Bangladesh government has made a policy decision that agricultural research should be firmly in the Ministry of Agriculture, while the Ministry of Education runs BAU as an educational institution.[7]

There is, to our knowledge, at least one significant exception to this pattern. Ahmadu Bello University was established in 1962 in northern Nigeria next to the long-established Institute of Agricultural Research. The institute was made an integral part of the university. Moreover, the institute contains a sizable extension-research unit and provides training

for extension workers in northern Nigeria. The Institute has generally been considered quite successful and may indeed be a prototype for other developing nations.

A different organizational pattern currently being utilized in Brazil is the public corporation. The Brazilian Public Corporation for Agricultural Research (EMBRAPA) has replaced the National Department of Agricultural Research in the Ministry of Agriculture in 1974. Emphasis is placed on applied research (Pastore and Alves 1977:394-403).

Regional Organizations

Regional agricultural research activities take many forms. Compared with national programs, they may work on problems of a more complex or at least of a multinational nature. Still, they are likely to retain an operational-technological orientation and do not get far into purely scientific research. Where the countries involved are small, regional programs may partly replace national programs and thus will have a relatively operational orientation.

Africa. The French government has sponsored an extensive research program in its former colonies in Africa through two organizations: the Office de la Recherche Scientifique et Technique d'Outre-Mer (ORSTOM), and the Groupement d'Etudes et de Recherches Pour la Developpement de l'Agronomie Tropical (GERDAT) (see Appendix A). ORSTOM emphasizes basic research in several areas, one of which is agriculture; it has central stations in three African nations and 20 research centers (NRC 1974:172). GERDAT is wholly oriented to applied research in agriculture; it has eight commodity research institutes with headquarters in France and a network of about 50 stations, principally in Africa. Rice research, for example, is carried out by the Institut de Recherches Agronomiques Tropicals et des Cultures Vivrieres (IRAT); this group has two regional centers and several secondary stations. Rice research in West Africa also is coordinated by the West African Rice Development Association, a group that is partially sponsored by the Consultative Group on International Agricultural Research.

Regional research in three east African nations (Kenya, Uganda, and Tanzania), partly funded by the United Kingdom, is carried out by the East African Agriculture and Forestry Research Organization (EAAFRO) and the East African Veterinary Research Organization (EAVRO). EAAFRO is responsible for undertaking research on problems that: (1) are common to at least

two of the three countries and that can be investigated most efficiently and economically by a central research organization; (2) require longer term investigations or more intensive study than can be undertaken by national departments; and (3) require highly specialized and expensive equipment or the services of similar specialists. Hence EAAFRO is not concerned with purely local problems unless specifically invited to investigate them by a member government ("Agricultural Research--Tanzania," Appendix B, unpublished report, AID, 1975). The Scientific, Technical and Research Commission of the Organization of African Unity (OAU/STRC) also has taken on two research programs; one of these projects is supported by AID (NRC 1974:48-51, 169-173).

FAO, under United Nations Development Programme (UNDP) funding, established a one-person regional wheat and barley program in the Near East and North Africa in 1962. The project proved quite successful and by 1975 had been expanded to a regional field food crop project with a manager and seven specialists. It includes 22 countries (FAO 1975a:1,4).

Latin America. The Inter-American Institute for Agricultural Sciences (IICA), established with central headquarters at Turrialba, Costa Rica in 1943, was among the first research centers organized to assist countries of a region with general agricultural development. It was to concentrate on tropical and subtropical agriculture in Latin America. The initial facilities and equipment were provided by the U.S. government. Over the years, IICA diversified into other research activities and in 1973 Turrialba was made an autonomous institution. It was renamed the Tropical Agricultural Research and Training Center (Centro Agronomico Tropical de Investigacion y Ensenanza, CATIE). CATIE was subsequently made an Associate Program of IICA and receives substantial funding from IICA. It now concentrates primarily on Central America and the Caribbean. Emphasis is placed on three areas: dairy and beef, food cropping systems, and forestry (Moseman 1970:90; J. Porter 1976, unpublished data, Agricultural History Branch, Economic Research Service, USDA; Inter-American Institute of Agricultural Sciences 1975:79-80).

Asia. In Asia, a Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) operates under the auspices of the Southeast Asian Ministers of Education Organization. It is located at the University of the Philippines and has recently sponsored several workshops on agricultural research management in Asia (SEARCA 1974, 1975, 1976). The East-West Center at the University of Hawaii also has several research activities that are regionally

oriented.

International Organizations

One of the most striking changes in global agricultural research organization in recent years has been the emergence of international agricultural research institutions or centers for food crops. These organizations stress interdisciplinary team approaches to practical problems. This movement was based on the Rockefeller Foundation's work with wheat and corn in Mexico in the early 1940s. The first international center was the International Rice Research Institute (IRRI) which was formally organized by the Ford and Rockefeller Foundations in 1960 and which was opened in 1962. It was followed by the establishment of an International Center for Corn and Wheat Improvement in Mexico in 1963; this group was subsequently reorganized to form the International Maize and Wheat Improvement Center (CIMMYT) in 1966.

These institutions were followed by two others, also established by the two foundations: the International Institute for Tropical Agriculture (IITA) in Nigeria, and the International Center for Tropical Agriculture (CIAT), Colombia. Both were initiated in 1967 but because of the civil war in Nigeria, IITA did not really get underway until 1969.

The financial burdens posed by the costs of these centers led to a series of meetings with prospective donors in Bellagio, Italy, which resulted in the establishment of the Consultative Group on International Agricultural Research in 1971. The United States, through the Agency for International Development, was a charter member. CGIAR was sponsored by the World Bank, UNDP, and FAO. Initially, 15 donor members provided funding of $20 million for 1972. In addition to the four centers already mentioned, two others were added: the International Potato Center (CIP) in Peru and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India.

In subsequent years, three other centers were added to the CGIAR family, two of which are at an advanced stage of development--the International Livestock Center for Africa (ILCA), Ethiopia, and the International Laboratory for Research on Animal Diseases (ILRAD), Kenya--and one of which is in the early stages--the International Centre for Agricultural Research in the Dry Areas (ICARDA) in Lebanon, Syria, and Iran. Two other programs also have been included: the West Africa Rice Development Association (WARDA), headquartered in Liberia (partial support), and the International Board for Plant Genetic Resources

(IBPGR), headquartered with FAO in Rome (CGIAR 1976a).

The CGIAR budget for these centers and programs has increased sharply through 1976 (Figure 4). Total funding in 1977 is estimated to be about $79 million. For 1976, there were 26 donors to CGIAR activities: three international organizations, one regional development bank, 18 nations, three American foundations, and one Canadian "foundation." Among the 18 nations are three developing countries: Nigeria, Iran, and Saudi Arabia. Nearly all the western high-income countries participate, but as yet no Communist nations have indicated an interest in joining.

CGIAR activities encompass most of the international agricultural research activity. Some activities not included are the Asian Vegetable Research and Development Center (AVRDC) in Taiwan, the International Fertilizer Development Center (IFDC) in Alabama, and the International Food Policy Research Institute (IFPRI) in Washington, D.C. The Agricultural Development Council also conducts and sponsors economic and social research, primarily in east and south Asia.

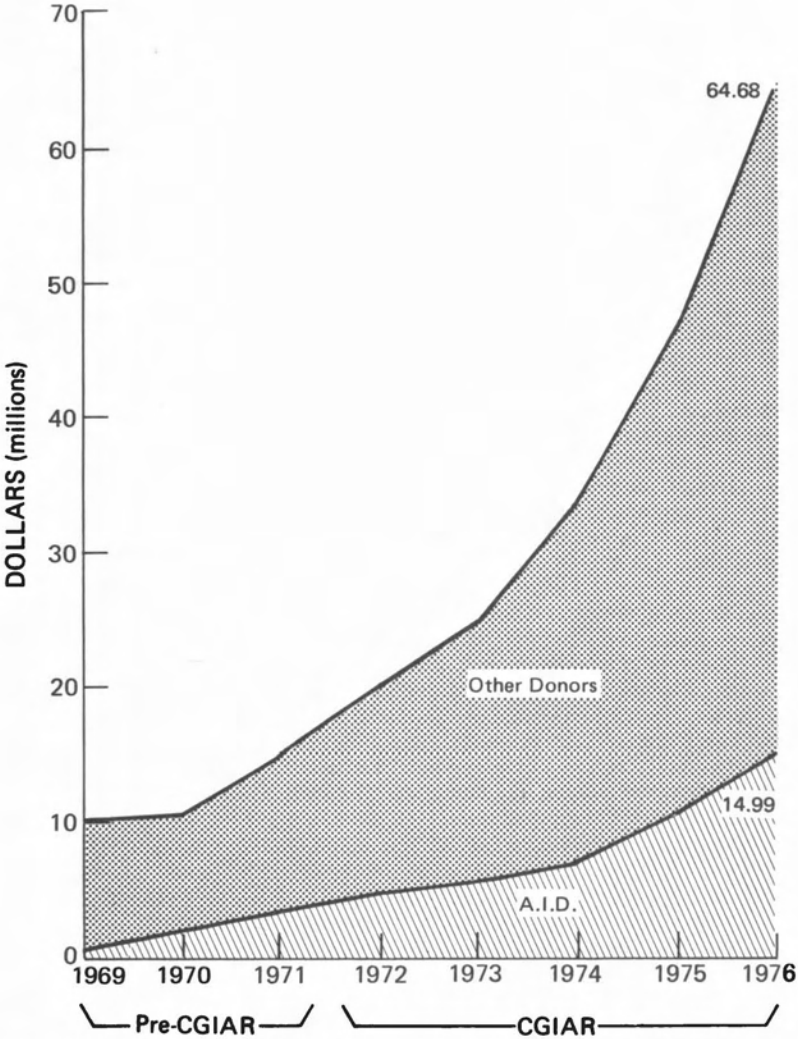
Most CGIAR and other activities are clearly international in scope while others are more regional. In some cases, one international center will act as a relay station for the products of another international center.

Food and nutrition research may at times be undertaken as part of the total program at many international scientific organizations. No attempt is made to discuss all such organizations, but one that has an important specific agricultural component is the International Institute for Applied Systems Analysis (IIASA) in Austria. This is a broad scientific unit concentrating on world models and sponsored by several national academies of sciences including those of the United States and U.S.S.R. The United States should continue to cooperate with IIASA in food and nutrition research.

Within High-income Countries

High-income countries have and can make significant technical contributions to agricultural research for the developing nations. For decades the high-income countries have provided agricultural scientists for the developing nations, either through loan of their own scientists or through training of students from developing countries. Many of their research findings have been applied in the developing nations.

For years the former colonial powers, especially the United Kingdom and France, were particularly active in this area. A tradition of foreign service in



*Excludes funding for international agricultural research outside CGIAR (such as the Asian Vegetable Research and Development Center or the International Fertilizer Development Center).

Source: Unpublished data, Agency for International Development, 1976.

FIGURE 4 Trends in funding for international research, Consultative Group for International Agricultural Research (CGIAR)*.

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agriculture was established (Masefield 1972). To some extent, research funding and facilities were provided by the colonial power for the developing country. It was reported in 1968, for instance, that in the United Kingdom a number of specialized organizations were maintained by the Ministry of Overseas Development: the Anti-Locust Research Centre, the Tropical Products Institute,[8] the Tropical Stored Products Centre, and the Tropical Pesticides Research Unit. In France, as noted previously, two organizations provide research assistance, ORSTOM and GERDAT. Both organizations also contract with French universities or private research organizations. Japan established a Tropical Agricultural Research Center in 1970 (see Appendix B).

The United States has not followed a similar pattern. (Details on U.S. contributions are provided in a later section.) Suffice it to say here that USDA did help establish several cooperative agricultural experiment stations or missions in Latin America (including Turrialba) before and during World War II. Following the war considerable training in agriculture was provided at American colleges and universities, but no special research institutions for developing country agriculture were established in the United States. During the 1960s and 1970s, however, numerous contracts were made with American colleges and universities for research work on matters relating to the agriculture of the developing countries, some for building institutions.[9] One exception to this contract pattern came in 1975 with the establishment of the International Fertilizer Development Center in Alabama in 1975.

Title XII of the Foreign Assistance Act of 1961, as amended, to be discussed in greater detail in a later section, is specifically devoted to agricultural research and the role that American research institutions might play. With its passage the United States appears to be more firmly in a position to carry out research for developing country needs.

Research Networks

The individual components of the global agricultural research system relating to agriculture in the developing countries have four major institutional units: developing countries, regional organizations, international institutes, and high-income countries.

Linkages are maintained among scientists and among institutions. These linkages may be informal or formal in nature. Informal contacts are those that scientists generally maintain among themselves. Many agricultural scientists have been to the same graduate schools in

the United States or Europe, and in most cases the total number of scientists is usually not great.

More formal networks may exist among scientists in a given scientific field[10] or among those working on a similar commodity or problem area within agriculture. The sorghum network is depicted in Figure 5. Networks also can be factor oriented or problem oriented, either in the technical or socioeconomic fields.

Even the more formal networks are seldom highly structured in terms of official organization. One or more institutions usually serve as a nerve center. Institutions attain that status by their central position, their excellence, and mobilized research power. Nerve centers provide scientific leadership, a systematic exchange of information, training and advisory services, or other coordinating or supporting services for the network. They often are located initially in a high-income country or international institute. For many problems, the best of the developing country research institutions could begin to play this role, at least on a local basis.[11]

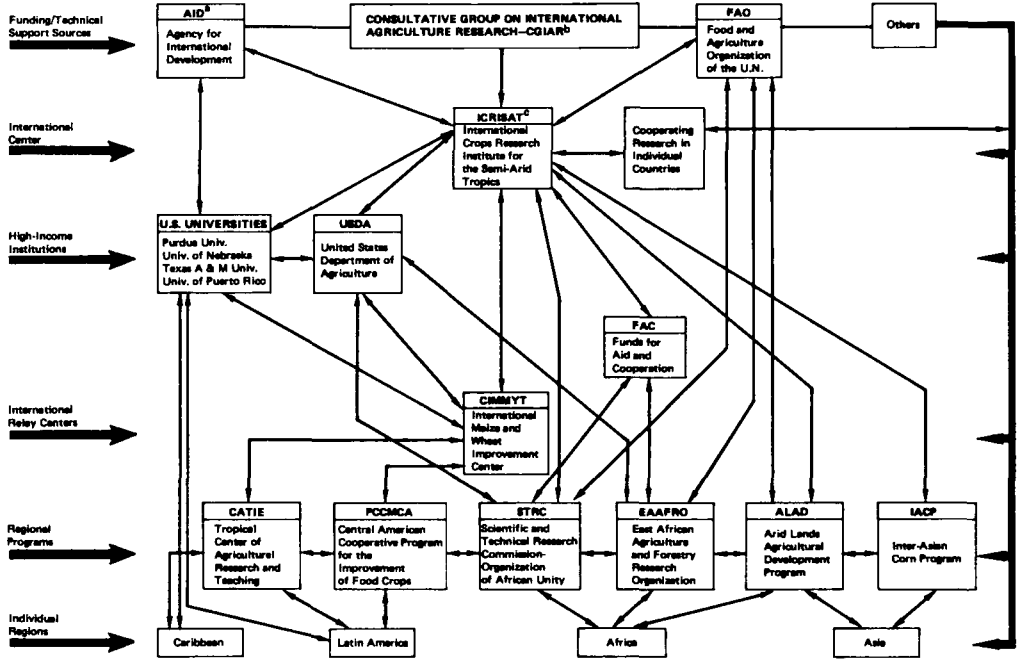
Research networks are based on the concept that national, regional, and international agricultural research programs are usually complementary or synergistic. The existence of a network can lead to a more efficient allocation of resources, both by reducing duplication and by providing an opportunity for an appropriate division of labor within and between echelons. This is particularly valuable for the developing countries.

Since research networks represent an extension of the informal network that tends to spring up among scientists, they are not difficult or expensive to establish or maintain. Networks often can exist without many of the usual bureaucratic trappings found in more traditional organizational structures, although they do require some type of nerve center.

Due to their nature, it is often difficult to demonstrate the existence of networks in other than diagrammatic form or to demonstrate their effectiveness since the results show up in the programs of the individual members. Still, research networks represent an important but somewhat nebulous link in the global agricultural research organization.

DEFICIENCIES IN THE PRESENT SYSTEM

While the global agricultural research system has developed substantially over the past decade, the list of constraints and deficiencies that remain is long. The list involves all five elements of the system: the developing countries, regional organizations,



[a]AID is shown apart in order to indicate funding linkages to U.S. research institutions. AID also contributes through bilateral arrangements to individual country programs. Other donor members of CGIAR have corresponding additional linkages.
[b]The donor members supporting ICRISAT (for 1977) are Australia, Canada, Germany, Japan, Netherlands, Norway, Saudi Arabia, Sweden, Switzerland, United Kingdom, United States, IDRC, UNDP, and EEC. All CGIAR members are potential financers of operating linkages within the network.
[c]The links between ICRISAT and the individual countries take the form of information and materials exchange, the conduct of seminars and workshops, cooperative research projects advisory services, and training.

Source: Agency for International Development, 1975.

FIGURE 5 International sorghum research network, major linkages.

international institutes, the high-income countries, and research networks.

National Systems in the Developing Countries

Perhaps the greatest deficiencies in the developing countries lie in their national public research systems. Most of these systems began late and have had very limited resources. The natural consequence of this neglect is that too little research is underway and a portion of that is likely to be of low quality, inappropriate, or less than useful: important crops such as cassava and groundnuts may be neglected (Table 4). Important areas such as storage, processing, and marketing may be overlooked (PSAC 1967:Vol. II, 596, 617). Fortunately, the conditions underlying such problems may be corrected or ameliorated.

Overall Problems

One of the most striking characteristics of agricultural research systems in the developing countries is how they differ in their degree of development. The Technical Advisory Committee (TAC) of CGIAR has noted that:

> ...national capacity in the developing countries ranged from the highly sophisticated (e.g. India) to those at the other end of the spectrum (e.g. some Central American and African countries) where national agricultural research efforts were almost non-existent (CGIAR, TAC 1975b:30).

There is, moreover, often a wide range in the development of research organizations within a given country.

These variations are partly historical and partly the result of national policy. Some nations have given higher priority to agricultural research than others. This higher priority may result from the seriousness of the food problem in the past, the availability of food aid or imports and the ability to pay for them, and the degree to which other agricultural needs are more binding.

Because of these variations, it is difficult to generalize about organizational problems of research. Each country is, to a certain extent, a special case. But a few common problems tend to be present.

Resources. Agricultural research in lower income developing nations, as we noted in Tables 1 to 3, has

not been well funded by most standards. Thus both the physical and human resources available for research have been limited.

In terms of physical resources, the World Food Conference in 1974 noted that:

> Poor physical facilities inhibit both output and reliability of research in many developing countries. While there are usually a considerable number of "farms" variously labelled as experiment stations, seed farms, livestock breeding farms, these tend to be of inadequate size, the experimental fields have not been laid out to minimize soil variability, water supplies are uncertain, laboratories and offices are inadequate, field machines and laboratory equipment are deficient, and transport is limited (FAO 1974b:87).

There is also a severe shortage of trained scientists in most developing countries. Those available may have received less academic training, and some of that to a lower standard, than in the high-income countries. Moreover, many of the trained scientists may not be in a position to do important research; they may be located at a college or university where little emphasis is given to research, or they may be drafted into government administrative service. In some nations, there may be more Ph.D.s at agricultural colleges not doing research than there are elsewhere in the government research structure. In the case of the Ministries of Agriculture in several Asian nations a few years ago, there were fewer than five Ph.D. and 10 M.S. degree-level scientists in the entire organization (FAO 1974b:87).

Similarly, many research stations have few trained workers. FAO studies have shown that in the developing world as a whole, 70 percent of the research institutes have fewer than 10 trained research workers and in most regions between 40 to 60 percent of the institutes have fewer than five trained workers (Near East, 40 percent; Asia and Latin America, 50 percent; and Africa, 40 percent) (FAO 1974b:87; CGIAR, TAC 1975a:2).

Clearly human resources of this scale are not sufficient to make breakthroughs in agricultural technology. Hence in the few instances where facilities are adequate, it is often difficult to obtain adequate staffing. Good facilities may remain empty. Further, adequate operational funds may not be provided even when staff and facilities are available.

Planning and Organization. What little there is in the way of agricultural research resources may not be

put to the best use because of inadequate planning and organization.

Research may not reflect national needs and priorities, largely because of poor communication and understanding between planners, ministerial officials, and research directors. The machinery for review and appraisal of the validity of research programs to changing national goals also may be inadequate (CGIAR, TAC 1975a:2).

A key difficulty to improved planning is the lack of an effective linkage between planners, scientists, and users. Regarding science in general in the developing countries:

> There is no tradition of purposeful research, mainly because there are no external users around to convey their needs and wants to the scientists, and there is no established culture of such links between the academic and the practical (Moravcsik and Ziman 1975:711).

This situation may not be as severe in agriculture as in other areas, but the developing and high-income countries differ in this respect. In most high-income countries, farmers are well organized and make their research wants and needs well known; in the developing countries farmers express their needs less clearly. Without knowledge of the existing methods of agriculture, it is difficult for the urban-based planner or the laboratory scientist to do much effective planning.

Thorough planning of research goals can be undone by poor organization. Research may not interest those in the upper echelons of government or it may be headed by political appointees with little if any experience in agriculture. (This is a problem in the high-income countries as well.) Despite limited resources, there may be a tremendous fragmentation of institutions and responsibilities between various ministries, departments, and semiautonomous agencies. This fragmentation and the small size of many research institutes result in the dissipation of resources and a lack of interdisciplinary effort, and emphasize the personnel constraint (CGIAR, TAC 1975a:2).

Conditions of Employment. The conditions of service in public agricultural research in many developing countries are not very attractive. Good scientists usually can find better facilities and better pay in private industry or in another country. Some may find greater opportunities elsewhere in the government. As Wellhausen (1976) recently stated about the National Institute of Agricultural Research in Mexico:

> Owing to low salaries and the lack of career opportunities, Mexico's most competent agricultural research workers began to become widely dispersed in administrative positions and more remunerative activities....

The same story has been repeated many times in other nations, including the high-income ones. A sense of dedication is necessary to stay and work in agricultural research in many developing countries.

It is not sufficient, however, to provide improved facilities and higher pay. An incentive system must exist to reward useful research. As Ruttan has written:

> The low productivity of agricultural scientists in many developing countries is due to the fact that many societies have not yet succeeded in developing incentives that lead to the focus of scientific effort on the significant problems of domestic agriculture. Under such conditions scientific skills atrophy or are directed to the reward systems of the international scientific community (V. Ruttan 1976, unpublished article, "Technical Change and the Amplification of Agriculture's Capacity to Produce," Agricultural Development Council).

An incentive system also may be necessary to encourage interdisciplinary team research if complex applied problems are to be solved (an approach that has been used to particularly good advantage by the international institutes).

The administrative climate can facilitate rather than restrain research in part by providing a certain amount of freedom and flexibility:

> A constant topic of complaint among scientists from all developing countries is the administrative climate in which they must do their work. The standard pejorative term is "bureaucracy"--by which is meant a whole complex of time wasting, irrational and rigid procedures, accentuated by a hierarchial and authoritarian decision-making apparatus, that hinder the simple spontaneous initiative, demanded in active research (Moravcsik and Ziman 1975:708).

These problems are, of course, found in all societies but may be particularly serious in the developing countries.

In addition, the experiment station's infrastructure must function properly: the researcher must be given adequate assistance, both at the laboratory and field level. There may be a greater need for trained technicians than for scientists with Ph.D.s. At the least, land should be plowed properly, planting must be done accurately, and irrigations must be made on schedule. Moreover, the infrastructure must be able to support such seemingly small but key activities as foreign scientific periodicals and travel both within and outside of the country.

In all the thinking and talk about agricultural research organization, there has been too little attention given to the questions of how to attract good researchers into public agricultural research, how to motivate them, what rewards and incentives they need, how much individual freedom is required, and other such personal matters. These issues will not be solved by a good organization chart. They require a human touch and often that is lacking. A productive agricultural research worker should be treated as the valuable resource that he or she is.

Liaison/Outreach. The poor linkages between the research institute and the farm level often are noted. However, the reverse, the lack of use of available research, is also a serious gap. In theory this two-way linkage is provided by an extension service. In reality it occurs too infrequently, despite large expenditures for extension. But it should be said that effective extension work is much more difficult in a society of many small farmers than in one of a few large-scale farms.

Something must be done to improve the two-way flow of information. Many extension techniques have been tried. Some, such as crop production campaigns and increased farm demonstrations, have had reasonably good success. Others have not. The fault may not be entirely with the extension service; it also may reflect the location of the research work and the nature of the research product. Greater use of branch experiment stations and more research designed with the recipient in mind could alleviate the situation (CGIAR, TAC 1975a:2).[12]

More than just extension/outreach is involved in the adoption of new technologies. There must be an economic and social infrastructure as well as appropriate policies. These are of enormous importance in a given setting and often must be developed along with research. But a detailed discussion of them is beyond the scope of this report.

Multicountry Problems

Perhaps all of the general problems noted above can be found on a multicountry basis. Some are more localized and share political or geographic characteristics.

One multicountry problem has already been mentioned: the influence of colonialism in Asia and Africa. The colonial research systems emphasized crop-specific research. Where this emphasis continues in relatively autonomous institutes, it may lead to difficulties in coordinating national research programs, and neglect of work on cropping and farming systems and/or other areas such as soils, water, nutrition, and nontechnical constraints. The neglect of work on systems can be important where the need is to increase output of all crops per unit of land per year rather than just to maximize yields of an individual crop. On the other hand, crop or farming systems work can be difficult and may be more location-specific.

As Moseman (1970:57) noted, the research capacity of many excolonies deteriorated when expatriate scientists departed and their replacements were less experienced and/or inadequately trained. The Congo (Zaire) is a particular case in point. Belgian aid to agricultural research traditionally concentrated on the Institut National pour l'Etude Agronomique en Afrique Centrale (INEAC).[13] Following independence in 1960, Belgian support was not exactly welcome and most of the expatriate staff left. The new government had neither the trained agricultural scientists nor the financial resources to maintain the system at its former level. It is yet to recover. On the other hand, some countries, particularly France, seem to have maintained close ties with former research stations.

Language has been a problem in some regions. English is the most widely used language among agricultural scientists. Many U.S. agricultural scientists have learned Spanish and to some extent Portuguese. But few American agriculturists are at home with French, which is a particular problem in Africa (University of Minnesota 1974-75:3-4). French-speaking agriculturists often do not know English. Thus language restrains scientific exchange between these two groups.

International Support for Agricultural Research in the Developing Countries

It is difficult to obtain meaningful information on the support provided by the high-income countries for

agricultural systems in the developing countries. Boyce and Evenson (1975:51, 53, 62-63) suggest that international funding (principally from France, the United Kingdom, and the United States) of national research systems in the low-income countries increased from $55 million in 1959 to $80-100 million in 1965 and then dropped to $60-70 million by 1971.[14] They propose that the decline in funding of national systems after 1968 was partially due to the diversion of funds to the international institutes. We doubt this. Rather, it is likely that the decline in funding of national programs was a largely independent event.

It has been suggested that some donors were frustrated in their attempts to strengthen national research systems in the 1960s. A TAC document (CGIAR, TAC 1975a:1) refers to "a feeling amongst some donors that support for national research programs was not a particularly profitable form of investment." Another TAC paper (CGIAR, TAC 1975b:30) also refers to "frustrations experienced in attempts to strengthen national systems in the last decade." During the same period, the international institutes attained more than a fair degree of success with wheat and rice.

Hence it would not be improbable that increased investments in the international centers grew out of both frustrations with national programs and successes with international research. The international results in turn have highlighted the need for improved research programs at the national level, and it appears that the latter are now receiving increased support from both the high-income countries and international organizations.

Within the United States the Rockefeller and Ford Foundations have long been involved in agricultural research activities in the developing countries. Similar actions were not given much attention in AID until the late 1960s. Moseman (1971:8) notes that:

> As recently as 1966...it was most difficult to obtain acceptance within USAID for support to the International Rice Research Institute for cooperative adaptive research to improve rice production in India, Pakistan, and other countries where shortages of this food grain were then reaching critical proportions.

A few research efforts were funded as part of the overall agricultural college development programs in the developing countries. In 1969, AID began to contribute to CIMMYT, and in 1970 to IRRI, IITA, and CIAT. This support gradually increased. A number of loans and grants for national agricultural systems were established in the early and mid-1970s. The evolution

and nature of U.S. support will be discussed in detail later in this report.

France did not contribute to CGIAR until 1975 and then offered only $130,000; by 1976 the figure had increased only to $520,000. By comparison, France contributed major sums to agricultural research, principally in Africa, through ORSTOM and GERDAT.[15] Hence it is highly doubtful that France's limited participation in CGIAR significantly influenced its support of national programs.

The United Kingdom was a "charter member" of CGIAR in 1972 with a contribution of $630,000; by 1976 this figure had grown to $3.24 million. We understand that the U.K. contribution to CGIAR has not reduced its contributions to other programs, but we do not have firm evidence.

All in all, however, we suspect that the reaction of the other donors has tended to be like that of the United States: the experience with the international centers has led to increased or renewed interest in national programs. Moreover, CGIAR funding comes from a multilateral pocket whereas the national funding comes from a bilateral one.

Regional Systems

Regional agriculture systems among the developing countries, like their national counterparts, are quite varied in their stage of development. Usually the major problem is inadequate funding. Where some outside sources of financing have been available, the regional systems have done well. Where they have depended on full funding from local national governments, they have generally experienced financial difficulties. Moreover, using local funds for regional programs may reduce resources available for the national program; this, in turn, may reduce productive interchange between the regional and national programs. Another problem is that political pressures may accompany national funds.

Changing national political conditions as well as agricultural research constituencies influence the effective life span of regional research organizations. Technical and economic arguments for regional associations may find themselves unevenly balanced against the pull of national sovereignty, international economic and political associations, varied languages, differing national political and social purposes, and limited management capabilities.

When, however, some budget and technical support come from a more general regional organization or from outside of the region, the influences of more local

forces may be reduced. The West African Rice Development Association appears to be quite successful in this respect. Yet it still may be difficult to secure even partial local funding, as CATIE and some other regional groups have found.

In short, regional associations may be useful in certain regions, yet it is quite difficult to sustain them with local funds alone. Perhaps their most certain course is as a vehicle for handling outside funding and technical assistance.

International Institutes

International agricultural research institutes, while located in the developing countries, face problems more typical of research organizations in the high-income countries. They have been catalogued as follows:

> ...large multi-disciplinary institutes are costly to establish, expensive to run, and hard to disengage from or to alter the course of if they cease to be highly productive. There are also problems of site specificity of the results, where research is centralized largely at one location. This has led to doubts about continuing to add to their number, and to a search for other institutional approaches...which are cheaper or more flexible (CGIAR, TAC 1976:20[16]).

While the institutes are first-class organizations, their current financial situation is shaky. It consists almost entirely of annual funding provided through CGIAR. Institutes have no endowments and small cash reserves. Thus if a major donor should experience delays in receiving approval for its budget, as has happened, the centers face some difficulty. But these problems are minor compared to what would happen if a major donor failed to make or sharply reduced its contribution. CGIAR's total budget in 1977 was nearly $79 million. While this figure is negligible in comparison, say, to the cost of military hardware, it comes out of generally strained foreign aid budgets, and no one donor is in a position to cover a major shortfall of another. The financial situation is particularly precarious for one center, the Asian Vegetable Research and Development Center, which, principally because of political problems arising from its location in Taiwan, has not been given CGIAR membership.

Even if the budget situation were worked out there are limits as to what international centers can do. To date, for example, the international centers have confined their efforts to food crops and animals, principally those for domestic use. This means that some important agricultural commodities have been excluded, including sugarcane, coconuts, coffee, grapes, chillies and spices, and cotton (Table 4). It is possible that research on some dual-purpose food or feed crops, such as coconuts, cotton (seed or oil), and certain other oilseed crops, may eventually be recommended for funding. On the whole, however, research on these crops will probably have to be done largely at the regional or national levels.

Another question is to what extent should the centers take up--beyond their participation in networks--regional or national technical assistance and outreach efforts. This is a complicated issue (in part because some centers have both commodity and regional functions) and is of real concern to the centers, TAC, and CGIAR.

Individual centers, of course, have many other problems. Some, such as identification of research managers, are not unique. Others, such as delicate relations with the host country, are more unusual. Intercenter relationships about specific programs sometimes create difficulties. Most of these issues are minor and can be handled by the centers and the CGIAR system. The overall problem in the future will likely be a financial one. In this respect, the international centers may share a problem with the developing country national systems.

National Systems in the High-income Countries

The extent to which research institutions in the high-income countries are involved in agricultural matters in the developing countries varies widely. In some countries, such as the United Kingdom, there is a long history of institutional involvement. In others, such as the United States, individuals have long been involved, but the interest of institutions is limited largely to the last 25 years.

We do not know much about the experiences of other high-income nations, but we are somewhat familiar with the problems of research groups in the United States. At first, their problems centered on a lack of experienced personnel and difficulties in obtaining institutional commitments for international activities. As these matters were resolved the primary difficulties turned out to be an increase in teaching duties and a lack of support for research. Virtually no funding has

been available for research activities aimed at application in the countries except through foundations and AID. The foundation funds for this kind of work have become more limited. And the process of securing an AID contract has been time-consuming and complex. The total research program has not been large.

Research done in or by the high-income countries is probably more basic in nature than that carried out in the developing countries. We do not know how much basic research has been done in the high-income countries because of the difficulty in assessing research outside the usual agricultural research system. At the public level, basic research has been more difficult to sell to legislative bodies than applied research. Still, the United States and other high-income countries probably have fared better than the developing countries in this matter.

Research Networks

The essential characteristics of a research network are a willingness and an ability to work together on a subject of common interest. For agricultural science and technology, the willingness is usually there as the goal of increasing food production usually transcends national political boundaries.

But if the will to work together exists, the ability to do so may be hampered. The major problems exist for scientists in the developing countries who are handicapped by "poverty, by geographical distance and by administrative barriers (Moravcsik and Ziman 1975:173)." To some extent these problems can be reduced by establishing joint research projects with the developing countries on major problems. These projects provide many points of interchange, though some may be neglected from the point of view of the scientist in the developing country.

To be more specific, FAO (1975b:19) has suggested that any successful network should include mechanisms for: (1) establishing and executing a cooperative program, (2) exchanging research information, (3) exchanging research materials, (4) group training and fellowships, (5) securing a multidisciplinary approach for applying research results at the national level, and (6) some kind of nerve center.

Most of these elements also are needed for an effective research program. Thus the additional inputs required may not be great. Still, additional funds may be needed for the support of participating national institutions as well as any central coordinating body.

HOW TO IMPROVE THE RESEARCH SYSTEM

The variability of the global agricultural research system makes it difficult to specify changes. Thus one group may emphasize building more institutions while others may want to strengthen particular research areas. There is some agreement, however, on improving developing country programs and on featuring an interdisciplinary and systems approach to the problems of increasing food production.

National Systems in the Developing Countries

National systems in the developing countries may be considered the weak link in the global research system. They play a critical part in adapting to local conditions the results of research undertaken internationally, regionally, and in the developing countries. Evenson and Kislev (1975:77) have noted that little outside knowledge is borrowed unless indigenous research is also underway. No matter how significant the outside efforts, "the great bulk of the research on developing countries' agricultural problems must be carried out in the developing countries through their own institutions (FAO 1974b:92)."

The charge is not an easy one. As stated in a recent TAC document (CGIAR, TAC 1975a:1):

> ...building research capacity in the developing countries has been found to be a slow, difficult, and complex task. The number of countries involved, and the overall financial magnitudes also make it a complex one in terms of logistics and donor support.

A prerequisite to any strengthening is to:

> ...obtain from national leaders some formal recognition of the vital need for a sustained flow of adapted new technology for food production and overall development and some serious commitment to providing the required research facilities on a more ample scale than hitherto. This in turn requires a special effort by those in charge of research to acquaint the government leadership with the kinds of research most critical to national development and the types of organizations and facilities required to undertake it (FAO 1974b:12).

Outside donors can be helpful at some stages of the process, but ultimately the national government must build most of the facilities, provide the annual operating budget, and recruit and employ scientists. While outside groups alone cannot accomplish such actions, they can help provide financial and technical assistance and improve analysis, planning, organization, and management as well.

Improving Analysis and Planning

Virtually every agricultural research system has limited resources--both human and capital--which must be allocated carefully. This requires analyzing current and potential problems and establishing priorities.[17]

Priorities and timing are particularly important. Some developing countries try to cover all crops and all major disciplines:

> This misallocation of scarce resources prevents sufficient attention being focused on any one single problem, so that none are solved. To select a few issues and concentrate resources upon them may involve taking invidious decisions, but it will be in the national interest. Most of the items should be problems of immediate urgency, but the decision-makers must also look ahead and, anticipating the nation's needs in 5 to 10 years time, must initiate now the programs slow-maturing in character whose results will be demanded then (FAO 1974b:94).

Perhaps the job would be less difficult if it were possible to concentrate first on the important domestic food commodities where the chance of success is relatively great. A demonstration of the potential of modern science and a high return relative to cost would help persuade the more skeptical observers.

The difficulty with this approach is that it may lead to a neglect of other types of research. Hence early attention should be given to a more comprehensive agricultural research system. The country might sponsor interdisciplinary teams of scientists working on major problems in the major ecological areas.

A few research systems in the developing countries are well established in this regard. Still they may experience difficulty analyzing problems and planning research for effective solutions. Such quests require an interdisciplinary staff for analysis and planning that is relatively free of day-to-day operations.

Improving Organization Within the Government

Where and how should the agricultural research organization be placed within the national government of a developing country?

An initial step might be to establish an internal organization that links national planners, ministries for agricultural development, research directors, universities, and the private sector. One way to do this is to create a national agricultural research council (affiliated with a national science council where it exists). In addition to providing coordination, this group may work toward formulating an overall agricultural research policy. Further, it may stimulate a multidisciplinary and systems-oriented approach to research. Its secretariat might develop ties with external assistance agencies.

Under the research council, a national agricultural research institute might be formed to relate public agricultural research in the physical, biological, and social sciences. The institute would develop research programs according to the policies of the council. The institute would, further, have public funding to conduct research in its own facilities or in other institutions on a grant or contract basis. The institute would likely be distinct from the Ministry of Agriculture, although it could be housed and supported there.[18]

While a separate institute might be questioned, it could be desirable where a ministry research program is weak and/or where autonomous or semiautonomous research institutes are supported by public funds. And there might be a place for an institute where the ministry changes frequently, is highly politicized, or where employment conditions are unattractive for scientists.

The degree of autonomy for such an institute is debatable. To be sure, autonomy tends to free research from some bureaucratic constraints. On the other hand, if research is to be disseminated and implemented, close links with government and other organizations are needed. And autonomy may accent rivalry rather than cooperation.

It should be possible eventually to obtain better answers to these questions. Research councils and institutes have recently been formed in some developing countries under several administrative arrangements. At least four countries--Ethiopia, Egypt, India, and Malaysia--have established central research institutes. The Philippines has organized a Council of Agricultural Research.

An Agricultural Research Council began in Bangladesh in May 1974 to coordinate research activities and resources.[19] While it had initial

authority over crops for which the Ministry of Agriculture was responsible (excluding jute, sugarcane, livestock, and fisheries), it is expected to assume eventually the leadership role for all agricultural research activities. The council has an International Staff Support and Coordination Cell, which is a channel for AID funding and also for contact with the international centers. Further, the council will provide some funds to such groups as the Bangladesh Agricultural University ("Bangladesh Agricultural Research Project Paper," unpublished report, AID, 1975).

While there is no single model that fits all purposes, it would seem that some form of a general coordinating body would be a useful addition to many national systems. More information is needed on the outcome of these central bodies in the countries in which they have been tried. The public research corporation, currently being tried in Brazil, also merits special study.

Improving Organization and Management Within the Research System

What is the correct degree of centralization vs. the degree of decentralizaion? Ideally it might be desirable to have the following balance (Moseman 1970:102):

-- a strong national center for background research and for leadership for national and regional projects;
-- regional centers for adaptive research and specialized attention to the agricultural requirements of the major cropping regions of the country;
-- localized research and/or verification stations designed to fit innovations to specific soil and climate conditions.

It is difficult to get the proper mix between these elements, especially with limited resources. In addition, there is the question of how much autonomy the regional station should have with respect to the national stations--how free it should be to work on local problems.[20]

Overcentralization may isolate researchers from producers and consumers. A regional approach implies some degree of autonomy, but excessive decentralization can lead to scientific isolation, lack of incentives, fewer skills, and resulting inefficiency (FAO 1975b:13).

Another question is how much freedom is to be provided the research worker. As Mosher (1971:263) states:

> ...it is important to find an effective balance between research on problems considered by many national planners or research administrators to be of high national priority, and projects that may be recognized as important--with high future payoff potential--by individual researchers, even though the latter projects do not at the moment rate high in national priorities.

The matter also is related to the degree of emphasis to be given to multidisciplinary team efforts. The team approach has been emphasized in the international centers and is finding favor elsewhere as a way of concentrating scientific talent on important problems. While this approach is promising, it undoubtedly has certain requirements for success that may not be present in every country program. These requirements need to be more thoroughly studied.

It should be kept in mind that not all scientists adapt well to a group or a team approach (Brown et al. 1975:28). The best members of the agricultural science community are likely to be very few in number, individualistic, and well trained.

> [Their] attack on the problems of nature cannot be commanded like the advance of a batallion of infantry. Only careful personal attention to their aspirations, needs and capabilities can really help them or direct their energies in the right directions. The cost of such attention is much higher in professional scientific grasp and human understanding than it is in dollars and cents (Moravcsik and Ziman 1975:722-723).

The number of research managers who can effectively carry out such a task is limited in any society; this is especially likely in developing countries. Developing such managers remains a major challenge.

Role of Coordinated National Research and Action Programs

National programs that emphasize specific commodities have been carried out both at the research and action levels in the developing countries. Both are promising vehicles for relating institutional

components and for developing and adopting new technologies. In certain aspects, they are similar to research networks.

Coordinated, multidisciplinary, problem-oriented research projects to improve food crop production were first tried in the United States and Japan in the mid-1920s. Perhaps the first comparable program in a developing country was established by the Rockefeller Foundation in India in 1957. It concentrated on maize, sorghum, and millet. Similar programs were subsequently developed for wheat and rice.[21] A program also was developed in India in 1966, with American help, to provide a team of scientists to assist state directors of agriculture in establishing closer links with institutes (including agricultural universities) and agricultural extension services (Scoville 1975:97-115).

Successfully coordinated projects normally require a full-time director; a well-equipped, well-staffed headquarters; and research facilities in the principal regions. Where both personnel and facilities must be developed, a period of 8 to 10 years is usually necessary before an effective project will result (Moseman 1977:367-380).

There are other considerations. One concerns the extent to which such programs may restrain the freedom of the individual researchers. Moreover, such programs have tended to relate to commodities rather than to functional approaches. Still, in larger countries with many research institutions at various levels and locations, coordinated national projects may be an effective way to manage.

Commodity action programs are a somewhat different matter. They represent a combination of applied research with a modified delivery system providing such inputs as credit and farm chemicals. Examples include some of the early wheat and rice programs utilizing high yielding varieties in countries such as Turkey and the Philippines, the Bimas program in Indonesia, and the Masagana 99 project for rice in the Philippines.[22] The results of the wheat and rice action programs appear to be favorable as long as the government of a developing country is committed to them. But when governments or key individuals change, those programs may decline.

On balance, where a clearly defined objective must be attained in a short period, and where resources are available, campaigns are a promising technique. They also may have an effect on institutional capacity in the long run.

External Assistance

Certain problems faced by research systems in the developing countries, despite their importance, are matters of internal policy and really can only be handled by the developing country (for example salaries, incentives, and employment conditions). There are, however, areas in which external assistance may help. FAO (1975b:11) has suggested six:

- -- identifying major priority areas in which research is needed to remove bottlenecks to development;
- -- providing technical assistance to national institutions in planning, organization, and institution building, and where necessary helping to establish and operate research institutions until national staff can take over;
- -- building national research capabilities through education and training;
- -- upgrading scientific and technical knowledge through consultation, information exchange, documentation and bibliographic services, and publications;
- -- helping to establish and operate appropriate cooperative research activities or research projects related to identified regional or national priorities;
- -- integrating research more closely with development institutions and services at the farm end.

Assistance in actually doing research also might be added.

Two other areas deserve attention: trained individuals and funding. An official of the World Bank has observed that people and not money represent the major constraint in helping countries strengthen their research capabilities. A trained staff must be available and governments must be willing to support further staff training and to accept expatriate assistance while the staff development program is in progress.[23]

There are situations in which outside funding can be significant. Outside donors can provide, through grants or loans, a substantial part of the capital needed to establish a new research center or to improve an existing one. The actual use of the funds may range over many activities; however, they usually emphasize the foreign exchange costs. The United States has substantially increased its loans and grants for national research programs over the past few years, as have other donors.

The American contributions will be noted in a subsequent section. Among other donors the World Bank

and the Inter-American Development Bank have been particularly active. As of May 1976, the World Bank had four large national loans in effect:

-- Spain, $12.7 million, research, approved November 1971;
-- Indonesia, $21.5 million, research and extension;
-- Malaysia, $28.5 million, research and extension, approved May 1975;
-- Brazil, $40 million, research, approved April 1976.

Further such loans are currently in prospect for other nations.[24] In addition, other World Bank loans have provided a significant research component (Table 5). Through December 31, 1975, the Inter-American Development Bank (IADB) had granted 12 loans to finance national agricultural research and extension projects in Latin America; the research component was estimated at being about $27 million (IADB 1976:1,2). Further such loans are quite possible.

For years FAO has administered a wide array of research projects in the developing countries. These projects are generally funded by other international organizations (such as the U.N. Development Programme and U.N. Environmental Programme), trust funds, or by the host government. Essentially none is funded by FAO itself. Despite FAO's extensive experience in this field, little historical information has been made available. It is not known what changes have taken place in the number and volume of such activities in recent years.[25]

Regional Systems

In the past, most regional activities have been in Africa and Latin America. In Africa, changing political conditions and the resulting changes in agricultural research constituencies influence the effective life span of regional research efforts. The shift from colonial to independent status was one major change that now is largely completed. But political alignments constantly change, which make heavy investments in physical plants for regional programs somewhat risky in certain cases. One possible solution would be to isolate certain areas of research in a specific institute operating with its own budget (NRC 1974:169).

At present, new regional activities are getting underway in Latin America. The subregional research activities sponsored for many years by IICA are now in the process of receiving additional support by the Inter-American Development Bank. A recent proposal called for a three-year grant of $3.5 million for a

Table 5. Research component of World Bank loans for national agricultural development projects*

Fiscal year	Number of projects	Amount (dollars)
1963	1	100,000
1964		
1965	1	900,000
1966		
1967	1	38,000
1968	2	400,000
1969	3	1,813,000
1970	4	1,217,000
1971	13	4,682,000
1972	11	5,105,000
1973	14	5,374,000
1974	14	11,832,000
1975	13	8,033,000
TOTAL	77	39,494,000

*Excludes projects exclusively devoted to strengthening national research capabilities and projects with unidentifiable amounts allocated for research.

Source: Data provided by J. Fransen, Research Advisor, Agriculture and Rural Development Department, International Bank for Reconstruction and Development, May 1976.

program of technical cooperation in research for six southern zone countries (Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay). Another request has been received from CATIE. On a slightly different level, the Inter-American Group for Agricultural Development in Latin America (IGAD/LA), consisting of regional and international organizations as well as AID has recently been formed and a secretariat established in the IADB; agricultural research is one of the main areas receiving consideration for support.

These efforts suggest the key role that regional development banks might play in providing the support and stability so often necessary to keep regional research activities funded and in operation. The Asia Development Bank has provided several grants to international research and outreach programs in its areas (including, for example, a recent grant to the Asian Vegetable Research and Development Center for work in three Asian nations).[26] It has not, however, provided other major regular support to regional research. The African Development Bank has not, to our knowledge, provided any support to research. The future experience of the Inter-American Development Bank in this respect will be worth watching.

International Institutes

The international agricultural research institutes are developing well. While there are numerous problems, most can be solved within the existing institutional structure. CGIAR recently sponsored a review of its system (CGIAR 1976b). Intensive reviews of individual centers also have been initiated on a five-year basis. Two have been completed (for IRRI and CIMMYT).

Certain problems can be expected to transcend the reviews, such as funding. Preliminary financial requests submitted to the CGIAR for 1977 totaled $84.5 million; these were subsequently reduced to $79.6 million by November 1976. If a figure of $80 million is used as a base and projected to 1980 with an inflation allowance and four variants of program growth (0 to 15 percent), the requirements would range from $110 million to $127 million (Table 6).

In 1976, CGIAR decided to enter three years of consolidation during which no new major centers or programs will be taken on. However, financial requirements will continue to expand beyond those caused by inflation. Established centers will take on some new activities and staff. Several new centers are being developed which will involve substantial funding to complete and staff. Thus a growth assumption of 10

Table 6. Potential growth in financial requirements of the Consultative Group on International Agricultural Research (current dollars, including inflation allowance*)

Program growth assumption (percent)	1977**	1978	1979	1980
		($ millions)		
None	80.0	89.6	100.3	110.3
5	80.0	94.1	105.3	115.9
10	80.0	98.5	110.3	121.4
15	80.0	103.0	115.4	126.9

*Assumes inflation of 12 percent for 1978 and 1979 and 10 percent for 1980.

**Preliminary stated requirements for 1977 were $84.5 million; this figure was subsequently reduced to $79.6 million by November 1976.

Source: Special calculation by Carlos Gavino of the Secretariat, Consultative Group on International Agricultural Research, August 10, 1976.

percent would seem moderate. This figure suggests a total need of $121.4 million by 1980 (Table 6). (If we round this figure off to $120 million, the contribution needed from AID at the 25 percent level, assuming funds are available from other donors, would be $30 million.)[27] The hazards of relying on annual funding to meet requirements of this magnitude must not be overlooked. Some way needs to be found to secure expanded and sustained financial security.

If the international centers within the CGIAR system operate on a financial razor's edge, the situation is even more precarious for some outside the system, such as the Asian Vegetable Research and Development Center on Taiwan. Two AID-funded activities--the International Soybean Research Base (INSOY) and the International Fertilizer Development Center--have attracted but little international support, largely because of their location in a high-income country. The International Food Policy Research Institute received initial funding for five years from private sources. CGIAR membership would not be a guarantee of increased funding (most donors designate their contributions), but the situation would very likely be improved.

Another more technical question is whether the present structure is well suited to keep up with advancements in basic science. At present such information is apt to be acquired in a rather haphazard way. Some flexible mechanism may be needed for scanning a broad range of scientific developments.

Research Systems in the High-income Countries

The high-income countries could provide more support for agricultural research in or for the developing countries through increased financial and technical support of the other components of the global research system, and by carrying out increased research of their own which would be directed at the problems of developing country agriculture.

Within the first category, it may be easier to provide the funds than the right kind and number of qualified professionals in the area of overall strategy, organization, and management. Schultz (1967:401) noted several years ago that "those among us who are research-oriented have in general no taste or talent for the difficult task of building research organizations and administering them efficiently." Hardin (1975) added more recently that:

> The scarcity of professional manpower that is competent, ready, and willing to provide the

services LDC's need to help strengthen and develop their agricultural institutions is likely to be one of the major constraints to getting on with the job.

Thought has been given as to how to organize limited resources to service better the developing countries, but such planning is not much beyond the early discussion stage in most high-income countries.[28] Within more specific agricultural or technical fields, the human resource situation is somewhat better. Almost every high-income country has technologists in some field of food and agricultural research who could be of assistance to the developing countries. The challenge is to mobilize effectively both types of individuals.

The next question is how to organize better the research strength of the high-income countries on issues important to the developing countries. It is sometimes thought that the high-income countries might do more basic research, leaving the applied activities to the international or developing country centers. The Organization for Economic Cooperation and Development (OECD) has been considering a proposal that would involve cooperation in four areas:[29] (1) improvement of nitrogen fixation for plant production; (2) improvement of the efficiency of photosynthesis; (3) the direct use or transformation of cellulose and other carbohydrate waste products for human or animal food; and (4) protection of harvested products against contamination by mycotoxins. As proposed, the project would be adopted for a three-year period and would be renewable. As of Fall 1976, the financial aspects of the program were being settled prior to implementation in the 1977 OECD budget. In addition, representatives of several European nations expressed an interest in doing more research relevant to the developing countries during the CGIAR International Centers Week in July 1976.

There is probably much research work already being done in the high-income countries that would be of some importance to the developing countries. Similarly, many of the high-income countries may actually be sponsoring research in the developing countries. Work carried on in public institutions in the high-income countries is relatively well indexed, but the same is not true of private industry or work sponsored in the developing countries (with a few exceptions, some sponsored by the United States[30]). A modest attempt has been made to secure information on public activities sponsored by the high-income countries in or for the developing countries through CGIAR, but the results to date have been limited. The TAC Secretariat

is currently at work on the project. Gathering such data is a complex, tedious task with limited public appeal. Thus while it seems clear that a much improved information base is needed, effective implementation is still in the future.

In any case, a greater degree of coordination among donors would improve the efficiency of resource use. Hardin (1975) notes that "at times there is a tendency to whipsaw the overworked and harassed governmental officers [in developing countries] responsible for coordinating outside assistance." Just who should carry out this coordination role is uncertain.

Research Networks

Improved research networks are an invaluable tool for tying the global agricultural research organization together for the benefit of individual members, but particularly for the developing nations.

How can such networks be strengthened? Unfortunately this aspect has not been closely studied. Still, as noted earlier, additional funds may have to be channeled to the support of participating national institutions as well as any central coordinating body:

> The latter is likely to incur the main costs, which may include additional scientific and supporting staff and equipment; but a portion of costs must be reserved as "seed money" for national workers cooperating in the research projects, preferably in convertible foreign currency. This can be used for purchase of small items of equipment and books, hire of vehicles for internal travel, statistical or other clerical assistance, etc., and helps to give much needed flexibility to the operations (FAO 1975b:19).

At present, there is relatively little funding available for such activities. Yet the costs involved would be modest compared to those of most research efforts.

Some progress is being made in this area. The International Development Research Centre of Canada has recently funded the development of a cassava network in Latin America and Asia (Anonymous 1976a:68). IRRI has initiated recently an "International Rice Research Newsletter" to expedite communication among rice scientists. Hopefully more such efforts will be forthcoming.

Substitutability in Research

To what extent can research conducted outside of a developing country substitute for or complement research done inside that country? We suspect that the opportunities for substituting increase as one moves from applied to more basic types of research. Important complementarities, however, could exist for all types of research and at every stage of a research system's development.

A more specific answer with respect to substitutability would depend on the specific situation. If a developing country had essentially no research capability, and a neighboring country, or regional program conducted under similar conditions, had a stock of knowledge, there could be considerable substitution. The greater the ecological contrasts, the greater the need for a local research establishment. In such a setting the country might concentrate its own research on applied matters and borrow the more basic knowledge.

But where technology is to be borrowed, there must be enough staff to do the borrowing and to put the knowledge to use. A small country or one with a limited research establishment need not immediately take on a broad range of research, but it will need some capacity to borrow. Naturally the more it can do, the better tailored the research product should be to local conditions. Still, diminishing returns can set in so that the cost of this action should be balanced against other development alternatives.

A reverse question is: To what degree can a well-developed research capacity make up for deficiencies that may limit agricultural development? If, for instance, increased tolerance to moisture variation can be built into a plant, less attention can be given to irrigation and drainage. Similarly, if a plant's capacity to fix nitrogen biologically can be expanded, less chemical fertilizer will be needed. Cropping or farming systems can be devised which reduce the need for insecticides and pesticides. But overall, there are clear limits to how much research can accomplish. Furthermore, no government can rely solely on technology to obviate the needs for other needed economic, political, or social changes.

The problem of a gap between the generation of knowledge and application at the farm level is a general one. Part of the answer is to improve the two-way flow of information between farmer and researcher. There are numerous ways of doing this, including a more technically-oriented extension service, reliance on production specialists who combine research and education, and having researchers do some outreach

work. The best approach, however, will have to be decided case by case, possibly with the advice of someone from outside the country (there are not, however, many people with expertise in this area).

PAST AND PRESENT CONTRIBUTIONS OF THE UNITED STATES

Until the late 1960s, the record of American contributions to improving global agricultural research, particularly in and for the developing countries, was a mixed one. Recently, American contributions have been more substantial.

Here we primarily focus on activities by public institutions. Private and foundation activities are largely excluded, not due to lack of recognition of their importance but because private activities have not been well recorded, whereas those of foundations have (Stakman et al. 1967). Public activities are reasonably well recorded but not well known.

1860 to 1960

American agricultural technology has found its way abroad since the 1800s. While much of it went to what are now the high-income countries, some was used by the more advanced parts of the current developing countries. Before the late 1800s, much of this improved technology was spread by individuals and private firms. American agricultural machinery was found around the world by the turn of the century.

U.S. Department of Agriculture

With the establishment of the U.S. Department of Agriculture in 1862, the public sector became more involved in the transfer of agricultural technology.

USDA at first had no statutory authority for foreign activities other than a general mandate to collect and disseminate information on agriculture and to collect, propagate, and distribute new seeds and plants. The exchange of information and agricultural materials with other governments was conducted from the outset.

By the turn of the century, the department was an acknowledged center of agricultural science. Foreign nations competed for the services of USDA scientists:

> Sometimes the requests came through diplomatic channels for loan of a man with certain specialized knowledge to analyze and suggest

> solutions for specific problems. On other occasions, men who had become known...were approached directly with offers of jobs. The department usually regarded such overseas employment as an opportunity to enlarge its own knowledge and maintain close contacts with former employees (Drosdoff 1966:1-4).

Leading U.S. colleges of agriculture experienced the same situation. By the 1930s, Americans had provided technical assistance in agriculture in five continents.

In 1938, President Roosevelt signed the Convention of Cultural Relations which authorized the detail of U.S. employees to the governments of the American Republics, the Philippines, and Liberia. Thus USDA was given, for the first time, legal authority to extend technical assistance. The next year Public Law 355 established cooperative tropical experiment stations in Latin American nations in order to develop crops complementary (noncompetitive) to U.S. production. Funds were first appropriated in July 1941. The first cooperative agricultural experiment station began with the signing of an agreement with Peru in April 1942. Studies on the export of nonfood crops also were initiated in numerous Latin American countries (Drosdoff 1966:5-9; PSAC 1967:Vol.I, 116-117).

U.S. Department of State

U.S. foreign assistance expanded sharply after World War II, but the path was a complex one.

In January 1948, President Truman signed the United States Information and Education Exchange Act which provided for worldwide cooperation with other governments. A few months later, in April 1948, the Foreign Assistance Act creating the European Recovery Program (the Marshall Plan) was approved. In turn, the Economic Cooperation Administration (ECA) was established. ECA ran its own agricultural program in technical assistance, but relied heavily on USDA and the agricultural colleges for technical personnel and guidance.

President Truman's inaugural address in January 1949 contained "Point Four" which broadened the scope of American technical assistance to include the underdeveloped nations. The Department of State was assigned the responsibility of planning such programs on January 27, 1949; on October 27, 1950, it announced the establishment of the Technical Cooperation Administration (TCA). In 1951, TCA was merged with ECA Technical Assistance into the Mutual Security Agency,

which was outside the State Department.

Following establishment of the Foreign Operations Administration in 1953, all foreign economic and technical assistance programs were transferred to it, and USDA's participation decreased rapidly. The group was renamed the International Cooperation Administration in July 1955. In 1957, development lending was separated and assigned to the new Development Loan Fund.

In 1961, these activities were combined into the new Agency for International Development, and USDA again became more heavily involved. Early in the 1950s, contracts were made with a number of American colleges to work with or help establish colleges in the developing countries. These colleges usually included research among their activities.[31]

Evaluation of Experience

Through the early 1960s, most of the technological emphasis in AID's predecessor agencies was on training and outreach or extension. Research was given little specific attention. Schultz (1964:201) summarized the situation in these terms:

> Although our government has been actively engaged in technical assistance in agriculture throughout Latin America for two decades, the sad truth is that not a single first-class agricultural research center has been developed as a consequence of these activities. Mexico has done well, but not because of any technical assistance from the U.S. Government. The funds and talent provided by The Rockefeller Foundation have, however, played a part in the Mexican advance. Japan has done exceedingly well on her own. But throughout South Asia, where we have both public and private commitments to assist agriculture, with few exceptions new agricultural research has been neglected.

Subsequently, Moseman (1970:66,73) observed that despite the strong dependence of U.S. agriculture on a steady generation of new technology, "the U.S. technical assistance programs for nearly two decades have neither developed nor utilized new agricultural technology in the cooperating countries with any real degree of effectiveness." While research was included in the programs to develop agricultural colleges, the actual research input was "modest or entirely lacking." Moreover, little attention was given to the role of

these institutions in integrated national agricultural research programs.

The 1960s

The research situation began to change in the 1960s with respect to research administered by AID and USDA.

U.S. Agency for International Development

The lack of a sound research component within the U.S. foreign assistance program was recognized when AID was established in 1961. A research program with special budget support was initiated in 1962.[32] Moreover, a Conference on International Rural Development in July 1964 concluded that greater support should be given to the research component, not only by AID itself but also within its contracts with U.S. agricultural universities.

The actual level of expenditures on agricultural research during the 1960s is difficult to specify. One AID summary places the total spent on food and nutrition research from central funds over the seven-year period from FY 1962 to FY 1968 at $21.96 million (agriculture, $19.63 million; nutrition, $2.33 million). This was nearly 45.8 percent of the total spent on all types of research. Another $3.72 million was spent on food and nutrition in FY 1969 (agriculture, $3.50 million; nutrition, $0.22 million).[33] Research expenditures funded in other ways, principally by regional bureaus, are not known but were probably small.

Progress between 1962 and 1967 was summarized as follows by Moseman (1970:75-76) (who was in charge of AID agricultural research from 1965 to 1967):

> Although the AID Central Research Program was late in initiation, slow in getting started, is still inadequately funded, and has been underway for only six years, it is a solid step in the right direction and the new technology and information that is being generated should improve the quality and substance of future foreign aid activities. There is still uncertainty, however, about the feasibility of building and maintaining an effective support base for research and other long-range activities within an organization so strongly oriented to general economic assistance, so concerned with highly visible and short-range operational projects, and so

subject to frequent reorganizations.

There is substantial merit in having a close association of technical assistance, including research, with economic assistance. But under the organization of the Agency for International Development which has prevailed since 1961 this relationship has not proved to be especially beneficial. The highly independent regional bureaus have not received effective technical inputs from their inadequate "technical" staff offices, and they have been neither responsive to nor supportive of the Central Office of Technical Cooperation and Research and its successor, the Research and Institutional Grants Staff. This continuing low priority to research in AID was fully demonstrated in the reorganization of February 1967 when the technical cooperation and research activities were considered expendable and the professional staff concerned with these functions were taken over as a major personnel resource for the new Office of the War on Hunger and shifted largely to operational programs. Most of the experienced research personnel subsequently left the Agency.

Other problems were evident in the 1960s. Wortman (1976:38) recently indicated that AID "was constrained politically until 1969...by reluctance to become involved in direct, visible efforts abroad to increase productivity of the basic food crops, particularly the cereal grains." This is a rather surprising statement but can be largely confirmed. Moseman (1966:99) acknowledged in February 1966:

> We have not focused research attention on the increase of production of crops such as rice and wheat, which have been in surplus in the United States. This reflected the attitude of the Congress of the American public, and of American farm organizations--a handicap that is still to be overcome.

This policy was expressed in an AID manual order (M.O. 1016.2) issued on August 1, 1962, which continued a policy established in September 1959. According to the order, continuation was necessary because of "legislative history." It stated, among other things:

> Subject to normal programming procedure aid of any kind may be provided for the purpose of increasing food and feeds for domestic

> consumption; but it may not be given to increase production of (1) surplus food and feeds with the result of substantially increasing exports or (2) surplus agricultural commodities other than food and feeds....The phrase "surplus agricultural commodity" includes those commodities determined by AID/W to be surplus for this purpose. Until changed, this phrase includes the following commodities which have been continuously in world or U.S. surplus: rice, sugar, wheat, vegetable oils, citrus fruits, cotton, coffee, and tobacco.

The tide for food crops began to change in February 1966 (the same month Moseman made the above statement). President Johnson, in his "War on Hunger" message of February 10, emphasized the need to assist countries in balancing agricultural productivity with population growth and stated that the surplus concept should be eliminated in food aid. The Food for Peace Act of 1966, approved November 11, 1966, reflected this policy (Sec 103i). On March 7, 1968, AID issued a new manual order on policy with regard to agricultural production:

> A. In providing assistance in any form, priority shall be given to production of food crops for domestic use. Assistance may be given to production of food crops for domestic use, but priority shall be given to food crops so as to obtain a greater increase in availability of food for human consumption.
> B. Assistance may also be given to growing and harvesting food and feed crops for export <u>provided</u> that due consideration shall be given to the continued expansion of markets for United States agricultural commodities or the products thereof....
> C. Assistance may be given to programs designed to improve the storage, handling, processing, and distribution of food and feed crops.
> D. Assistance shall not be given to increase the production of nonfood crops in world surplus. However, consideration may be given on a case-by-case basis....

Another problem was quite different. During the 1960s (and in fact into the mid-1970s), centrally-funded agricultural research fell under a congressionally-imposed financial ceiling on all development research.[34] Originally set at $6 million, the overall ceiling was raised to a peak of $12 million

in FY 1965 and FY 1966, and then declined to $8 million in FY 1968 and FY 1969.[35] It is not known how much agricultural research, if any, failed to be initiated because of this ceiling. But the ceiling appears to have had a pernicious effect on the design of what was carried out. In order to fit under the ceiling, the developmental aspects of research projects were often eliminated from the research activity. Thus highly desirable complementary activities such as training, dissemination of information, and outreach were either not done or were at best picked up under other programs.[36] Hence the ceiling may have been costly in terms of agricultural research not undertaken or implemented.

Despite the substantial difficulties of the period, U.S. agricultural research specialists were not without a global vision. Moseman (1970:93,94) states that for a meeting of the Development Assistance Committee of the Organization for Economic Cooperation and Development in the spring of 1967:

> The U.S. delegation presented a proposal for strengthening international collaboration in adaptive research with special emphasis on (1) World Centers patterned after the International Rice Research Institute, (2) Regional Centers to be concerned with problems in the major ecological regions, and (3) National Centers for attention to localized problems. Each of the proposed types of centers would provide for research and for training of researchers and extension specialists.
>
> The response to the U.S. proposal was sufficiently favorable to encourage a follow-up conference which was held in late October 1967. This meeting, however, failed to identify specific problem areas or world or regional centers acceptable for mutual support by the DAC member nations. There was an evident reluctance on the part of the European nations to commit resources to long-range core support for world or regional centers, and a strong preference to retain maximum flexibility in collaborating via the bilateral pattern.[37]

While this concept exceeded the realities of research in AID at the time, internal changes soon took place that laid the groundwork for subsequent support of the international research system. AID began to provide funding to CIMMYT in 1969 and to three other

international centers in 1970. A Technical Assistance Bureau, which provided a needed focus on research, was established in late 1969. Thus a decade that began and continued uncertainly ended on a promising note.

U.S. Department of Agriculture[38]

USDA faced a somewhat calmer and more stable situation than AID with respect to agricultural research for the developing countries during the 1960s. Such activities were possible under two programs.

A Special Foreign Currency Research Program (SFCRP) was authorized by the Agricultural Trade Development and Assistance Act of 1954 (P.L. 480), as amended in 1958 and 1959. Although enacted in the late 1950s, the program did not attain substantial proportions until the 1960s. SFCRP made use of local currencies paid to the United States for P.L. 480 sales. It was administered by the International Programs Division of the Agricultural Research Service, USDA. From the outset, the program operated under the policy that any research undertaken should be relevant to USDA programs and should have a potential for producing results for the foreign country as well. Grants are normally made for a five-year period.

P.L. 480 sales were initially made to a number of countries that are now among the high-income nations. Therefore, not all of the grants have been made to countries presently considered developing nations. In FY 1965, for instance, out of total expenditures of local currencies equivalent to $7.16 million, only $2.26 million or 31.6 percent were spent in the developing countries, principally India (21.0 percent).

Under Section 406(4) of the Food for Peace Act of 1966, as amended, USDA was authorized to assist friendly developing countries by entering into research contracts or agreements with land-grant universities and colleges and other institutions, and by conducting research on food products and making the results available to friendly developing countries. For these and other activities the department was authorized to spend up to $33 million per year. Actual funding would not come from the Food for Peace Act but through regular USDA channels. None was provided in the 1960s.

The 1970s

From 1970 to 1976, agricultural research for the developing countries finally came of age within the Agency for International Development. Significant changes in outlook and funding took place. Within the

Department of Agriculture a research program that was authorized in the 1960s was finally funded.

U.S. Agency for International Development

Both the Technical Assistance Bureau and the regional bureaus sharply increased their financial support for research for and in the developing countries from 1970 to 1976. Three main avenues of support were involved: bilateral, multilateral, and contracts with American institutions. Total annual expenditures under these programs are estimated at about $50 million in FY 1976 and FY 1977.[39] At the close of 1976, a research-oriented Board of International Food and Agricultural Development was established under Title XII of the Foreign Assistance Act. Despite a marked increase in activities and funding, however, the number of research specialists on the AID staff remained small.

Bilateral Assistance. AID bilateral assistance to research is funded through the regional bureaus and country missions. The number of research projects has increased significantly in recent years. It is, however, difficult to summarize this activity because the research component may vary from virtually all to only a small proportion of a specific project.

Despite the reporting problem, an attempt has been made to identify the most significant bilateral research projects in Table 7.[40] Some projects are largely for institutional development while others focus on a specific commodity. The amounts listed include both research and related activities; hence they provide an exaggerated impression of the total amount devoted to research. Nearly every project has at least a small outreach component. Where the research component is known to be less than about 85 percent, the estimated proportion is listed in the footnotes. The table, however, excludes other projects where research is a small proportion of the total effort.

Despite these caveats, the global total of AID-sponsored bilateral research activities--both grant and loan funded--was clearly significant. And additional projects under consideration may substantially expand the total.

AID bilateral programs do not extend to every developing country. Some countries are currently excluded because they are relatively developed and/or have fairly high incomes (e.g., OPEC countries). Others are excluded for political or other reasons.

Multilateral Support. Multilateral assistance is principally in the form of grants to the international

Table 7. Major aid grants and loans to developing nations for agricultural research and related activities (proposed projects as of November 1976 in parentheses)[a]

Region and country	Grant Amount ($ thousands)	Grant Period (fiscal years)	Loan Amount ($ thousands)	Loan Date agreement signed	Total amount ($ thousands)
Asia					
Bangladesh	2,561	1976-78	4,000	3/29/76	6,561
Indonesia	1,540	1971-78			1,540
Indonesia[b]	(1,800)	(1978-82)	(7,000)	(proposed)	(8,800)
Korea			5,000	1/28/74	5,000
Nepal	5,000	1975-81			5,000
Pakistan[c]	2,696	1969-79	7,600	4/30/74	10,296
Philippines	806	1975-78	5,000	12/23/75	5,806
Philippines			(10,000)	(proposed)	(10,000)
Sri Lanka[d]			(4,200)	(imminent)	(4,200)
Subtotal*	12,603		21,600		34,203
Near East					
Afghanistan[e]	(15,000)	(1977-82)			(15,000)
Egypt[f]	8,000	1976-81			8,000
Egypt[g]	(1,600)	(1977-82)			(1,600)
Morocco[h]	(2,550)	(1977-82)			(2,550)
Yemen[i]	1,730	1976-81			1,730
Yemen[j]	2,792	1976-81			2,792
Subtotal*	12,522				12,522

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Africa					
Lesotho[k]	(6,373)	(1978-82)			(6,373)
Liberia	(3,424)	(1978-82)			(3,424)
Sierra Leone	(4,000)	(1977-81)			(4,000)
Tanzania	3,860	1971-82			3,860
Regional:					
East Africa[l]	4,788	1972-81			4,788
West Africa[m]	3,636	1970-76			3,636
West Africa[n]	4,542	1975-79			4,542
West Africa[o]	(6,500)	(1977-81)			(6,500)
Subtotal*	16,826				16,826
Latin America					
Brazil[p]			11,930	3/9/71	11,930
El Salvador[q]			4,000	11/30/72	4,000
Honduras[r]	(1,200)	(1978-80)			(1,200)
Paraguay[s]	(1,100)	(1978)	(5,500)	(proposed)	(6,600)
Uruguay[t]			4,850	12/5/75	4,850
Regional:					
Central America[u]	1,580	1975-78			1,580
Subtotal*	1,580		20,780		22,360
TOTAL*	43,531		42,380		85,911
Total proposed	(43,547)		(26,700)		(70,247)

*Excludes proposed projects.

See footnotes on page 102.

Table 7. Continued

[a]National and regional projects funded by regional bureaus. Virtually all projects include an outreach component; some include other activities. Where the research component is thought to be less than 85 percent of the total, an estimate of the research portion is indicated in the footnotes. The research portion of some proposed projects is not clear yet.
[b]Sumatra (outer islands) agricultural research project (principally rice).
[c]About 56 percent of grant ($1.5 million) for research. In addition, a grant of $7.4 million in local currencies was made in 1974.
[d]Rice research. Awaiting signature in Colombo.
[e]Agricultural research and development. About 50 percent research.
[f]Onfarm water use and management. About 60 percent research.
[g]Rice research and training. About 80 percent research.
[h]Applied rainfed agricultural research. About 70 percent research.
[i]Tropical and subtropical horticulture. About 50 percent research.
[j]Sorghum and millet. About 50 percent research.
[k]Farming systems research.
[l]Food crops.
[m]Major cereals.
[n]With the West African Rice Development Association (WARDA). (Exclusive of grant made through the CGIAR.)
[o]Semiarid food grains. About 75 percent research.
[p]About 80 percent research.
[q]Research, education, and extension. About 40 percent research.
[r]About 50 percent research.
[s]Research and technical assistance. About 66 percent research.
[t]About 60 percent research.
[u]Development of small farmer cropping systems at CATIE. In addition, a grant of $1.66 million has been made to CATIE to develop a Central American system for agricultural research and information management.

Source: Regional bureaus, AID.

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agricultural research institutions under the aegis of CGIAR, but also includes two other centers. Early in the 1970s, some of the international center funding went through the regional bureaus but was later shifted to the Technical Assistance Bureau (Table 8).

Once CGIAR was established, AID followed the policy of providing up to 25 percent of the total contributions to the CGIAR centers and programs.[41] Actual AID contributions are listed in Table 9 (also see Figure 4). AID also provides substantial funds to two non-CGIAR international centers (Table 9). Clearly AID multilateral support to agricultural research has risen sharply since 1969.[42] This increase was not initially viewed with enthusiasm by some individuals in the agency, but there is now general support for the centers.

Contract Research. Contract research also is carried out with American institutions or groups of institutions who have ties to various national or regional programs in the developing countries, or the international centers. The levels of funding for food and nutrition research from FY 1970 through FY 1975 are shown in Table 10.

Expenditures for agricultural research expanded significantly in the mid-1970s, and continued in FY 1976 and FY 1977. Levels and major categories in the latter two years are summarized in Table 11. The main changes were a sharp increase in nutrition research in FY 1976 and the inclusion of Title XII in 1977.

The congressionally-imposed limitation on all centrally-funded contract research, except on population, continued into the mid-1970s. The level was $9 million in FY 1970 and was raised to $12 million in FY 1974.[43] As in the 1960s, it is not known how much agricultural research was not initiated because of this limitation, but it continued to have the effect of reducing the development dimension of the projects funded. With the inclusion of Title XII in the Foreign Assistance Act, this limitation ceased to be a factor in new food and nutrition research funded in FY 1977 and thereafter. This is a long overdue development and should lead to a marked improvement in the utilization of AID-sponsored research.

Title XII. The inclusion of Title XII, "Famine Prevention and Freedom from Hunger," in the Foreign Assistance Act of 1961, as amended, provides a significant new dimension to AID activities. In addition to consolidating AID research activities, it authorizes an expansion and strengthening of collaborative research efforts involving U.S. universities and research institutions in the developing countries.

Table 8. AID funding to international centers prior to the establishment of CGIAR

Center	1969	1970	1971
		($ millions)	
IRRI		0.475	1.000
CIMMYT	0.425	0.625	0.769
IITA		0.320	0.535
CIAT		0.259	0.680
TOTAL	0.425	1.679	2.984

Table 9. AID grants to international agricultural research centers and programs[a]

Sponsored by CGIAR[b]	1972	1973	1974	1975	1976
			($ thousands)		
Centers					
IRRI[c]	750	725	1,100	1,925	2,150
CIMMYT[d]	1,090	1,500	1,350	1,765	2,550
IITA[e]	746	1,200	1,500	2,080	2,500
CIAT[f]	721	875	950	1,230	1,700
CIP[g]	100	340	550	575	1,000
ICRISAT[h]	100	745	1,000	2,060	1,900
ILRAD[i]			342	540	1,500
ILCA[j]			100	140	1,200
ICARDA[k]				50	200
Programs					
WARDA[l]			108	120	90
IBPGR[m]				80	200
CARIS[n]				90	
Subtotal	3,507	5,385	7,000	10,655	14,990
Outside CGIAR					
AVRDC[o]	600	600	600	600	600
IFDC[p]				4,100	5,100
Subtotal	600	600	600	4,700	5,700
TOTAL	4,107	5,985	7,600	15,355	20,690

[a]Contributions to capital construction/equipment and core operations through Technical Assistance Bureau. Excludes special projects and other activities.
[b]Consultative Group on International Agricultural Research.
[c]International Rice Research Institute, Philippines.
[d]International Maize and Wheat Improvement Center, Mexico.
[e]International Institute of Tropical Agriculture, Nigeria.
[f]International Center for Tropical Agriculture, Colombia.
[g]International Potato Center, Peru.
[h]International Crops Research Institute for the Semi-Arid Tropics, India.
[i]International Laboratory for Research on Animal Diseases, Kenya.
[j]International Livestock Center for Africa, Ethiopia.
[k]International Center for Agricultural Research in the Dry Areas, Lebanon, Syria, Iran.

[l]West Africa Rice Development Association, Liberia.
[m]International Board for Plant Genetic Resources (Genes Board), FAO.
[n]Current Agricultural Research Information System, FAO (temporary sponsorship).
[o]Asian Vegetable Research and Development Center, Taiwan.
[p]International Fertilizer Development Center, United States. Includes $6.8 million for capital construction and equipment.

Table 10. U.S. contract funding for food and nutrition research

Fiscal year	Agriculture	Nutrition	Total	Agriculture and nutrition as proportion of all research* (percent)
	($ millions)			
1970	4.574	0.603	5.177	62.4
1971	4.528	0.738	5.266	61.7
1972	4.927	0.703	5.630	65.6
1973	5.624	0.785	5.409	64.1
1974	7.632	0.901	8.553	74.5
1975	8.060	0.317	8.377	74.4

*Excludes projects support cost.

Source: Based on statistics by J. Ryan, Office of Program and Methodology, Bureau for Technical Assistance, AID, October 21, 1976.

Table 11. AID contracts with U.S. institutions for agriculture and nutrition research[a]

Topic	Fiscal year 1976 (obligations)	1977 (authority)
	($ thousands)	
Agriculture		
Crop production	3,569	3,310
Water, tropical soils	2,652	2,528
Livestock production	1,020	622
Agricultural economics	797	250[b]
Fisheries	30	400
Subtotal	8,068	7,110
Nutrition		
Subtotal	2,049	995[c]
Total agriculture and nutrition	10,117	8,105
Title XII		2,500[d]
TOTAL	10,117	10,605
Agriculture, nutrition, and Title XII as proportion of all research	73.0 percent	73.8 percent

[a]Contracts administered by the Technical Assistance Bureau. Data reported here exclude projects in the following areas: adaptation and application, field services, program development and support, and section 211(d).

[b]While the 1977 research figure decreases from 1976, there is a significant expansion in adaptation and application work ("Expanded Program for Economic Analysis") in 1977 which is not reflected here.

[c]The main change from FY 1976 appears to be due to the expiration of several projects.

[d]To be spent on collaborative research efforts under the advice of the Board for International Food and Agriculture Development.

Source: USAID (1976).

Title XII provides for a Board for International Food and Agriculture Development, which was named in August 1976 and held its first monthly meeting in October 1976.[44] In turn, the board has decided to establish two joint committees (to be composed of AID, USDA, university, and other personnel): research and agricultural development (including extension and education).

In the case of the collaborative research activities, it is expected that U.S. universities would work as a team with the collaborating foreign institutions either under a consortium or prime grantee/subgrantee (subcontractor) arrangement. Specialized competencies not available within the group would be drawn from other institutions. The AID budget for 1977 contains an allocation of $2.5 million for initial activities; cooperating U.S. institutions are also expected to contribute some resources.

The joint research committee has focused its initial efforts on establishing priorities for collaborative research projects. Three areas identified for early action include sorghum and millet, fisheries, and small ruminants (sheep and goats). The next step will be the distribution of research planning grants to further develop the collaborative projects.

U.S. Department of Agriculture[45]

USDA continued the Special Foreign Currency Research Program into the 1970s. But because of a shift in P.L. 480 repayment terms from local currencies to dollars, the number of countries with excess local currencies available for this purpose declined. Hence the program has become limited to a few countries with large local currency holdings. Expenditures in the developing countries totaled $2.16 million in FY 1970 and $3.1 million in FY 1975. In the latter year, the developing country expenditures were particularly concentrated in Pakistan (19.1 percent of world total) and in India (16.8 percent). In terms of new obligations in FY 1975, however, Egypt placed first.

Funding for the Tropical and Subtropical Research and Training Program (TSRTP) under Section 406(4) of the Food for Peace Act was first provided in FY 1974. In that year, $500,000 was appropriated with the following general guidelines:

-- Two research and training centers, one in Hawaii and one in Puerto Rico, would be established.
-- Land-grant colleges and state universities would be an integral part of the activities.

-- Research and training centers would be considered networks rather than fixed facilities.

Two primary objectives emerged: providing tropical training and experience for USDA and land-grant college personnel by working on specific tropical research problems under tropical research conditions, and providing foreign nationals a place to learn techniques and methodology under tropical conditions with U.S. specialists supplying the training.

As it has evolved, TSRTP now centers on the University of Hawaii and the federal experiment station at Mayaguez, Puerto Rico, designated as the Mayaguez Institute for Tropical Agriculture.[46] In addition, some universities have projects underway through ARS financed under Section 406.[47] Coordination is provided by the International Programs Division of ARS. Funding for TSRTP was $500,000 in FY 1975, $529,000 in FY 1976, and $681,000 in 1977.

Although all Section 406 activities to date have been with U.S. and Puerto Rican institutions, it should be possible to place USDA scientists in international centers or to make agreements with the developing countries.

In addition to these two programs, USDA also conducts some research projects under Participating Agency Service Agreements (PASA) with AID. Examples of current PASA projects with ARS include tsetse fly research in East Africa and work with major cereal crops in East and West Africa (completed in 1976; an expanded project is being developed for East Africa). Numerous USDA scientists also have been involved with AID-funded research projects over time.

POTENTIAL CONTRIBUTIONS OF THE UNITED STATES

We now come to the key questions of this inquiry: What can the United States do to further facilitate and improve agricultural research in and for the developing countries? And how might it be done?

Future undertakings in international research likely will involve greater emphasis on collaborative undertakings with both other donors and with the developing countries themselves. Collaborative arrangements may involve a greater degree of sharing in planning and in conduct than is traditional in a grantor-grantee relationship.

Reasons for Greater U.S. Participation

Why should the United States and other high-income countries make a special effort to improve agricultural research in and for the developing countries?

One of the most pressing reasons for U.S. interest is the need for continuing and greater increases in food production in the developing countries lest they are faced with the need for massive food imports in the future. Such imports would be an immense financial burden for both the developing and the high-income countries. The need for imports--and for concessional food aid--could be sharply reduced if it were possible to increase the rate of growth in agricultural production. New and improved technology is basic to this process. Research to devise this technology should be conducted by public and private research organizations.

To the extent that research contributes to increased food supply, it also will benefit consumers by moderating food prices. While the primary effect of research in the developing countries will be on food prices in those countries, there will be a secondary effect on food prices in the high-income countries such as the United States. Consumers in every nation are influenced by world food price levels. Thus consumers in the United States have an interest in improving agriculture in the developing countries.[48]

There are other reasons for U.S. interest in agricultural research. One of the most significant is that much of the product of agricultural research in one area has use in other areas. While such applicability is more true of basic than applied or location-specific research, there is usually something to be learned from research done elsewhere. The United States, for instance, is now raising offspring of the Mexican semidwarf wheats in large areas of the southwest.[49] In fact, the United States has been making use of plants and varieties from other nations for over a century.[50]

Perhaps the most important argument, however, is the humanitarian one. The developing countries urgently need help in agricultural research if they are to provide better for present and future generations. The United States has the resources and the skills to be of assistance. Other nations have latent human and agricultural resources. We can help them realize their potential.

What Needs to be Done by the United States?

The United States is supporting significantly the cause of international agricultural research. Nevertheless, there are several additional things the United States could do at relatively modest cost from which it could benefit, along with international agricultural research. In considering possible U.S. actions, we are proceeding on the premise that financial support for international agricultural research is primarily the responsibility of the federal government.[51] While funding is but one constraint on greater U.S. assistance, it is a major one.

The U.S. Agricultural Research System

If the United States agricultural research system is to make an increased contribution to the international system, it must increase general funding in real terms and provide continuing funding for international research activities.

Strengthening the U.S. System. Although the United States has perhaps the world's leading agricultural research system, portions of it have stagnated financially in recent years. Most of this stagnation has been in the public sphere--in the Agricultural Research Service and the Economic Research Service of the U.S. Department of Agriculture and in the state agricultural experiment stations. While public funding for agricultural research increased significantly in real terms from World War II through about 1970 (Peterson and Fitzharris 1977:77), the rate of increase has subsequently declined in real terms. For many public research groups (such as the ARS-state experiment station complex), funding has not increased in real terms since the late 1960s.[52] For some individual components, it may have fallen.

Thus the major concern of most research directors at the moment is to meet their domestic challenges. Until these are more fully satisfied, many are not inclined to expand their foreign activities unless there is additional long-term funding. Increased funding for public agencies as suggested in several recent studies and proposals (NRC 1975b:9,10,29-33) would be of immediate benefit to the United States. But it would also lay the base for an increased international effort.

While such an action would go a long way in bringing traditional public agricultural research institutions into better financial condition, it is not entirely sufficient. Many other private and public institutions in the United States are capable of making

substantial research contributions. A number of recent studies suggest increased funding of competitive research grants which could be provided by several governmental sources and would be available to a wide range of institutions on a competitive basis. We endorse such a system.

Support for International Research by Federal Agencies. At present the support for international agricultural research by American research institutions is rather limited. Most of the public funds come from AID and are limited to specific projects.

Outside of AID, federal agencies have virtually no funds available for international agricultural research. The small amount USDA has under Section 406 is inadequate to meet the demands placed on it. Requests from foreign governments or institutions (national and multinational) for U.S. assistance must be accompanied by funding in order for U.S. agencies to respond to them. Personnel ceilings also cause difficulties.[53] These and other factors limit the countries to which assistance can readily be provided.

The lack of internal budget support also creates difficulty in building up a group of scientists to concentrate on international agricultural research. No funding means no international positions in the United States. Those who serve overseas may find it difficult to secure an appropriate position once they return. They may receive little credit for career advancement or promotion (current promotion criteria at the higher grade levels, for instance, emphasize supervisory responsibilities while international assignments may give greater emphasis to advisory activities). Awards are less frequent. Research oriented to the needs of the developing countries may result in different types of products and/or publications than are commonly rewarded at home. Hence scientists may find in international service a clear risk for traditional professional advancement.[54]

Such problems could be alleviated if USDA, and to a lesser extent other agencies, could set up a core of international scientists funded by that agency. Different job descriptions might be written and a specialized incentive system established. Such a group would enable more effective responses to requests for assistance from a wide variety of developing countries.

Support for International Research by State Institutions. Only a few states (e.g., New York and Minnesota) provide funds for a small staff of international agriculturists at their colleges of agriculture. Some others may carry the equivalent of one or two international staff members.

Perhaps the greatest need of the state agricultural experiment stations is for continuity of funding of a

more general international agricultural research program than is presently conceived of under Title XII. While Title XII is expected to cover specific programs (e.g., research on sorghum) for a group of stations for several years, it is not expected to provide annual funding for all interested stations.[55]

Virtually every station has some special knowledge which could be used in an international context and scientists who have international experience or are interested in international service. Some talents will be utilized by Title XII, while others may be neglected. The challenge is to find some way of more fully realizing the international potential of these resources.

One way would be for USDA to provide modest annual funding to each interested station to provide the base for a continuing international effort (methods of doing this will be discussed later). The idea would be to provide the equivalent of one or more positions in international agriculture. These positions might serve as the center of an international focus that would largely be funded from other sources, for example expanded competitive grants by USDA and through Title XII. It would be necessary, of course, to establish certain criteria in order to qualify for and to continue to receive such allocations.[56]

Even so, such a program would not be without its critics. Some state groups may not welcome further international activities (Whitaker and Wennergren 1976:498).[57] Others would say that it would lead to a fragmentation of effort and that it would be more efficient to concentrate funds at established centers of excellence. They may be right in some cases, especially in the short run. But over the long run, we think that the returns from such widespread institutional and individual development and the resulting research could be very high.

Tropical Agricultural Research Centers. It has been suggested that one or more centers be established in the United States and Puerto Rico to conduct research (and train scientists) in problems important to developing countries in the humid and semiarid tropics but not of major importance in the United States (NRC 1975b:45). The centers also could provide, where needed, a tropical ecological base for U.S. scientists.

Our present reaction to this proposal would depend in part on the nature, number, and location of centers envisaged. While we do not see a need to establish numerous new institutes, we see some potential for expanded support of tropical research in existing centers in Puerto Rico and Hawaii, and possibly at one or two places in the continental United States. It is

possible to provide at least some funds for such activities through existing USDA and AID channels.

But it is questionable whether substantial funds should be concentrated on even a few centers because of (1) a limited domestic support in comparison to the Title XII and other funding proposals outlined previously, (2) the organizational difficulties of some multi-institutional tropical programs such as the East-West Center and the University of Hawaii, (3) the presence of many U.S. colleges with international programs and institutes, and (4) the probability that such centers would have a unique advantage in any expanded competitive grants program.

Thus while we would certainly encourage some increased support to tropical agriculture in a few locations, we would not urge large funding at this time. It is a topic, however, that needs more study.

Support for Other Groups. A limitation to the previous proposals is that they would initially be limited to federal agencies and to state institutions presently receiving formula funds. Many other groups, particularly of a private or semiprivate nature, are able to assist international agricultural research. We need to know the best way to provide them with continuous funding.

A number of study groups have suggested increased funding for competitive grants open to a wide range of U.S. research organizations. These grants, however, would generally be for projects and long-term support. Perhaps another fund could be established to provide stable, long-term support to a limited number of individuals and/or institutions carefully selected on a competitive basis. We believe this approach is worthy of further study.

International and Regional Research Activities

The United States has been providing support for research at the international and regional level, both through direct financial support of international agricultural research institutes and indirectly through international and regional organizations.

In terms of direct support, the main need is for continuity. The United States should continue support of the CGIAR international research institutes up to 25 percent of the total annual budget (excluding special projects). This policy has been extremely effective in terms of generating support by other donors and its usefulness should continue. The problem is that U.S. support for CGIAR activities in absolute terms is reaching rather substantial levels--$15 million in 1976 and $18.35 million in 1977 (in addition, in FY 1977,

$0.6 million for the Asian Vegetable Research and Development Center and $5.7 million for IFDC)--and this support increasingly competes with other items in the AID food and nutrition budget. Moreover, CGIAR funds are part of the AID budget, which always seems to be uncertain. Should AID funds for CGIAR be seriously reduced or delayed in any given year, the effects on the international centers could be very damaging. It would be helpful to find some way to provide a more secure basis of year-to-year funding.

The question of indirect support is difficult to summarize. It may be said that the United States is a member of various regional and international organizations (such as FAO, the Inter-American Development Bank, the U.N. Development Programme and World Bank) which either provide funds for agricultural research or for closely related activities. The composition and agricultural talents of the U.S. delegation to such bodies often varies. Usually the State Department has the main representational responsibility, assisted by AID and USDA. In the case of FAO, USDA has the main responsibility.[58] Because of the many groups involved and the heterogeneous composition of the U.S. delegation, it is difficult to keep the U.S. representative fully informed or to speak with one voice on research. Aside from ensuring that competent technical advice is involved in the preparations for these meetings (which often cover a wide range of topics), there does not seem to be a fully satisfactory solution.

National Research Systems in the Developing Countries

Much of what needs to be done to improve agricultural research in the developing countries lies outside the scope and responsibility of a high-income country such as the United States. Nevertheless, there are several areas where the United States can make significant contributions. Some of these are already underway and should be continued; others are more conceptual and are yet to be developed.

AID has provided loans and grants for the improvement of national systems and grants for specific research projects (sometimes directly and sometimes through other U.S. groups). The grant component in the AID programs to improve national research systems has been about half of the value of bilateral research projects in the past but is expected to increase in the future (Table 7). The major World Bank funds are only in loan form. Some developing countries may find themselves in need of more grant funds. Such funds could be particularly useful for starting innovative

new programs which might eventually be taken over by regular funding within the developing country. The foundations have provided considerable funding of this nature in the past, but these resources have been seriously constrained in recent years. It might be worthwhile to determine if the lack of grant funds is a serious constraint to developing country systems and/or whether increased availability might make a significant contribution.

A somewhat related need, also found in the United States, is for a source of relatively small but quick grants. Existing funding sources often tend to be highly bureaucratic and time-consuming. Because of this, in part, it is often relatively expensive and cumbersome to process small projects. Yet in research, unanticipated but very promising ideas can come forth which need to be explored. And some very good projects simply do not require much money. Further, the big grants tend to go to the big or well-known research groups. Individual researchers or those outside the establishment may receive little attention (we have noted that colleges of agriculture in many developing countries have only limited research funds). Hence a program that would quickly provide relatively small grants (e.g., up to $50,000) might have an unusually great impact.

The administration of this activity could be handled in several ways. Special programs could be set up in AID and USDA (both currently provide some small grants). Another alternative would be to use some other group. For example, the Agricultural Development Council once handled a successful small grants program that included U.S. researchers. The new International Foundation for Science (IFS) in Stockholm provides small grants, principally in the field of biology applied to food production, to young scientists already employed at a research institute in a developing country (Barnaby 1976:91). These annual grants are renewable for four years. IFS was established in September 1975 and by May 1976 had given 100 grants. The total revenue of IFS in 1976 is expected to be about $790,000. While the United States is not yet among the donors the potential for such programs should be studied further.

International Research Networks and Communication

One way the United States could encourage research networks would be to provide specific support for information management and to provide funds to both U.S. and developing country researchers for professional meetings, conferences, seminars, and other

travel. New or existing networks may need funds to maintain or improve their operations. In addition, the United States might encourage international groups such as FAO and OECD to provide similar support.

Another small but key communication gap is the lack of an international periodical specifically concerned with the general scientific and administrative aspects of agricultural research. At one time USDA published an outstanding quarterly, Agricultural Science Review, for an American audience, but it was discontinued in 1973. Refashioning such a journal, with additional attention given to major current developments in individual research systems, could be an excellent way of providing a communications network. At the moment there would not seem to be an international body, except possibly FAO, in a position to publish such a journal. Whether the leadership of FAO would favor this effort is, however, uncertain.[59]

There is also a need for improved monitoring of world agricultural research. Several years ago FAO initiated several projects in this area: the United States has provided direct support to the Current Agricultural Research Information System (CARIS) through CGIAR, and indirect support for another system (AGRIS) through its contributions to FAO. The CARIS effort did not elicit enthusiastic support, but work is underway and is expected to result in the publication of three directories (research institutions, scientists, major lines of work) in late 1977. The continuation of such work will depend upon a greater degree of long-term support than has thus far been available.

How Can the United States Carry Out these Actions?

It is one thing to talk about what needs to be done by the United States to encourage international agricultural research; it is more difficult to indicate specific legislative and administrative changes that are needed.

Public Sector

We have suggested that, among public bodies, it is primarily the responsibility of the federal government to assist international agricultural research. AID and USDA are the agencies most involved. Each faces a slightly different type of restraint on increasing its activities in international agricultural research.

Agency for International Development. The recent consolidation and expansion of Title XII has given AID

a stronger mandate and probably all the authority that it needs to participate in international agricultural research. Funding, however, is a less certain process. The difficulties of the AID appropriation process are well known. One may try to isolate research funds from some of the more extreme influences of this process, but no technique has been found that would fit within the current U.S. budget process and that would provide increased stability. We hope that this study conveys the need for stable growth in funding for agricultural research, particularly in the case of the rather substantial funds provided the international agricultural research institutes.

It is unclear at this point to what degree alternative funding should be considered for the ongoing support of international research in the states. We have suggested that USDA provide these funds through existing channels. But if they are not, the question arises as to whether they might be provided from foreign aid funds and either distributed directly by AID (through Title XII) or transferred to USDA for distribution. Even if they could be provided in this way, however, there may be little enthusiasm for such a program within AID. On the other hand, such a program could lead to more support from the states for the U.S. international research program.

USDA and the States. USDA conducts research and distributes federal research funds to the states. International research done by USDA and the states is, with the exception of the TSRTP program (Section 406), conducted with funds from other agencies or sources. Aside from the TSRTP program, virtually no developing country-oriented research is done with regular USDA-appropriated funds.

The lack of USDA-funded international research, either within its own program or in the funds distributed to the states, has somewhat different origins. In the case of in-house research, it is a policy not to utilize funds unless a substantial benefit to the United States can be shown (the same policy that is stated for the SFCRP P.L. 480 research activities).[60] In the case of funds that go to the states, the limitation to the United States is set by the phrasing of the Hatch Act.

Since the limitation on USDA in-house use of the funds is administratively set, it presumably could be administratively removed. However, this might be difficult to do. First, USDA probably would feel a need to consult with Congress, the Office of Management and Budget (OMB), and others about changing such a policy. Second, even if this policy were modified, the funds would still have to compete (as do Section 406 funds) with domestic uses.

The situation with respect to the state Hatch Act funds could be more complicated. Section 2 of the Hatch Act (as amended in 1955) specifically confines uses to "experiments bearing directly on and contributing to the establishment and maintenance of a permanent and effective agricultural industry of the United States." As interpreted and administered by USDA, this has meant that no international research is allowed. While this view does not appear to have been legally tested, a change in interpretation would probably require a change in the law. This might not be easy for several reasons, not the least of which is that the state experiment station directors have learned to work with the Hatch Act in its present form.

Thus some changes would seem needed before USDA is provided with additional funds for in-house research (unless this is done through Section 406) or distributed to the states through the Hatch Act.

Potential Changes in USDA Funding. Without the constraints outlined in the previous section, one might think simply of initiating a policy that states that a portion of increased general research allocations to USDA for in-house use and for distribution to the states could be used for international research. The proportions would be determined by the respective administrators in light of their own organization's international experience and interest. One difficulty is that the administrators would probably face considerable domestic pressures to use the funds on problems of local concern. Thus it might be necessary to clearly state that a certain portion of the additional overall funds, perhaps 10 to 20 percent, is to be used for international research.[61]

While it is possible that such an action could be taken through Section 406, the opportunities for Hatch Act allocation are uncertain. However, it should be possible to distribute funds to the states for international research on a similar basis as the Hatch Act under other authorization. The chief problem in either case, however, would be to secure a significant allocation from the agricultural committees in Congress purely for international research. Also, it would be difficult to devise a widely accepted means for distributing such funds to the states.

One possible distribution system might make use of a modified Hatch Act formula. If an initial annual appropriation of, say, $5 million was distributed to 50 states, the allocation would vary from a low of $33,500 to a high of $185,000 (Table 12).[62] The figures might be doubled the second year. These levels should be considered a promising starting point by most state institutions. Many would, of course, also be receiving Title XII and other funds. The use of formulas for

Table 12. Funding to states (and Puerto Rico) for international agricultural research: hypothetical allocation of $5 million*

State	Amount (dollars)	State	Amount (dollars)
1. Alabama	102,965	27. Nebraska	92,148
2. Alaska	34,269	28. Nevada	33,692
3. Arizona	44,730	29. New Hampshire	40,797
4. Arkansas	91,567	30. New Jersey	59,463
5. California	119,344	31. New Mexico	45,811
6. Colorado	60,109	32. New York	144,928
7. Connecticut	52,869	33. North Carolina	185,116
8. Delaware	36,164	34. North Dakota	68,926
9. Florida	82,888	35. Ohio	179,281
10. Georgia	116,921	36. Oklahoma	87,589
11. Hawaii	34,444	37. Oregon	69,653
12. Idaho	57,186	38. Pennsylvania	173,456
13. Illinois	168,101	39. Puerto Rico	123,887
14. Indiana	155,848	40. Rhode Island	33,536
15. Iowa	163,858	41. South Carolina	91,526
16. Kansas	97,868	42. South Dakota	71,669
17. Kentucky	148,605	43. Tennessee	138,678
18. Louisiana	88,259	44. Texas	171,688
19. Maine	48,421	45. Utah	40,683
20. Maryland	68,883	46. Vermont	43,518
21. Massachusetts	59,373	47. Virginia	117,758
22. Michigan	152,226	48. Washington	78,819
23. Minnesota	154,858	49. West Virginia	72,354
24. Mississippi	106,625	50. Wisconsin	154,195
25. Missouri	140,242	51. Wyoming	39,343
26. Montana	54,864	Administration (USDA)	200,000
		TOTAL	5,000,000

*The funds are distributed among states (plus Puerto Rico) on the following basis: divided equally among all states, 30 percent; farm population (1970), 33 percent; rural population (1970), 33 percent; and administration (USDA), 4 percent. The latter three proportions are similar to those provided in Title V of the Rural Development Act of 1972. Both the Rural Development and Hatch Acts include funds for regional research; this category has not been included here (and the 10 percent provided for this purpose in the Rural Development Act has been added to the 20 percent provided for equal distribution to all states). Calculations assumed that all states would wish to participate; if not, increased funds would be available to other states.

Source: Calculated from tables compiled by the Cooperative State Research Service, USDA.

distributing funds, however, is controversial and some other system may need to be found.[63]

We feel that federal support to the states for international research is a good idea, but much further study is needed to work out an appropriate system.

Expanding Current ARS Research Programs. In pursuing such concepts, one should not lose sight of the two programs of international agricultural research presently administered by the Agricultural Research Service: the Special Foreign Currency Research Program and the Tropical and Subtropical Research and Training Program.

SFCRP has operated for about 15 years. This program focuses on research problems of mutual interest, and has spent $40.7 million on research in 15 developing countries through FY 1975. SFCRP has proven to be a successful collaborative undertaking, although it is sometimes difficult to develop projects of true mutual value.[64] The major problem is that the present program is limited to a few countries where the United States has extensive (or "excess") holdings of local currencies from P.L. 480 sales. At the moment these are principally India, Pakistan, and Egypt. While local currency payments will continue to accrue in these countries for some time, there is no prospect, under existing P.L. 480 legislation, that they will accrue in other developing countries. Thus it appears little can be done to further expand or enlarge this program, unless it were decided to make dollar appropriations available for this work, or to substitute additional support to national research programs for part of the dollar repayment of the P.L. 480 loan.

It is possible that the latter might be done under the new loan forgiveness provision of the P.L. 480 act which allows, under certain circumstances, for a portion of the value of the loan to be used for local development purposes.[65] The implementation of this amendment is now being studied. Support for national agricultural research might be one use.

Although TSRTP was authorized in 1966, no funds were provided until 1974, and then only $500,000. The FY 1977 appropriation, however, was increased 26.5 percent over 1976. Funds for international research have to compete with all other USDA programs. Since USDA's primary orientation is domestic, this means that international research funds are a low priority. Even if they were given a higher priority by USDA, they would still have to be accepted by OMB and the congressional committees that handle the USDA budget. Hence unless USDA is given a stronger mandate to do international research by the administration and Congress, there is relatively little possibility for

substantially expanding this most promising program.

Research by Other Government Agencies. Many other government agencies have some interest and involvement in international agricultural research. We make no attempt to review them all.

One group that might play an increased rôle is the National Science Foundation. This organization has funded some basic research in the past related to agriculture, particularly on the biological side. But it might play a much larger role, particularly through contracts. It has the scientific capacity to venture into the more basic areas of research which may go beyond AID's and USDA's scope, and which in any case may be inappropriate for an essentially action-oriented agency.

There are, however, a few problems with NSF. One is that NSF, like USDA and AID, has its own measure of internal controls, clearances, and administrative machinery. NSF also seems too understaffed, at least in some areas, to handle adequately its present volume of research contracts. NSF's ability to handle an increased volume of international agricultural research would have to be studied.

The Private Sector

Could U.S. industry play a larger role in agricultural research in the developing countries? Given the free enterprise orientation of the United States, it would be tempting to hope so. The realities of the situation, however, are not quite as promising.

A mid-1960 study conducted in conjunction with the report by the President's Science Advisory Committee (PSAC), The World Food Problem, was revealing in this respect. Of 85 industrial firms contacted who belonged to the Agricultural Research Institute, 71 replied. Of the 71, 32 did not do any overseas research, and 39 did. The 39 firms who did, however, concentrated their activities in other high-income countries. The main operations in the developing countries, in terms of scientists, were in Argentina, Mexico, and Honduras (PSAC 1967:Vol. III, 213-277). The orientation of American firms to other high-income countries also was reflected in a more recent and more general report (Anonymous 1976b).

American firms contacted in the PSAC report indicated that they might increase their research operations abroad given increased stability of foreign governments and a reasonable degree of assurance of a financially successful operation. Of the 39, there were 32 who said they would conduct research and development in a developing country if supported by the

U.S. government.

Subsequently, some governmental support was given through AID to encourage American food firms to conduct investment feasibility studies for high-protein food products in the developing countries. Grants of up to $60,000 were provided. Products were adapted for use in the developing countries, but they were not widely used by low-income groups because of their cost. No direct U.S. investment resulted.[66] Moreover, the program did not elicit a favorable public reaction--not so much because of the product but because of the idea of government underwriting products that might eventually produce a profit for the American firm.

There is also a more complex problem. Left to its own devices, industry has concentrated on the development and sale of mechanical technology, which is often labor-saving. But many developing countries need technologies that increase employment. Often these needed technologies are biological in nature, and they tend to be relatively neglected in the usual mix of industrial research (Hayami and Ruttan 1971:165-166). Thus while profitable private research and development may, as one economist has recently suggested (Peterson 1966:324-326), be socially profitable, the social profit might be substantially greater for biological rather than mechanical technology.

If American industrial research in the developing countries is to be encouraged, it might in the first instance be in the area of biological research. American seed firms, for example, have been operating quietly and effectively within individual developing countries for years. Encouraging such research might be particularly appropriate. But even where such activities seem effective from a development point of view, they might not, as suggested above, always draw a positive reaction. And certain firms may not be well received by some within the developing countries. Multinational corporations have in particular been singled out for criticism in some quarters.

Coordination and Organization of Activities

If the increased activities outlined here are to be carried out by the United States, they would represent a substantial growth in activity by a number of public and semipublic agencies, and to a lesser extent, the private sector. How could the increased activities outlined here be given focus and coordination?

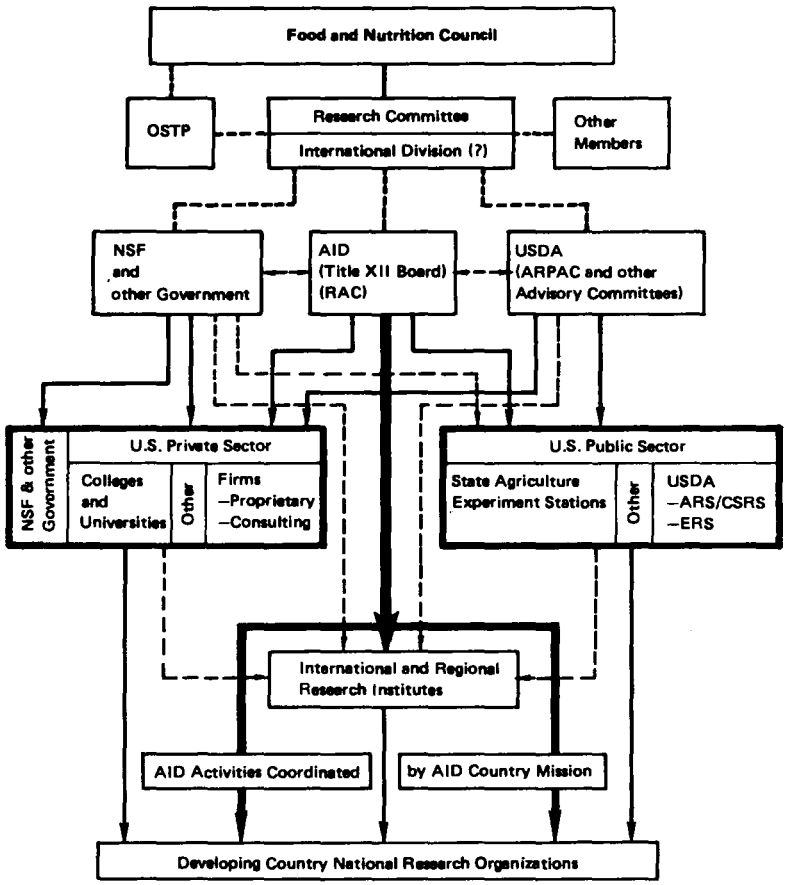
About 10 years ago, when a considerably smaller research program existed, the PSAC report (1967:Vol.II, 637) stated:

> A mechanism must be created to improve the coordination and implementation of United States efforts in food-population research....This would require the establishment of some kind of organizational unit through which most of the funds would be provided for research and education on world food-population problems. It would require an advisory council from other agencies and organizations.

The same basic idea of a coordinating group and/or an advisory council has emerged in several subsequent studies. A recent National Academy of Sciences report (NRC 1975b:9) suggested the establishment of a National Agricultural Research Policy Council representing federal and state agencies. A similar but somewhat more broadly based advisory board to advise the Secretary of Agriculture on research strategies was suggested in the proposed National Agricultural Research Policy Act of 1976.[67] Under Title XII a Board of International Food and Agricultural Development has been created which will have a Joint Research Committee. AID already has a Research Advisory Committee. While these and related activities and proposals clearly provide ample precedent for the establishment of a coordinating body and related advisory council, they also, in a sense, crowd the way.

In order to systematize and organize the U.S. effort in the food and nutrition area, Study Team 14 proposes the establishment of a national Food and Nutrition Council in the Executive Office of the President. The council would in turn have several major committees, one of which would be concerned with food and nutrition research. This committee would be composed of members of the board involved in this subject and would have a small staff. Whether this group should in turn have a subcommittee on international agricultural research is uncertain. In any case, the dominant federal interest in international food and nutrition research would be in AID and USDA. NSF and other agencies would have less direct involvement but would have some, and perhaps a growing, interest. Private industry would presumably be represented in some way on the board or on the research committee.

The possible organizational relationship between these groups is outlined in the upper portion of Figure 6. It is assumed that the council and the research committee would have only advisory functions (shown by dotted lines); they would not be directly responsible for procuring funds from Congress, although they might advise the President and the Office of Management and



Note: Dotted lines indicate advisory and coordination linkage, not direct funding. Solid arrows indicate principal linkage (including funding). Dotted arrows indicate secondary linkage (including funding).

FIGURE 6 U.S. program of international agricultural research: possible organization and flow of funds.

Budget on such matters. The individual agencies would continue their present practice of going to Congress for their appropriations. Presumably the major agencies also would continue to sponsor and support their present research activities and facilities. These are shown on the lower half of Figure 6.

While the organization pattern outlined would seem to encompass most of the major elements considered at present, the matter of advisory groups might prove to be a complication. Differentiating the functions of existing AID and USDA research advisory groups from those of a multiagency advisory group might present some problems. The existing boards, including the recently established Title XII board, might not welcome another group, particularly if it would usurp some of their powers. Various federal agencies also may have to devote considerable human resources to servicing and participating in board meetings.

These are substantial problems. Yet the benefits received from having a supra-agency advisory committee for agricultural research should compensate. Eventually it should be possible to work out territorial rights between the various advisory groups and to begin to see complementarities.[68] The Research Committee of the Food and Nutrition Council might, for example, be more concerned with broad policy issues than the agency advisory groups. The agency groups might find the research committee of assistance in obtaining support for their budgets.

The final resolution of these matters will depend on the roles defined for some of the new groups (such as the Joint Research Committee of Title XII). Clearly, though, some form of increased research coordination is needed if the United States is to carry out an expanded agricultural research program in the most effective manner.

* * * * *

While recommendations of needed changes in U.S. agricultural research organization are important, such changes should not be allowed to dominate the spotlight or to become an end in themselves. Their basic purpose, in the context of this report, is to lay a better domestic base for improving agriculture in the developing countries. The small farmer and the rural poor are of particular concern in this process. They and the developing country itself can seldom be helped by a simple transfer of "big" science and technology from high-income countries. The development of appropriate local technology, over the longer run, can generally best be done by research within the developing nations themselves.

Appendix A

FRENCH INTERNATIONAL AGRICULTURAL RESEARCH

France initiated a program of scientific and technical cooperation in agriculture with what were then its colonies just after World War II. As these countries began to obtain independence, starting with Madagascar in 1960, a program of contractual, bilateral cooperation was established with each.

Groupement d'Etudes et de Recherches pour le Developpement de l'Agronomie Tropicale (GERDAT)[69]

GERDAT is composed of eight commodity institutes and a farm machinery institute, principally funded by the French government. The individual institutes are: Centre Technique Forestier Tropical (CTFT), Institut d'Elevage et de Medecine Veterinaire de Pays Tropicaux (IEMVT), Institut Francais de Recherches Fruitieres Outre-Mer (IFAC), Institut Francais du Cafe, du Cacao et Autres Plantes Stimulantes (IFCC), Institut de Recherches Agronomiques Tropicales et de Cultures Vivrieres (IRAT), Institute de Recherches sur le Caoutchouc (Rubber) en Afrique (IRCA), Institut de Recherches du Coton et des Textiles Exotiques (IRCT), Institut de Recherches pour les Huiles et Oleagineux (IRHO), and Centre d'Etudes et d'Experimentation du Machinisme Agricole et Tropical (CEEMAT).

Both GERDAT and each institute have a headquarters and/or central laboratory facility in France and utilize a network of about 50 national stations in the developing countries, almost entirely in Africa. In some instances, such as IEMVT, the GERDAT institute may manage the station. Generally, however, stations are used according to the terms of agreement with the specific country in which they are located. The more important base stations are: Cameroon, N'Kolbisson (IFCC); Chad, Fort Lamy (IEMVT) and Bebedja (IRCT); Dahomey, Pobe (IRHO); Ivory Coast, Bouake (CTFT, IEMVT,

IRAT, IRCT), Bingerville (IFCC), and Bimbresso (IRCA); Madagascar (Malagasy Republic), Tananarive (CTFT, IEMVT, IRAT), Ilaka-Est (IFCC), and Tulear (IRCT); and Senegal, Dakar (IEMVT), Bambey (IRAT), and Darou (IRHO).

The other or secondary stations are comparatively small and not as well equipped. Other African countries with one or more GERDAT secondary stations include: Central African Republic, Congo-Brazzaville, Ethiopia, Gabon, Mali, Mauritania, Niger, Reunion, Togo, Uganda, and Upper Volta. Elsewhere, GERDAT-affiliated stations are found in the Caribbean (IFAC)--Guadeloupe, Guiana, Martinque; in Asia, New Caledonia (CTFT, IFAC); and in Cambodia, New Hebrides, and Polynesia (all IRHO).

As of 1971 the overall GERDAT staff totaled 650 experts and supporting technical staff, 300 technical officers, and associated administrative officers and working staff. The member institutes issue 10 periodicals and have contributed to a number of commodity books.

According to one secondary source, the 1974 budget totaled $54.6 million. This was composed of salaries, 76.2 percent; operations, 22.0 percent; and equipment 1.8 percent (Charreau 1975).

Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres (IRAT)[70]

IRAT was founded in July 1960 and is a French private law corporation. Its headquarters is located in Paris and the technical services and central laboratories at Nogent-sur-Marne. IRAT does both crop and general agricultural research. The principal food crops studied are rice, sorghum, millet, and corn. The general agricultural research includes farming systems in several ecological zones.

In terms of operations:

> Each country specifies its program of work according to its priority and knowledge and work carried out in other countries with similar ecological conditions. This allows IRAT to direct its work concerning the main food crops on a regional basis.

IRAT research in various agricultural disciplines is supported by work carried out in France in connection with universities or the GERDAT facilities in Montpellier.

As of 1969, the IRAT staff was composed of 140 senior scientists, 40 stationed at headquarters and 100

abroad; and 75 technical research assistants, 25 at headquarters and 50 abroad. The total budget in 1969 was about $7.1 million (fr 37 million) and by 1975 had increased to $11.1 million (fr 47 million). It was financed from four sources: the French Aid and Cooperation Fund, the French Overseas Department Investment Fund, international funds, and contracts with individual governments and organizations.

Appendix B

JAPANESE INTERNATIONAL AGRICULTURAL RESEARCH

TROPICAL AGRICULTURE RESEARCH CENTER[71]

In 1966, Japan initiated a Tropical Agriculture Research Unit under the Research Council of the Ministry of Agriculture and Forestry. This unit was reestablished in June 1970 as the Tropical Agriculture Research Center (TARC). A new headquarters and research facility was completed in Tsukuba New City in 1974. A branch station is located in Okinawa.

TARC's objective is to contribute to the development of tropical agricultural technology by carrying out research at both the center and abroad. The most important activity is the undertaking of joint or cooperative research programs with scientists located in tropical and subtropical countries. As of 1975, TARC had 93 staff members, 67 of which were research scientists. Of the scientists, 35 were engaged in research work in Brazil, Indonesia, Malaysia, the Philippines, Sri Lanka, Thailand, and at IRRI, ICRISAT, and CIAT.

In addition to cooperative research programs, TARC sponsors an annual international symposium, invites foreign scientists to study in Japan, and provides information services, including the publication of the Japan Agricultural Research Quarterly.

Report of Subgroup C, Study Team 14

DEVELOPMENT OF RESEARCH PERSONNEL

INTRODUCTION

This subgroup was charged with assessing research personnel requirements for international food and nutrition programs. We reviewed the need to: (1) increase the number of trained research personnel, (2) improve the quality of training and educational programs, (3) improve the planning and management of international training, and (4) strengthen training and educational institutions.

While undertaking this study, we drew extensively from similar discussions going on within the Food and Agriculture Organization and the regional meetings on international agricultural training that were sponsored jointly during the spring of 1976 by the U.S. Agency for International Development, the International Science and Education Council (ISEC), and the Association of U.S. University Directors of International Agricultural Programs (AUSUDIAP). These discussions generally reinforced our thinking regarding research personnel requirements (particularly in the developing countries) and future training needs. We have attempted to move beyond general recommendations about international training to specific actions that should be implemented in the United States if existing deficiencies in research personnel, especially those found in most developing countries, are to be systematically addressed and eventually alleviated.

INCREASING THE NUMBER OF TRAINED RESEARCH PERSONNEL

Presently, there is no accurate, comprehensive profile of research personnel resources in the developing countries. FAO is attempting to develop such an inventory through its Current Agricultural Research Information System program and expects to have initial survey data available by mid-1977. In the meantime, we proceeded with somewhat incomplete and greatly aggregated data (see Table 13) that do not

clearly delineate a profile of the worldwide agricultural research personnel situation. They can only serve as a general guide to show the extreme imbalance in numbers of researchers between the industrially developed countries and the developing countries.

Projections of the numbers and types of research personnel needed to staff food and nutrition research programs, especially in the developing countries, also are difficult to make. This is partly due to the number of different and sometimes conflicting assumptions that can be used to address the question, "What ought to be?" Many of these issues involve decisions relating to the organization of national research capacity, the level of possible and/or acceptable international cooperation, or even the question of what constitutes "sufficient" research capability.

The complexity of the problem is reflected in the proceedings of the FAO conference on agricultural research held in Rome in 1975 (FAO 1975b). The conference participants concluded that research is chronically underfinanced, often not well aligned to national needs and priorities, and is suffering from an acute shortage of trained scientists. Clearly, from these statements the problem is difficult. On one hand they conclude that there is an acute shortage of researchers, but, on the other, those available are underutilized because research is improperly oriented and/or inadequately funded--the problem of effectiveness. Even if we assume that existing efforts and recommendations will improve the financing of food and nutrition research, we still have to determine just how wide the gap is and where it is widest. In discussing this question, FAO's Rome conference (FAO 1975b) reported:

> 73. A recent FAO assessment of numbers of qualified agricultural research workers and technicians in developing countries, based on the most up-to-date information from regional surveys indicates that there were approximately 3,600 in Africa, 3,750 in Latin America, 4,200 in the Near East, and 7,700 in Asia and the Far East--a total of 19,250, excluding China with an estimated 5,500 workers, and Japan with 3,850.
>
> 74. These figures are not directly comparable with data quoted by Evenson [1973] for 1965 showing a total of 9,850, since the latter only covers 58 developing countries in respect of crops and livestock, whereas

Table 13. Estimated number of scientist-years allocated to agricultural research in 1974 by country and region

Country	Number of scientist-years
Western Europe	
Denmark	560
Finland	242
Iceland	35
Ireland	490
Norway	480
Sweden	300
United Kingdom	3,310
Austria	110
Belgium	800
France	1,240
Germany	3,000
Netherlands	1,100
Switzerland	325
Greece	390
Italy	1,200
Portugal	500
Spain	670
REGIONAL TOTAL	14,752
Eastern Europe and U.S.S.R.	
Bulgaria	960
Czechoslovakia	4,100
Hungary	1,500
Poland	5,150
Romania	3,200
Yugoslavia	1,970
U.S.S.R.	33,350
Other	2,026
REGIONAL TOTAL	52,256
North America and Oceania	
Australia	3,200
New Zealand	700
Canada	1,520
United States	7,500
Other	19
REGIONAL TOTAL	12,939
Latin America	
Argentina	880
Chile	192
Paraguay	131
Uruguay	100
Bolivia	50
Brazil	2,000
Colombia	870
Ecuador	200
Peru	220
Venezuela	160
Costa Rica	71
El Salvador	85
Honduras	72
Mexico	1,000
Nicaragua	34
Other countries	792
REGIONAL TOTAL	6,757
Africa	
Morocco	65
Sudan	140
U.A.R.	800
Cameroon	96
Chad	30
Dahomey	16
Gambia	5
Gabon	5
Ghana	140
Ivory Coast	110
Liberia	16
Mali	35
Nigeria	300
Senegal	160
Sierra Leone	36
Upper Volta	11
Zaire	85
Burundi	28
Ethiopia	65
Kenya	280

Country	Number of scientist-years
Africa	
Malagasy Republic	80
Malawi	75
Mauritius	65
Rwanda	18
Tanzania	145
Uganda	80
Botswana	16
Lesotho	10
Rhodesia	180
South Africa	1,000
Swaziland	12
Other countries and regional organizations	535
REGIONAL TOTAL	4,806
Asia	
Cyprus	52
Iran	500
Israel	110
Turkey	580
Syria	540
Bangladesh	190
Sri Lanka	130
India	2,150
Pakistan	280
Indonesia	380
Malaysia	240
Philippines	620
Thailand	725
South Vietnam	20
China	16,000*
Hongkong	12
Japan	14,000*
South Korea	650
Taiwan	400
Other countries	330
REGIONAL TOTAL	38,359
Regional total for Asia (excluding China and Japan)	8,359

*FAO estimates the number of research workers in China and Japan as 5,500 and 3,850, respectively.

Source: Boyce and Evenson (1975).

the FAO data cover more countries and all sectors of agriculture. While comparisons of data for individual countries suggest that there has probably been an overall improvement, two factors need to be borne in mind. These are:

(i) The summarized figures conceal the fact that roughly 50 percent of all the workers in developing countries are concentrated in five countries--Brazil, Egypt, India, Pakistan, and the Philippines. In this respect the situation has changed little since 1965.

(ii) Even assuming that there had been no increase since 1965 in the scientific establishment of the 26 economically "developed" countries listed by Evenson, they would still have, with 45,000 scientists in the crop and livestock sectors alone, more than twice as many scientific workers than all developing countries in all sectors of agriculture in 1975. The imbalance is striking in relation to the urgent problems faced by the latter, and suggests that shortage of trained manpower remains the principal restraint on strengthening their national research efforts.

75. Narrowing this gap should therefore be a main aim of national and international effort, but it is difficult to assess the magnitude of the problem because we have no "overview" of the need and no consolidated record of existing training programmes.

76. Allowing for an annual wastage even as low as 10 percent, approximately 2,000 scientists per year would have to be trained just to hold the present inadequate level steady; and given the present concentration of force in a few countries, there is clearly an enormous job of training new entrants to be done for most other countries. Assuming optimistically that present numbers of agricultural scientists in developing countries were to be doubled by 1985, at least 50,000 would have to be trained during the next decade. This excludes the equally important task of retraining and updating both scientists and production

specialists, which the standards of entrants for the "in-service" training programmes of the International Centres indicates to be of the utmost urgency. Training of middle level technicians is also vital; in many countries inadequately trained supporting staff is a major constraint on the work of scientists.

It is clear from these deliberations that the training task is a large one and that many new scientists must be trained annually just to maintain the present inadequate levels. It also is clear that the international scientific community does not have enough information on the numbers and types of trained research personnel presently working in agricultural research, and on the numbers and types of scientists being trained each year in educational institutions in the developing countries.

Even data on foreign researchers presently being trained in the United States are often highly aggregated. For example, the data in Table 14 for numbers of foreign students studying in U.S. universities in selected years show enrollment trends, but fail to differentiate between fields of study within agriculture. However, these data do show that U.S. universities substantially contribute to training scientific personnel on a worldwide basis. Thus continued emphasis should be placed on developing and maintaining appropriate, high quality educational programs in these universities if the quality of international research is to be maintained.

These data should be supplemented with similar information from other educational and research institutions around the world if they are to be useful in maintaining an accurate profile of research personnel availability by field of study and country. Data on the total numbers of scientists being trained in various disciplines are available for the United States on an annual basis (Table 15), and they provide useful information on research training trends in the United States. However, in the United States research priorities (expenditures) and research training tend to go hand in hand; therefore, these data may not reflect accurately future requirements for research personnel.

Conclusions

The availability of trained, competent research workers in most developing countries is grossly inadequate. Presently, around 2,250 foreign graduate students are studying agriculture in U.S. universities,

of which only 519 or 23 percent are being directly supported by AID. Given the soaring costs of higher education in this country and the problems of training foreign research personnel in a different cultural and ecological setting, the developing countries must continue to develop their own research training capability. However, to help meet the short-run research personnel requirements of many developing countries as well as to help these countries build a research training capacity:

- We recommend that the United States substantially increase its commitment to training research personnel from the developing countries.

Specific recommendations for using additional resources are found in a later section.

To help guide and direct these training efforts.

- We recommend that current efforts to survey the availability of existing research personnel (including numbers of scientists, by field of study and level of training) on a country-by-country basis be completed, and that the current educational and training capacity of educational institutions in the developing countries be surveyed and described.

IMPROVING THE QUALITY OF TRAINING PROGRAMS

Most U.S. educators feel that training programs for scientists in world food and nutrition research should be strengthened substantially. Larger numbers of scientists should be trained in this area, and training programs should be modified continually to fit the changing needs of trainees and of national research programs.

In the United States, an almost infinite range of educational programs exists for research scientists. However, there are some problems in utilizing this potential. First, there is a lag in adjusting the support for these programs to the changing problems faced in world food and nutrition research. A report by the Board on Agriculture and Renewable Resources of the National Academy of Sciences (NRC 1975b) stresses the need to strengthen educational programs for both basic and applied scientists in this overall area. The present deficiencies relate in part to the "food surplus mentality" of public administrators during recent years. This mentality has resulted in a shift

Table 14. Numbers of foreign students studying agriculture in U.S. universities by regions in selected years

Region	1964-65[a]				1969-70[b]				1973-74[c]			
	Undergraduate	Graduate	Other	Total	Undergraduate	Graduate	Other	Total	Undergraduate	Graduate	Other	Total
Africa	254	252	62	568	117	218	25	360	153	329	36	518
Far East	103	775	57	935	143	1,038	75	1,256	263	1,103	37	1,403
Near and Middle East	144	273	16	433	101	263	14	378	96	218	9	323
Latin America	330	275	44	649	455	440	50	945	323	491	82	896
Subtotal	831	1,575	179	2,585	816	1,959	164	2,939	835	2,141	164	3,140
Oceania	5	55	4	64	19	50	2	71	14	39	1	54
Europe	44	159	65	268	43	195	57	295	60	175	12	247
North America	144	137	12	293	155	150	9	314	106	80	2	188
Unknown		1		1	16	31	1	48	12	46	1	59
TOTAL	1,024	1,927	260	3,211	1,049	2,385	233	3,667	1,027	2,481	180	3,688

[a]IIE (1966), [b]IIE (1971), [c]IIE (1975).

Table 15. Numbers of earned master's and doctoral degrees conferred by institutions of higher learning in the United States in selected fields of study (agricultural and food sciences, and selected biological sciences) for selected years

Fields of study	1964-65[a]		1969-70[b]		1973-74[c]	
	Master's degrees	Doctoral degrees	Master's degrees	Doctoral degrees	Master's degrees	Doctoral degrees
General agriculture	72		69		220	3
Agronomy	239	110	294	185	271	156
Soil science	59	71	87	77	87	72
Animal science	237	117	301	159	370	129
Dairy science	75	29	48	32	55	27
Poultry science	57	15	38	20	46	10
Fish, game, and wildlife	72	15	177	51	295	58
Horticulture	136	80	146	68	166	45
Ornamental horticulture	6	2	16	5	24	2
Agriculture and farm management	8	2			14	10
Agricultural economics	329	128	406	181	415	165
Agricultural business			4		27	3
Food science and technology	103	34	153	99	197	88
Forestry	272	51	327	97	408	78

Natural resources management	*	*	*	*	160	26
Agriculture and forestry technology	*	*	*	*	8	12
Range management	*	*	*	*	43	19
Other agriculture and natural resources	91	3	144	30	133	27
Agricultural education	368	28	476	49	474	27
Foods and nutrition	115	16	210	30	407	51
Home economics education	448	14	712	15	607	20
Plant pathology	73	81	132	105	90	82
Plant physiology	17	21	21	40	16	34
Entomology	151	132	220	173	198	172
Bacteriology (general)	341	225	469	359	57	36
Microbiology	Included in bacteriology		Included in becteriology		452	348
Molecular biology	*	*	14	31	25	57
Cell biology	*	*	*	*	5	9
Marine biology	*	*	*	*	99	25
Genetics	63	86	71	95	97	93
Nutrition, scientific	62	21	118	47	144	81

*Not listed as a specific group during these years.

Sources: Baker, et al. (1976), Hooper (1970), and Mason and Rice (1967).

of research funding away from food and nutrition. Since graduate-level training is closely tied to ongoing research programs, training activities in this area have lagged. This is particularly critical in view of the substantial proportion of the agricultural scientists from the developing countries who are trained in U.S. institutions.

A second problem is that too little effort has been made to adjust teaching programs to the students' changing backgrounds. The educational programs of most major U.S. universities should be equipped to train researchers in the practical aspects of agricultural production. The era in which almost all U.S. students in agriculture had farm backgrounds has passed. The majority of today's agricultural students, from both the developing countries as well as most of the high-income countries, are generally unfamiliar with the practical side of agriculture.

Third, there is limited knowledge about the complexities of food and nutrition problems in the tropics and subtropics. During the 1950s and 1960s, the professional staff from some U.S. universities participated in food and nutrition research and training activities abroad. However, in recent years technical assistance programs have not provided the opportunities for the continuous collaborative research and scientific exchange that are essential. Thus the competency of U.S. scientists in international agricultural research, developed at great cost to both universities and donor agencies, is presently not being used effectively and is rapidly diminishing. This should not be allowed to occur. Practically no federal funding is being invested currently to maintain, let alone update, U.S. educational programs directly relevant to students (both domestic and foreign) specializing in international food and nutrition problems.

Training Programs for Research Educators

The most effective method of alleviating the long-term research personnel needs in food and nutrition research is to continue to develop universities and colleges with quality programs in these areas. In countries where the educational capacity for research workers is weak or nonexistent, strong baccalaureate degree programs should be developed in the agricultural and food sciences, nutrition, and the related social sciences.

As the colleges of agriculture and the allied basic and social science departments become strong, most countries will need to establish graduate programs. To

do so, national universities must have access to ongoing, broad-based research programs.

At first, universities in the developing countries probably will lack the staff to offer a full complement of graduate courses in a specific field of study. As graduate programs are developing, appropriate mechanisms (such as cooperative degree programs) should be developed with U.S. and other national/regional universities to fill in the gaps.

Developing Subject Matter Competency

In most fields of study there are a number of highly competent universities around the world that have excellent graduate programs for the individual who plans to return home to teach. However, there is a need for these programs to emphasize priority research areas and to treat the problems of international agriculture in greater detail.

This need was recognized in the regional meetings mentioned earlier held in 1976 and sponsored by AID, AUSUDIAP, and ISEC. At these meetings, the U.S. educational community saw a need to upgrade the international aspect of agricultural courses to achieve greater flexibility in the curriculum and to improve the balance between academic and nonacademic training. Specifically, they saw a need to: (1) strengthen institutional resources for training in international agriculture, (2) encourage training at home whenever possible, (3) support more relevant academic training programs, (4) provide opportunities for faculty awareness and utilization of other disciplines, and finally, (5) provide appropriate interdisciplinary training programs for international students.

We do not intend to detail the specific characteristics of a curriculum for international agriculture. However, such a curriculum should prepare students who have little or no practical experience in agriculture and a limited understanding of the problems of the rural poor to identify and solve problems in their professional area, to recognize critical needs in their own countries, and to respond to these needs.

Students should learn the scientific principles essential to solving problems in their professional area. However, they also should recognize that even though these principles do not change, their application of them changes quite rapidly. Thus there is a need for training programs that give students a solid foundation in the basic sciences, but that also have a strong problem solving orientation, providing up-to-date information and practical experience in the applied areas of food and nutrition research.

The fact that students can go through baccalaureate, master's, and doctoral degree programs in the agricultural sciences and never step onto a farm is a problem in reaching training goals. If research educators (and scientists) are to be problem oriented, concerned, and competent about increasing food production and alleviating malnutrition, then the appropriate practical training should be provided where students lack this type of experience. Many people agree that this type of experience is important, but few institutions or agencies have taken the responsibility of ensuring that students get these experiences.

Training also must be at the appropriate level to meet specific needs. Not all training and educational programs should be oriented toward degree training; however, foreign educators within their national universities will generally require advanced degrees. In addition, given the lack of research opportunities in many universities in the developing countries, some research educators would benefit from an updating or upgrading educational activity, which might be in the form of staff exchange, additional course work, or postdoctoral research training.

Developing Teaching Skills

There are at least two problems in developing appropriate professional skills and attitudes among foreign students studying in U.S. universities. First, many foreign students who come to the United States for graduate work in the agricultural sciences have some type of fellowship support rather than working as teaching (or research) assistants. Pursuing full-time graduate studies minimizes the time and cost necessary to complete a degree program, but it also preempts the opportunity, which many U.S. graduate students must pursue out of financial necessity, to gain valuable on-the-job experience working as a teaching assistant with the undergraduate program. Furthermore, even if the decision were made to give foreign students who plan to return home as research educators this experience, implementing this type of program would not be easy due to language problems and to foreign students' lack of familiarity with local production problems. At the same time, however, if U.S. universities are going to prepare foreign students adequately to return home as research educators, they should be provided with comparable experience.

Conclusion

After reviewing current efforts to train research educators, we concluded that the following program changes should be encouraged:

- -- High priority should be given to the continued development of relevant curriculum for training food and nutrition researchers in institutions in both the high-income and developing countries.
- -- Practical training exercises should be developed by universities, and students who lack this background should be required to complete this training before graduation.
- -- Training programs should be made more flexible (or take advantage of existing flexibility) to encourage interdisciplinary training directed at solving specific problems in the student's home country.
- -- The skills and knowledge of the university faculty members in the developing countries should be upgraded through study leaves and other opportunities for scientific exchange.
- -- Students who definitely plan to become research educators should be given specific training to develop their professional teaching skills prior to graduation.
- -- Institutional cooperation between universities in the high-income and developing countries for the purpose of executing graduate-level academic program should be encouraged and supported.

Training Programs for Research Scientists

To develop national food systems, research scientists are needed to conduct: (1) work in the basic sciences to maintain existing technology and to enable future technological breakthroughs; (2) research to improve production technology which will increase the quality and quantity of food products; (3) research to produce postharvest and food processing technology, to reduce food losses, and to increase the utilization of food supplies; and (4) social science research to anticipate and assess the consequences of technological change, to develop food and nutrition policies, and to assist in the development and dissemination of food production and utilization technology.

Program Needs for the Basic Scientist

Basic research scientists must be highly trained in their respective disciplines, but they also should be aware of current research in fields of study closely related to their own. Therefore, scientists trained to work on the high priority research areas within food and nutrition programs must maintain a full understanding and appreciation of multidisciplinary, problem-oriented research.

The methodology of training individuals in the basic sciences will probably follow the traditional pattern: giving advanced graduate students and postdoctoral fellows the opportunity (through assistantships and fellowships) to work with the best research scientists on high priority research projects. Particularly where these projects directly tie into ongoing work at the international or regional centers in the tropics and subtropics, predoctoral students and postdoctoral fellows should be encouraged (and supported) to go into the field and carry out research projects in these areas.

It is not uncommon for basic research scientists to get totally involved in the theoretical aspects of a problem and to neglect the possible technological spin-off benefits that might result from their work. Giving scientists from the United States and other high-income countries the opportunity to work in the tropics and subtropics as part of their advanced training will help make them more sensitive to the food and nutrition problems faced by poor nations.

During the next decade, much of the basic research work related to world food and nutrition problems probably will be done in the more developed countries because of the existing research infrastructure. Even so, the developing countries must cooperate with the advanced research institutes and universities in the tropics and subtropics, including giving advanced training to research personnel in these institutions. After returning home these individuals would probably become key collaborators in future joint research projects.

In larger countries such as India, Brazil, and the Philippines, which already have a considerable research infrastructure, the national research capacity could be strengthened through collaborative research projects. Furthermore, new resources allocated to the priority areas could mean new breakthroughs. Therefore, collaborative research with competent scientists and agricultural research institutions in the tropics and subtropics becomes important, if not essential.

Frequently scientists in these countries lack resources (particularly foreign exchange) to buy the

equipment necessary for comparable research in their own environment. Also, the high cost of international travel makes it difficult for developing country and U.S. scientists to meet for analysis and planning purposes. Much of this work can be done by correspondence, but direct meetings between collaborators, at least once or twice a year, are essential for rapid progress.

Program Needs for the Production Scientist

Most research workers in crop and livestock improvement programs need at least two basic types of skills and knowledge. First, they must be good farmers and husbandrymen. Unless research workers can grow a good crop or properly feed and care for livestock, it is doubtful that they can contribute to national food production through research. Second, they need analytical skills in order to make accurate observations and critical judgments about technological innovations. A third type of skill, which at least a few production scientists need, is the creative ability of a research inventor.

Within the overall research continuum the assignments of research workers in food production programs can be classified into three phases: (1) translating knowledge into technological components (partially a central experiment station activity), (2) testing technological components under local ecological conditions (branch experiment station activity), and (3) combining and testing different technological components to develop a production technology or package appropriate for local use.

Probably the most familiar research activity, under the first phase of developing new technological components, is the task of the plant breeder who develops new, improved crop varieties or populations. Combining at least 20 different desired genetic characteristics within a single variety is a complex and time-consuming process. Usually it takes a minimum of 10 to 12 years in the United States to develop and release a new variety of wheat. The scientist's creative ability in this area must be developed largely through extensive research experience which makes staff continuity so important.

Testing new technological components under local environmental conditions requires good research and farming skills. Less experienced scientists should be assigned to this activity. Extensive field experience would sharpen their creative skills and insights as to how physiological and ecological factors interact to affect production.

Developing new farming practices or systems is a complex research task requiring good analytical and production skills as well as creativity and insights into relationships between production factors. Again, research and production skills can be handled systematically by combining academic and on-the-job training in an ongoing research program, but the creative skills of the biological inventor/scientist come largely from extensive field experience.

One problem associated with this last group of trainees is that large numbers of production research workers are needed. Agricultural technology tends to be location-specific so that each ecological region needs production research workers who can modify and improve technologies used by farmers. To meet this large research personnel requirement, there is a need for a multiplier effect through a national training mechanism.

We feel that the experience gained from several relatively successful regional production programs such as Masagana 99 in the Philippines, Operation Armadillo in Brazil, and the Puebla Project in Mexico provides useful guidelines about how national training programs for production research personnel should be organized. Specifically, these programs concentrate on training large numbers of field-level research (and extension) personnel, the critical research link between the experiment station and the producer.

In most developing countries outside assistance will be required to develop a national training capacity for these production-oriented field research personnel. International centers are in a unique position to help train leaders for such programs, but these centers do not have enough outreach staff to help large numbers of developing countries set up such national production research and training programs. The United States should increase substantially its efforts to strengthen the research capacity in the developing countries by supporting national training programs for field-level production research (and extension) workers. Where the developing countries lack this training capacity (either within the national university or the ministry of agriculture), international centers and U.S. universities should work together to assist national institutions in implementing these training activities. Wherever possible, these programs should be handled by the national university or college of agriculture. This linkage with national production and training programs should keep the regular degree programs of these educational institutions tied more closely to production problems in the field.

A serious impediment to training large numbers of production-oriented scientists and technicians in the developing countries is the lack of prestige currently associated with production research. We recommend that this problem be studied further and that actions be taken to reward scientists who carry out essential research activities.

Improving a farmer's production technology is a complicated and demanding research assignment requiring competent research personnel. It is a serious mistake to put all of the best trained research scientists in central research laboratories. Each phase of the research process needs senior-level, experienced research personnel (generally M.S. and Ph.D. level) who can direct and implement research tasks as well as analyze and ensure the use of research findings. Younger, middle-level research workers and technicians (B.S. and M.S. level) with research and production skills to carry out day-to-day field operations are needed to support senior-level research scientists.

Program Needs for Food Preservation and Utilization

Increasing food production will do little to alleviate malnutrition and hunger unless more attention is given to the utilization side of national food systems. Strengthening a nation's research capacity to study and solve problems of food storage, processing, and preservation and of food distribution and of human nutrition requires trained research workers in both the technical and social sciences.

Several major research efforts are needed in the developing countries. First, safe, inexpensive methods of food preservation and storage must be developed (see Study Team 6's report, "Food Availability to Consumers"). Particularly in the humid tropics, microbiological activity is high and the nutritional value of many foods once harvested will deteriorate rapidly. Rodents cause significant food losses because of storage problems. The economics of food preservation and storage is critically important in the developing countries because food preservation and processing techniques used in the industrialized nations are frequently too costly for general use. Therefore, innovative scientists are needed urgently to work on low-cost, village-level types of food preservation and storage technology.

A second major effort should be made in the area of policies and economics of food distribution. Issues of food distribution generally are tied into larger questions of national development. Even so, the problem of moving food from producers to consumers and

the related distribution problems are very important in increasing the efficiency of national food systems.

Third, more attention must be given to nutrition research and education to ensure the effective utilization of food by consumers. The developing countries must learn more about the nutritional problems and deficiencies faced by consumers (especially the very poor) and how people living in food-deficit countries can make the best nutritional use of existing food resources. There also is a need for research into the problems of disseminating information on nutrition to millions of consumers who have little or no knowledge about nutrition and nutrition-related health problems.

The training needs of research workers in the food storage and preservation areas (particularly agricultural engineering and the food sciences) are similar to those of research personnel in agricultural production. Academic training in the appropriate field of study is necessary and can be handled effectively by many universities. However, practical training in the research itself requires more attention. Much of the problem stems from the fact that research in this area has received only low-level support; therefore, training opportunities and procedures are lacking generally.

Program Needs in the Social Sciences

Social scientists play an important role in both food production and utilization. The social consequences of technological innovations often can be assessed by social scientists who, if working closely with technical scientists, can make suggestions about the appropriateness of alternative innovations.

The social scientist also can help remove institutional bottlenecks in the technology delivery system. For example, credit procedures in many developing countries make it difficult for small producers to have access to improved technology. Organizing small producers into credit unions or cooperatives as well as helping banks streamline credit procedures are important research tasks for social scientists.

Agricultural policies regarding the allocation of scarce resources within the agricultural sector also have a considerable effect on the potential use of research results as well as on determining what types of research should be undertaken. Likewise, food price and distribution policies have major consequences for a nation in terms of achieving social and developmental goals.

Social scientists working in operational research programs within national food systems need basic training in their respective disciplines and on-the-job experience. To date, successful training programs that could provide these operational research skills for social scientists have been very limited. Several international centers have small-scale training efforts underway in association with regular technical research programs. It would appear that operational research training programs for social scientists can best be carried out in the context of their own national or provincial production/utilization programs. For this reason, international training and exchange activities are somewhat more difficult to implement due to the language, institutional, and cultural factors of individual nations.

Because problem-oriented research training for social scientists is important for the development, dissemination, and utilization of new technologies, we recommend that it be determined how this type of training activity can be carried out more effectively, and that greatly expanded multidisciplinary training opportunities be provided for social and agricultural scientists so that a closer working relationship can be developed.

Conclusion

Increased attention should be given to the entire range of research scientists that are needed, especially by the developing countries, to generate knowledge and to develop technologies to solve immediate and longer term food production and utilization problems. Wherever possible, U.S. universities and other agricultural research institutions should join the international research centers in helping the developing countries initiate their own research training programs. Specifically, we concluded that:

-- Increased attention and resources should be given to training field-level production research workers within national programs, drawing on the recent experiences of successful production research and training programs in other countries.
-- International centers should continue, and, wherever possible, expand their training programs for research scientists.
-- Competent research workers within national programs should be rewarded for effective production research work by being selected for additional academic training and for international conferences

and workshops that are organized to address serious research and development problems.

-- Increased attention should be given to training scientists for research on food processing, storage, and utilization.
-- Increased efforts should be made to include social scientists in research and development programs and to include social scientists and technical assistance workers directly in national production training programs.
-- Renewed attention should be given to the more applied research within U.S. state universities so that graduate students (both foreign and domestic) will have the opportunity to gain practical research experience within academic degree programs.
-- More opportunities for graduate-level and postdoctoral research training in the basic sciences should be made available to younger scientists from both the high-income and developing countries, especially in those disciplines related to the high priority research areas.
-- Collaborative programs should be established with selected universities and research institutions in the tropics and subtropics where advanced-level graduate students and postdoctoral fellows can gain research experience working under tropical and subtropical conditions.

Training Programs for Research Administrators

Three types of administrative personnel are essential to a nation's food and nutrition research: policymakers, research directors, and research or experiment station managers. These administrators allocate scarce research resources and are key individuals in determining the effectiveness of research programs. However, the skills and knowledge needed by these three types of research administrators are different; training objectives and methods must reflect these differences.

Program Needs for Research Policymakers

The leaders responsible for allocating national resources seldom are trained in agriculture, and frequently they have a low regard for agriculture in relation to more prestigious industrial projects. The world food crisis and higher food prices have pointed out the importance of strengthening national food production systems. It is extremely important that

these leaders are aware of the alternatives for developing agriculture and the costs and potential returns of these alternatives. Only then can they make reasoned decisions regarding the development of national food and nutrition programs.

Policymakers in the area of agricultural research need short-term orientation programs so that they can learn about food production problems and the possibilities that exist through research and increased investment in the agricultural sector. Frequently, giving these policymakers the opportunity to interact with their counterparts from other developing countries where agricultural research and production are given high priority is the most effective mechanism for laying out policy alternatives and guidelines.

Program Needs for Research Directors

Research directors must allocate scarce resources among different research activities and administer programs at a regional or national level. The research director requires two types of skills: general administrative and program decision making. Administrative skills include the ability to deal effectively with the different publics served by the research organization (i.e., producers and/or consumers), with intermediate organizations within the technology delivery and/or utilization systems, and with superior governmental officials (e.g., the minister of agriculture). To maintain the performance of research workers, there has to be some type of organizational structure, rules of behavior, and a system of sanctions (positive and negative). Most of these administrative responsibilities are well known and can be readily taught.

The decision-making skills of a research director are critical to the short-term and long-term success of a research organization. Research directors must make decisions on the allocation of scarce research resources, taking into consideration the potential technological payoffs.

There is a saying around research organizations that captures some important folk wisdom: "A good research director must first be a good scientist." However, many scientists lack basic administrative skills. The problem is complicated in some countries where economic rewards and prestige can be obtained only by pursuing higher level administrative positions. In these cases, where the criteria for advancement are based largely on seniority, it is difficult for those with a good balance between research and administrative skills to be selected for higher level research

administration.

Some administrative training should be given during degree training to those agricultural researchers who might assume administrative roles soon after returning home. When researchers are forced into administrative positions because of economic necessity, donor agencies and other international organizations should provide and/or facilitate incentives (e.g., research grants, opportunities to participate in research conferences) to keep good scientists active in research and to let those individuals who are more inclined toward administrative work move into these types of positions.

Program decision-making skills are learned largely through broad-based research experience, not through formal training. These are mostly judgmental skills based on a thorough knowledge of the research process and research alternatives. Presently, agricultural economists are devoting considerable attention to this problem and are attempting to develop analytical tools that a research administrator could use in supplementing this decision-making process. Technological innovation is a complex process and it is too early to assess the usefulness of this work.

Most research directors do not have time to attend academic degree programs in research administration, so these training needs must be handled on a short-term and more ad hoc basis. International centers, regional research and educational institutions (such as IICA, SEARCA), and/or U.S. universities should provide the leadership in this area. When new analytical techniques are developed that can aid program decision making, traveling seminars may be an appropriate way of transmitting these skills to research administrators in the developing countries.

In addition to short-term formal training programs, we believe that junior-level research administrators should have the opportunity to get on-the-job experience working with competent research administrators in other countries.

Research directors also need the opportunity for regular professional exchange with their counterparts from other national programs in the region. Both regional and international mechanisms for reviewing research policies and programs should be encouraged and facilitated whenever possible.

Program Needs for Research Managers

On the agricultural production side, there is a critical need for effective and efficient experiment station managers. Experiment stations must be properly laid out and supporting research tasks correctly

carried out so that scientists conducting field research can obtain precise empirical data on which to base production recommendations.

An experiment station manager should have basic administrative skills and should be a good farmer. He or she must know how to operate farm machinery as well as how and when different cultural practices (e.g., seedbed preparation, planting, weeding, cultivating) should be carried out. An experiment station manager also must have a basic understanding of the research process as well as good interpersonal skills. Accommodating the varied demands of a number of scientists during peak labor periods can be difficult.

Experiment station managers play an essential role in research and development activities, but their efforts frequently go unrewarded. Opportunities for advancement are limited. The result is that the poorest trained and/or poorly motivated research personnel are frequently assigned to these positions. Incompetence or lack of continuity in the management of experiment stations is an important obstacle to effective field research in many national research programs.

Since station managers require many skills which are not easily handled through formal training programs, we recommend that more opportunities be made available, possibly at the international centers or arranged in cooperation with a national experiment station in the region, for on-the-job or apprenticeship training. As an apprentice, the trainee should learn all the production skills and techniques of operating a farm as well as how to work directly with researchers.

A station manager who returns home to manage a station should receive the same salary and career benefits as a research specialist. Station managers should be encouraged to become involved in applied research trials and other research activities to make their job more interesting and to give them more incentive to ensure that the best possible data are collected.

Experiment station managers are not related to either professional (disciplinary) or commodity groups. For this reason, they frequently are overlooked for training. In cases where job-specific training cannot be arranged, a possible alternative would be a production training program such as the one on rice production at the International Rice Research Institute.

Conclusion

Several steps must be taken to improve the training of research administrators:

- -- Orientation programs should be established and kept current to keep policymakers aware of new technological developments in food and nutrition research institutions.
- -- Specialized short courses should be developed and made available to research directors to upgrade their decision-making and administrative skills.
- -- Individuals who are specifically preparing for administrative assignments should receive academic training in research administration. Some administrative training should be given to foreign graduate students where there is a high probability that they will return home to take up administrative assignments.
- -- International centers and/or regional research and educational institutions (e.g., SEARCA and IICA) should take the lead in developing and executing nonacademic training programs for research administrators.
- -- Practical training and on-the-job experience should be provided for experiment station directors and research managers.

IMPROVING THE PLANNING AND EXECUTION OF INTERNATIONAL TRAINING PROGRAMS FOR RESEARCH PERSONNEL

Educational programs for researchers in food and nutrition should receive serious, continuous support. Mutually supporting relationships between teaching, research, and public service activities should be encouraged, but educational activities should not be completely dependent on research programs. We believe the time has come to handle the task of developing research personnel more systematically so that key deficiencies are identified and appropriate training models are employed to resolve them.

Systems for Improved Planning

During the past decade a number of models have been suggested for improving the effectiveness of educational activities, and many of them have proven to be useful. In spite of general agreement among researchers and educators that these models substantially improve training, limited use has been made of them. For example, considerable emphasis has

been placed on completing graduate degree thesis work in the student's home institution, yet this model is used by a very small proportion of the participants. Even the concept of "training as close to home as possible" recognizes a basic conflict between the desirable and the practical.

The primary reason these models have not been used more extensively is that there is no existing mechanism to ensure implementation. Therefore, results have been sporadic. If sustained and systematic action is not taken to improve training efforts, there will be a strong tendency to provide "what is available."

Educators are beginning to look more seriously at the key issues in international training and are making specific recommendations for improving these programs. The actions of several U.S. groups during the past year have resulted in an increased awareness on the part of the U.S. academic community of the problems and needs of international training. We support the attention now being given to international training and recommend that the momentum developed at the U.S. AID-ISEC-AUSUDIAP regional training meetings be utilized. Furthermore, we support the concept of an international advisory committee for training.

Conclusion

Specifically, we recommend that the Board for International Food and Agricultural Development (BIFAD) be requested to form a joint committee on international education under Title XII of the Foreign Assistance Act to:

-- Cooperate with national and international research organizations in the developing countries (perhaps with a committee under CGIAR) to assess personnel requirements and to mobilize the resources required to overcome serious personnel shortages in international food and nutrition research.
-- Work with appropriate U.S. groups such as the International Science and Education Council and resident instruction sections of U.S. university associations to monitor and assess U.S. training efforts in food and nutrition research both domestically and abroad.
-- Establish systems to: (1) communicate specific training opportunities to universities in the developing countries, (2) more effectively communicate training needs to training institutions in the high-income countries, (3) develop acceptable standards of excellence for specific course offerings, and (4) facilitate more

cooperation between institutions in the high-income and developing countries in executing academic programs for research personnel.

-- Provide counsel to BIFAD regarding how training efforts in food and nutrition programs can be continually improved.

Improving the Management of International Training

The management of international training is at best a difficult undertaking. Parents know that the outcome of training their own children is uncertain. U.S. schools and colleges, both public and private, observe well-planned educational programs that fail with one student while succeeding with another. In international training many obstacles stand in the way of realizing optimal objectives. Thus the management of training assumes major importance if training objectives are to be realized.

At least four parties are involved in establishing an international training program: trainee, home agency or institution, training institution, and sponsor. A training program is most likely to be effective when all parties are in reasonably close agreement on the content and objectives of training.

Key Elements in International Training

The management of a training program for foreign participants in the United States (or some other third country) requires the following elements:[72]

In-country Preparation. The five key tasks performed in this phase of the training cycle include: (1) planning by host country personnel, (2) determining project and training objectives, (3) identifying and selecting participants, (4) preparing, gathering, and transmitting documentation, and (5) preparing and orienting participants prior to departure.

Prearrival Actions in the United States. Six tasks are performed at this point in the training process: (1) analyzing the training request; (2) determining the adequacy of documentation and information received from the host country; (3) analyzing academic or professional credentials; (4) determining the need for pretraining upgrading, including English language capability and prerequisite courses needed; (5) identifying potential training resources; and (6) arranging placement.

Orientation upon Arrival in the United States. At this point the necessary tasks are: (1) furnishing

port of entry services; (2) providing a general and cultural orientation; (3) reviewing the training plan with the trainee, host institution, and sponsor; (4) providing prerequisite work as needed in English, math, or other areas; and (5) doing any housekeeping chores such as housing arrangements, registration, and assigning program adviser.

Program Monitoring. Management functions during the training program include: (1) reviewing transcripts and progress from the training institution; (2) maintaining contact with trainee and adviser; (3) making program adjustments; and (4) making arrangements for field trips, special courses, on-the-job training, and other related activities.

Post Training Review. Once the trainee has returned home there are three follow-up functions: (1) training program review, (2) training utilization, and (3) subsequent follow-up and evaluation.

Conclusion

We recommend that careful attention be given to developing and maintaining an effective, uniform system to manage and coordinate the programs at the national (U.S.) and international levels. We also feel that the recommendations from the meetings on international agricultural training sponsored by AID, ISEC, and AUSUDIAP be implemented (see the Appendix).

STRENGTHENING TRAINING AND EDUCATIONAL INSTITUTIONS

During recent years the world community of educational and research institutions has developed a substantial capacity to train personnel in food and nutrition research. Yet much has to be done to mobilize and improve this capacity. Since the responsibility for executing training programs rests with these institutions, they must have adequate resources to carry out recommended programs.

Strengthening U.S. Educational Institutions

Table 14 indicates that the number of foreign students studying agriculture in the United States has increased slightly during recent years, remaining at about 3,500 students annually. This figure represents a highly significant input into the international research system. If we add to this an even larger number of U.S. students who enter the field of international research, either directly or indirectly,

it becomes clear that key changes in the U.S. system could influence worldwide research in a relatively short period of time. All indications are that foreign students will continue to demand training, especially at the doctoral and postdoctoral levels.

On most U.S. campuses there is a surprising array of resources that could be used to further develop educational programs in international agriculture. These resources include: (1) a large agricultural faculty experienced in international agriculture; (2) faculty in areas other than agriculture who are increasingly aware of and interested in world food problems; (3) an increasing number of consortia serving as mechanisms for aggregating expertise and promoting collaboration among universities; (4) research networks including working relations with the international research centers; (5) long-standing linkages with institutions abroad; (6) area study, language, and research centers specializing in various aspects of international education; (7) strong state teaching, research, and extension programs to provide a base for international activities; and (8) a substantial number of foreign and U.S. students interested in international agriculture. On many campuses these resources are not fully utilized because there have been no means--including operational funds--for mobilizing them at the working level.

Title XII legislation has brought about a series of activities on most campuses that indicate a willingness to direct programs toward world food and nutrition problems if there is a possibility of adequate funding.

Conclusion

One way in which the educational capacity for training food and nutrition researchers could be substantially strengthened in U.S. institutions is by providing long-term formula funding to support faculty specializing in international food and nutrition problems. Specifically, individuals working under this program would be expected: (1) to carry on collaborative research with colleagues in the developing countries, (2) to maintain strong working relations with personnel in the international research centers, (3) to develop and teach specialized courses dealing with international food and nutrition problems, and (4) to advise foreign and internationally-oriented domestic students as well as to work with these students on their thesis research problems.

Scientists supported by this program would be ideally suited to strengthen U.S. educational programs. Collaborative research projects with former students in

the developing countries and with international center scientists would keep these individuals up to date on research findings overseas. This expertise would result in these scientists serving as the essential "scientific interface" between the U.S. and foreign scientific communities.

Another means for strengthening the U.S. educational capacity for training food and nutrition researchers would be to provide support for U.S. graduate students and postdoctoral fellows to do research on international food and nutrition problems through a competitive grants program. The proposed competitive grants program would give predoctoral and postdoctoral students an opportunity to conduct research overseas, either at an international center or in association with a university or research institute in a developing country.

Strengthening International Research Centers

International research centers are well suited to conduct commodity-oriented production research and thus are an important resource for certain types of training. At the 1974 World Food Conference (FAO 1975b) it was pointed out that:

> The international institutes also perform a major training function. They provide in-service training fellowships for young scientists, facilities for doctoral and postdoctoral research, and special training in agricultural economics, laboratory technology, experiment station management, and courses for research directors. At any one time there may be up to 150 people on these longer courses at the older Centres. There are shorter courses (for which there is a large unsatisfied demand) to train production specialists for on-farm testing and demonstration of experimental results linking adaptive research to extension work. This overall output of trained people is not only of great value to the developing countries, but contributes a major input to the Centres' programmes since they are all actively involved in the mechanics of the research in their training, and when they return to their own countries provide strong working linkages between the Centres and the national system. This helps to provide an antidote to the "brain-drain" in science: a recent evaluation of the training programmes of CIMMYT and IRRI shows that an

> encouragingly high proportion of ex-trainees are still employed by their countries in activities directly relevant to their training.

The problem is that the training capacity of these centers and regional educational institutions such as SEARCA and IICA is limited (estimated by FAO to have a capacity of around 800 trainees per year). In discussing possible approaches to increasing training, the FAO conference (1975b) noted:

> The training capacity of International Centres or regional research institutions (such as SEARCA, IICA) might be expanded. However, the older established International Centres might have difficulty in expanding training without their research work suffering. To what should they give priority in training--scientists, managers or production specialists?

Furthermore, while international centers are in an excellent position to provide many of the essential research and development skills that national production scientists need, they are not designed to provide trainees with the essential theoretical background that all researchers need. Educational programs of this type are best handled by universities. However, until more national educational institutions start producing substantial numbers of graduates, foreign universities in other developing countries, as well as in high-income countries, will have to help bridge this training gap. Therefore, for the immediate future there must be a close working partnership between the international centers and universities in the United States and other high-income countries as well as with national universities and regional training institutions in the developing countries.

In addition to international training programs, more in-service training programs are needed within national programs for production agronomists, production economists, and other technical assistance personnel (e.g., extension workers) who are conducting applied research trials on farms or otherwise providing technical advice and new inputs. International centers can play an important role in this process, but it appears they do not have the resources to work with large numbers of national training programs. U.S. universities, particularly through the Title XII program, are in an excellent position to work jointly with national programs and the centers. Therefore, we recommend that resources be made available to facilitate collaborative training programs.

Conclusion

International research centers are already well organized for the development and promotion of their existing activities. It is presumed they could use similar procedures to expand training programs if they chose to do so. As is the case with the university community, specific funding for training is important. Unless this funding is made available, any expansion in training activities probably would detract from research funds, resulting in a conflict between the two programs. The centers and major donors should consider increased financing for training activities. Specifically, we recommend that support be given to increasing the capacity of the international research centers to develop and maintain in-service and special short-term training programs for scientists and research administrators. We also recommend that support be provided so that doctoral and postdoctoral students and exchange scientists might conduct research at the centers.

Strengthening Educational Institutions in the Developing Countries

We must set forth some basic assumptions this study team made before discussing how the developing countries can best undertake the task of developing research personnel. First, each nation must invest the necessary resources in research to meet its technological needs in the area of food production and nutrition programs. The technical assistance of donor agencies and governments such as the United States can aid in this process, but this assistance will be of minimal importance until strong leadership for agricultural and nutrition research is forthcoming from individual national programs.

Second, training programs for research workers in the developing countries should be undertaken in and/or as close to the home country as possible. This is not to say that institutions of higher learning in the United States and other high-income countries are no longer needed. In fact, the graduate programs of universities in these countries will be important in alleviating shortages of high-level research personnel during the next two decades and probably longer. There also is an urgent need to train more middle-level research personnel and technicians (B.S. level). Most of these personnel will have to be trained in educational institutions in local or neighboring countries.

Third, each country must decide which types of research or institutions should be given priority in both the short and long run. We feel that very small, very poor countries should build enough research and development capacity to meet their immediate technological needs by adapting and modifying technological components developed by other national or international programs.

The efforts of U.S. universities to establish institutions during the 1950s and 1960s helped lay the groundwork so that a number of countries could meet their requirements for research personnel. Many of these fledgling institutions still need additional support but this is not to say that the institutional situation in many developing countries has not changed.

The need for faculty from U.S. universities to staff teaching positions in the developing countries should continue to decrease. However, as national educators take over the teaching responsibilities in these institutions, the availability of textbooks, references, and other instructional materials relevant to local problems and conditions still will be extremely limited.

Conclusion

Major emphasis should be placed on (1) the further development of established institutions in the developing countries through scientific exchange in research, teaching, and public service activities, and (2) the development of new national and/or regional educational institutions where research personnel needs demand it. Title XII could be the principal source of U.S. funding for these programs. Thus the Joint Committee on Agricultural Development and the Joint Committee on Research provide important support for and link to the developing countries. Specifically, we recommend that U.S. universities continue to assist in building national educational capacity. We strongly recommend that university institutional development programs, with modifications to reflect changing needs, be fully reinstated within U.S. technical assistance efforts through Title XII. We also recommend support for developing country efforts to train production-oriented, field research personnel. Where the developing countries lack this training capacity, international centers and U.S. universities should work together to assist them.

RECOMMENDATIONS

The United States should take action in the following areas to strengthen training and educational institutions both in the United States and in the developing countries, to increase the number of trained research personnel, and to improve the quality of research training programs.

Graduate Fellowship Programs

Given the enrollment trends shown in Table 15, it is estimated that there are currently around 2,250 foreign graduate students from the developing countries studying agriculture in U.S. universities. In 1976, AID supported 331 master's degree candidates and 188 doctoral degree candidates, or about 23 percent of the total number of foreign graduate students from the developing countries who were studying agriculture in the United States.

Assuming that it takes 18 months to complete a master's degree and 3.5 years to complete a doctoral degree, AID's international training efforts are resulting in an average of 220 new master's degrees and 54 new doctoral degrees annually. This contribution to the research base of the developing countries is substantial, but it does not begin to close the vast gap that exists in research personnel. Therefore, we recommend that the United States double its training of scientists from the developing countries and that approximately half of all fellowships go for the training of university personnel who will help train future generations of food and nutrition research workers. It is estimated that this increase in the number of graduate fellowships would cost approximately $6.5 million in additional training funds for a total annual fellowship program cost of $13 million.

Research Fellowship Programs

Only a small proportion of foreign students studying in the United States returns home to conduct field research. (AID estimates that only 7 percent of their scholars return home to conduct field research.) Establishing a research fellowship program for predoctoral thesis research and for postdoctoral research studies would be one way of substantially increasing the amount of research conducted in developing countries on their problems. Research grants should be awarded on a competitive basis, using a peer review committee composed of scientists from

both the United States and the developing countries.

To facilitate the review process and to maintain balance among the biological, physical, and social sciences, we suggest that both doctoral and postdoctoral fellowships be considered.

Approximately 175 doctoral thesis research grants should be made annually: 50 grants in the social sciences dealing with food, nutrition, and rural development problems; 75 grants in the agricultural and biological sciences dealing with food production; and 50 grants in areas of food utilization and human nutrition research.

It costs an estimated $25,000 per grant to send a graduate student to the field for data collection (average time, 12 months), including a two-week field visit by the graduate student's thesis adviser, and to provide approximately nine months of additional assistantship support for data analysis and writing. Therefore, this program would cost approximately $4.5 million a year.

Approximately 100 postdoctoral research grants should be awarded annually: 30 grants in the social sciences, 40 in the agricultural and biological sciences associated with food production, and 30 in research areas concerned with food utilization and human nutrition. The annual cost of this program would be approximately $5 million assuming that the average postdoctoral research study would be for two years with an average cost of about $25,000 a year to cover stipend, travel, and research expenses.

We suggest that U.S. graduate students have access to research resources of this type to facilitate training U.S. scholars in international food and nutrition programs. Until alternative programs are implemented within the proposed U.S. competitive research grants program (see the other sections of the Study Team 14 report), at least 10 percent but not more than 25 percent of the research fellowships awarded within this AID-funded program should be made available to U.S. scholars.

Visiting Scholar/Scientist Fellowships

Research scientists and educators who are working at the national or regional levels in the developing countries should have the opportunity to recharge their academic batteries through study leaves, to conduct research that is not possible for them to do locally because of inadequate facilities, or to write textbooks and other instructional materials relevant to problems in their home countries or regions. To reward competent, productive scientists and educators for

their contributions to food and nutrition research, we recommend that a competitive visiting scholar/scientist fellowship program be established. Such a program would provide research scientists and educators with a stipend, travel, and research funds for a 12-month study leave. In most cases, those who receive these grants would be expected to join the faculty of a U.S. university or the staff of an international research center as a visiting professor/scientist.

Seventy study research grants should be made available each year on a competitive, peer review basis: 20 grants in the social science areas related to food and nutrition programs, 30 in the agricultural and biological sciences related to food production, and 20 in the areas of food utilization and human nutrition. It is estimated that a program of this type would cost $3 million annually.

Nondegree Training Programs

Presently, the United States sponsors directly and indirectly a number of agricultural trainees in nondegree training programs. Some of these trainees will return to research positions in food and nutrition programs. It was not possible to ascertain actual numbers and costs associated with this type of training, but we strongly endorse in principle the type of research training that currently is being provided by the international research centers. We recommend that whenever possible increased numbers of trainees receive this type of on-the-job research training.

Long-term Career Support for Scientists and Educators in International Food and Nutrition Research

We strongly endorse federal government support for U.S. research scientists and educators who wish to pursue careers in all areas of international food and nutrition research. Specifically, mechanisms should be worked out through USDA and/or Title XII of the Foreign Assistance Act to provide long-term federal support for career scientists in the social, biological, and physical sciences that relate directly to international food and nutrition research. Since there are approximately 7,500 agricultural scientists now working in the United States, we believe that at least 2 percent or 150 scientists should be supported directly to work on international agricultural problems with corresponding numbers in the associated social and food sciences, including human nutrition research. This increase would probably double the number of career

scientists available for work in international food and nutrition research.

National Research Training Capacity

The training of intermediate-level research personnel must be shifted as rapidly as possible to educational and training institutions in the developing countries. To do this, the Title XII mechanism should be systematically utilized to help strengthen, through institutional development programs, universities, and schools of agriculture in those countries. In addition, these universities should develop an outreach capability to provide practical, production-oriented research training for field-level research personnel. Title XII appears well suited to enlist the support of U.S. universities and international research centers in helping national programs design and develop new training programs for these research personnel. We endorse the use of Title XII for this purpose.

Appendix

SUMMARY OF RECOMMENDATIONS FROM MEETINGS ON INTERNATIONAL AGRICULTURAL TRAINING SPONSORED BY AID, ISEC, AND AUSUDIAP, SPRING 1976[73]

PROGRAM DEVELOPMENT

The basic recommendations related to program development were as follows:

1. Emphasize practical training opportunities including: on-the-job training, short courses, experimental learning, and internships.

While many practical training opportunities exist, increased emphasis needs to be directed toward building practical training into participants' programs. It is not enough for participants to be well grounded in theory and knowledge in a particular academic discipline; they also need the application experience necessary to put theory into practice. Many participants from the developing countries come with little or no practical farm experience. Building on-the-job training, special technical courses, internships, and individual learning experiences into programs could result in participants returning home not only with the knowledge but with the ability to do what needs to be done to bring about agricultural development.

2. Strengthen and build institutional resources in the United States.

Strong and viable international training programs can only emerge from institutions with the necessary resources (both human and capital) to design, implement, and evaluate such programs. Institution building is not accomplished in a week, a month, or a year; rather, it is a time-consuming process and it must be recognized as

such by funding organizations. As the international capabilities of U.S. institutions are strengthened, they become better able to operate outside the control of one or more funding sources. With the reduction of sustained and large-scale faculty involvement overseas, it becomes necessary to reexamine the process for training new faculty and sustaining and rewarding existing faculty as professionals in the field of international agricultural training. It may further be necessary to provide for more stable and less soft money international program operations.

3. Encourage participant research on home country problems where possible and provide for adequate adviser support in the field.

The relevance of U.S. research training for those from the developing countries needs questioning in terms of: levels of sophistication and equipment, availability here and there, home country problem situations, transferability of U.S. research training to home country situation, context within which the student will work upon return home, and the expectations of the home country and sponsor. All of these factors impinge on the type of research that might best be undertaken by a student. Home country research has many advantages including: (1) advancement of science in the developing countries; (2) adaptation of research to local problems, conditions, and equipment; and (3) development of commitments to local problems with opportunities to readily expand on thesis research after completion of training.

While not all thesis research must be based on home country experimentation and data collection, where appropriate and feasible this appears to be an important key to training an effective developing country scientist. This type of research arrangement requires that U.S. faculty advisers be supported so that they can travel to the field as necessary to supervise the research problem.

4. Support more relevant academic training programs in the U.S. universities.

More attention must be directed to the design of academic training programs appropriate to the needs of students from the developing countries. This implies course work that provides a solid

grounding in a specific agricultural discipline and related disciplines but that should not be limited to this focus. Developing country students need training beyond that provided the U.S. student because professional support mechanisms available in the United States are frequently lacking in developing countries. Relevant academic training programs imply the need for: (1) some specially designed courses, (2) interdisciplinary training, (3) practical training, and (4) training directly related to the development process.

5. Provide change agent, management, and organizational development training for all participants.

There is a need to provide a course or series of courses related to change agent skills, management, and organizational development for all international participants studying in the United States. Very often it is the lack of these skills that prevents a U.S.-trained participant from returning home and creating the type of change necessary to bring about agricultural development. In addition, many U.S.-trained participants return home only to very quickly assume the roles of managers and administrators rather than the role of agricultural technicians. This course (courses) appears vital to participant utilization and should be implemented even if more U.S. training time is required.

6. Provide opportunities for building agricultural faculty awareness and utilization of data from other disciplines and provide for appropriate interdisciplinary training for international students.

Problems do not always categorize themselves neatly into disciplines, and it is important that both faculty and students develop sensitivities in terms of the potential contributions which can be made to international agricultural training from other disciplines.

A number of faculty advisers and teachers have expressed a desire to strengthen their own knowledge of areas other than the agricultural sciences so as to improve their abilities as trainers and advisers. They are further searching for ways they can bring an interdisciplinary view to international teaching and research efforts.

In regard to training in countries other than the United States the following recommendations were made:

1. Develop linkages with international research centers.

These linkages are important for U.S. institutional efforts to help the developing countries strengthen their research and development efforts, for allowing collaborative work on problems of mutual interest as scientific colleagues, for the cooperative development of training and research programs, and for the provision of adequate training program design and follow-up.

2. Foster development of in-country training institutions concentrating on technical and practical training facilities and resources.

Helping the developing countries develop new and strengthen existing training institutions, particularly in the practical and technical areas, can potentially allow them to better meet their own personnel needs in both the short run and on a long-term basis. Such institution building and training for trainers could create a powerful multiplier effect.

MANAGEMENT OF PARTICIPANTS

A summary of recommendations from the Regional Conferences on Training made the following recommendations for improving the management of international agricultural program participants.

1. Improve in-country preparation before training.

Increased attention to the following five functions is imperative if international agricultural training programs are to be improved in the United States: host country personnel planning; determination of project and training objectives; participant identification and selection; preparation/gathering/transmittal of documents; and predeparture preparation and orientation. Many problems within the present system can be traced to incomplete and inadequately stated objectives, incomplete preparation and transmittal of documents necessary to facilitate appropriate placement, and unrealistic participant expectations built on the

basis of erroneous predeparture information. It is impossible to design an adequate training program with incomplete data concerning the participants themselves, their institutions, and their home countries and cultures. Too often participants are selected on the basis of their dispensability to the organization for which they work rather than on the basis of being the best candidate for training. U.S. training is expensive and it is imperative that sponsors select participants for advanced degree training who have adequate academic qualifications and a strong commitment to agricultural development and that clearly stated training objectives and support documents be effectively communicated to those providing training in the United States.

2. Improve pretraining upgrading in the United States particularly with respect to English language skills.

Many international participants come to the United States for training lacking the English language skills and, in some cases, the subject matter prerequisites to most effectively pursue a given course of agricultural study. The Economic Institute has demonstrated that when English language training is provided in a participant's area of study, language skills improve more rapidly than when language training is treated as a separate entity. The approach also appears to benefit the participant in his or her subject matter improvement as well. A second approach suggested with respect to improvement in this area is to consider the first semester of a participant's training program as the period for increasing language facility, but counting it for credit only if the participant is able to quickly and effectively compete in the English language.

3. Improve communications and linkages with the sponsors of agricultural participants.

Strong lines of communication between university academic advisers and host countries and missions are important if the most effective training is to be delivered. Unless academic advisers have a realistic and current picture of the home country needs and problems, it is difficult to design an appropriate course of study and research for an international participant. Universities are interested in becoming more directly involved with developing nations rather

than having all training requests funneled to them from AID/Washington. Universities wish to be viewed as a partner in development assistance rather than a source of services that can easily be procured.

4. Improve communication between the USDA program specialist and the agricultural contact and academic adviser.

The USDA program specialist can play a key role in communication, coordination, and administration of an international participant's programs. If communication is strengthened between the program specialist and the agricultural contact and between the agricultural contact and the academic adviser, few misunderstandings and problems should result. The program specialist, with overall responsibility for the training program, is in a position to directly communicate with the sponsoring agency and handle administrative and coordination details. The agricultural contact communicates with the program specialist so as to effectively carry out the administrative function on campus. The contact is also in the best position to communicate directly with the academic adviser concerning the participant's training program and progress. The role of the contact as liaison among the student and the adviser at the university and the sponsor should be recognized as vital for coordination in the conduct of international training programs.

5. Pay increased attention to post-training review, utilization, follow-up, and evaluation.

Post-training review and evaluation at all levels of the training system are essential for gleaning the necessary feedback for the continual improvement of training programs. Increased follow-up with respect to the utilization of participants following U.S. training is necessary to provide data as to whether or not participants are actually used upon returning home in their country's development efforts. If participants are not utilized as effectively as possible and in the areas for which they are trained, this indicates that the system needs to be changed. More emphasis may need to be directed to follow-up in the home country so as to support the U.S.-trained participant who may be operating in an organization without the benefit of professional

colleagues and support structures of the U.S. system.

GENERAL RECOMMENDATIONS FOR IMPROVING TRAINING SYSTEMS

1. Strengthen the training management and communication system and improve relationships among cooperators in the training system.

The partnership among the developing countries, AID, USDA, and the universities has been useful and successful in the past. It can be improved so that it more successfully relates training objectives to country development objectives, defines and arranges for appropriate learning experiences to meet training objectives, and provides and administers procedures and financial support that enables the training to be conducted with minimal anxiety on the part of the trainee. Increased attention to management, communication, and cooperative relationships throughout the system appear key to training system improvement.

2. Recognize and support the national training function of state institutions in the area of international agricultural training.

If state institutions are to be involved at the national level in international development assistance efforts, these contributions of state institutions must be recognized and appropriately financed from the national level.

3. Improve communication of training-related experience from within and without agriculture, throughout the agricultural training network.

Communications systems can be improved so that it is possible to share among all concerned with international agriculture training information concerning training models and methods and approaches that have worked successfully. At present, this occurs more by chance than by design. Furthermore, much experience outside of agriculture is relevant to the agriculture development process and is an important potential resource.

4. Support experimentation on methods for improving developing country populations at the lowest levels ("Poorest of the Poor").

Most of the early development assistance programs resulted in improving the situation of the rich rather than improving the quality of life for the poorer segments of country populations. The international agricultural community can move toward increased experimentation with methods designed to reach the lowest levels of the developing countries' populations and document and disseminate the results of such experimentation to others involved in the same effort. Such experimentation will, of necessity, have to be in its initial stages country-specific, culture-specific, and economy-specific.

5. Increase communication and coordination with other major international development organizations.

There is a need to continue to work closely with AID and FAO, but recognize that there are other organizations and agencies with prominent and potentially strong roles to play in the development process. Linkages to these organizations, in both the public and private sectors, may provide new and creative opportunities for international agricultural training programs.

6. Build international training into a prominent position in the implementation of Title XII.

At present, little explicit attention has been given to the role of international training as it relates to the improvement of national food systems under Title XII. It is imperative that this important development assistance component not be overlooked in the implementation and funding of the legislation.

NOTES

1. The title of this report is somewhat broader than its actual scope. It is primarily oriented to research on food commodities in and for developing nations. Virtually nothing is said specifically about nutrition due to our lack of knowledge about this rather specialized area (see Study Team 9's report on nutrition). However, much of the discussion would be relevant to many aspects of nutrition research. The international organizational suggestions provided in the reports of Study Teams 1-10 and 12 are not specifically noted in this draft. Most would fit within the organizational framework, or some variant thereof, outlined here. Study Team 9 proposes a consortium of U.S. institutions, which is considerably larger than similar efforts envisaged in our deliberations. Study Team 7 ("Rural Institutions, Policies, and Social Science Research") has made some useful suggestions concerning social science research on a range of organizations serving agriculture in the developing countries.
2. For examples pertaining to tube wells, see Sanson (1969:109-121), Dommen (1975:483-485), and Dalrymple (1970:300).
3. A similar situation was faced in Holland in the early 1900s. See Arnon (1968:23).
4. Compiling such data was extremely difficult, and the figures are subject to an unknown degree of error. The data for the developing countries might be expected to be less complete than the data for the high-income countries, thus resulting in some underestimation. The data also are reported on the basis of geographic regions and individual nations.
5. Some of the complexities of this process are suggested in Mellor (1977:484-493) and Ramalho de Castro and Schuh (1977:504-522).
6. One exception is the Ivory Coast where the agricultural college is supported through the Ministry of Agriculture.

7. See "Agricultural Research Project, Bangladesh," unpublished report, AID, 1974; and "Bangladesh--Agricultrual Research Project Paper," unpublished report, AID, 1975. AID has been studying ways of providing some research funding to BAU. Presumably the Ministry of Agriculture could allocate some research funds to BAU for specific projects if it wished.
8. For details on the Tropical Products Institute, see Melville (1962).
9. For historical details, see Moseman (1970:66-76).
10. There are a number of international nongovernmental scientific organizations coordinated within the International Union of Biological Sciences and the International Council of Scientific Unions.
11. Taken partly from U.S. Agency for International Development (1972). Regional research has long been encouraged within the United States by a provision in the Hatch Act that allocates 10 percent of its total funds for regional projects. The Farm Foundation also has encouraged regional activities.
12. The People's Republic of China appears to have moved farther than any other nation in placing its scientists in contact with local units, but may have gone too far in terms of maintaining a balance with more scientific forms of research. For details, see NRC (1975c:3-6).
13. An Organization for Economic Cooperation and Development (OECD) report (1968:166) states regarding INEAC:
    Before the Congo's independence, INEAC had a staff of about 400 Europeans, mostly university-trained, and some 9,000 Congelese workers. It was one of the largest and most significant research establishments in the developing world. With its research headquarters in Yangambi and a network of some 30 smaller experimental stations throughout the country, the Institute effectively provided research services for all the important food and export crops grown in the Congo.
14. An FAO article (1972:148) suggests that perhaps $60 million was being spent bilaterally in 1970, including private foundations.
15. The precise amount is not clear at this point. Boyce and Evenson (1975:51) cite figures of $13 million in 1970 and $17 million in 1975. This total reportedly included all expenditures in the GERDAT system plus one-fourth of the ORSTOM system. According to another source, however, the total ORSTOM budget was $26 million in 1972 and the

GERDAT budget in 1974 was $54.6 million. On this basis the total agriculture figure might have been more nearly $60 million (Charreau 1975). The total ORSTOM budget in 1973 was fr 134 million or about $27.3 million (August 2, 1976 exchange rate) (ORSTOM 1975:4). While it is difficult to separate the agricultural portion of the ORSTOM budget because of its scientific nature, one official of the Ministry of Cooperation which provides the funds estimates that they would represent at least half the total (H. Vernede 1976, personal communication, Sous Directeur de la Recherche Scientifique, Ministere de la Cooperation, Washington, D.C.).

16. This statement was contained in a draft dated January 19, 1976; it was not included in a revised version issued May 30, 1976.
17. Also see Arnon (1975) and Arndt, et al. (1977).
18. The concept of a research council and a research institute was taken from "Strengthening National Research Systems" (CGIAR, TAC 1975a:4) and "Strengthening of National and International Agricultural Research" (FAO 1975b:13). A similar formulation is presented in African Agricultural Research Capabilities (NRC 1974:152-153). The institute also might be affiliated with the national college of agriculture. This was done in the case of the Philippine Council of Agricultural Research and the College of Agriculture of the University of the Philippines. One side effect in this case, however, was that the college lost some of its best talent to the Council.
19. The Council's chairman is the Minister of Agriculture and its members include representation from that ministry, the Planning Commission, Bangladesh Agricultural University, the Bangladesh Rice Research Institute, the Atomic Energy Commission, the Council of Scientific and Industrial Research Laboratories, the Jute Research Institute, two public representatives, a prominent agricultural scientist, and the secretary of the Council.
20. This has long been a problem in the United States. See Waggoner (1976:237-243).
21. Details on these crop improvement programs, as well as others in Asia, are provided in Moseman (1971:120-158). Some colonial efforts, such as the Malaysian Rubber Research Institute, might be considered predecessors to the food crop programs discussed here.
22. Background on the Masagana 99 program is provided by Swanson (1976:4-6). Also see Mangahas (1975:300-301).

23. Comments by J. Fransen (World Bank) at the ninth meeting of the Technical Advisory Committee, CGIAR, February 1975. Training is clearly of major importance and is the subject of Subgroup C.
24. An appraisal of a second loan has been completed for Spain and an appraisal team started work in West Bengal in May 1976 (J. Fransen 1976, personal communication, Agriculture and Rural Development Department, International Bank for Reconstruction and Development).
25. The first and, to date, only such listing of these activities is provided in the "Register of FAO Activities Related to Agricultural Research" (FAO 1974a).
26. This grant was approved on April 15, 1975, and was for $390,000. The countries included were South Korea, the Philippines, and Thailand. The Asian Development Bank also made an initial grant of $300,000 to help AVRDC get established (March 11, 1969) and made a grant of $300,000 to IRRI (February 10, 1975) in part to cover an expanded training program.
27. The figure excludes contributions to non-CGIAR international research programs such as the International Fertilizer Development Center and the Asian Vegetable Research and Development Center.
28. See, for example, "Strengthening of National and International Agricultural Research" (CGIAR, TAC 1975a:14-15). One exception is the newly established International Agricultural Development Service (IADS) in New York. IADS is a professional, nonprofit organization designed to provide experienced technical assistance that is responsive to the needs of the developing countries. Initially it is drawing on the experience and talents of the Rockefeller Foundation and is concentrating on production and training activities. In addition, IADS is preparing a series of nontechnical publications on various aspects of agricultural development for policymakers.
29. The idea was first suggested by a USDA official in April 1975, and presented to a meeting of Ministers of Scientific and Technological Policy of the OECD countries in June 1975. The matter was further considered at the Third Working Conference of Directors of Agricultural Research at OECD in December 1975. Subsequently, the proposal was endorsed by the Committee for Agriculture in January 1976, and further reviewed in June 1976.
30. AID, for instance, publishes a quarterly listing in AID Research and Development Abstracts (Technical Assistance Bureau). The work conducted under the

Special Foreign Currency Funds is fully cataloged.

31. The early administrative history of this program is fully discussed by Richardson (1969). Historical details on several of these projects are provided in Reed (1974) and Turk (1975).

32. This group initially ran into severe administrative problems and a congressional investigation. Several operational changes made then, such as setting up an internal Research and Development Committee and an external Research Advisory Committee, are still in effect. For details, see Brenneman (1963) and U.S. Congress (1962); both are on file in the AID Reference Center.

33. Based on statistics provided by J. Ryan, Office of Program and Methodology, Technical Assistance Bureau, AID, October 21, 1976. In both 1966 and 1967, the amount spent on agricultural research was less than $5 million (PSAC 1967:Vol. II, 624). Another writer places the figure at up to $5 million per year during the mid-1960s (Adams 1969:6).

34. This ceiling was an outgrowth of the events cited in note 32 above. It applied to "development research" conducted principally by American institutions under Title V, Section 241 of the Foreign Assistance Act. The level of the ceiling was set in Section 113 of the annual Foreign Assistance Appropriation Act. The ceiling did not apply to bilateral research funded by the regional bureaus.

35. This figure included project support costs which averaged 7.17 percent of total expenditures during the seven-year period from FY 1962 to FY 1968.

36. Based on information provided by H. C. Ladenheim, Office of Program Planning and Utilization, Technical Assistance Bureau, AID, October 21, 1976.

37. The 1967 Development Assistance Committee (DAC) review stated that "during the coming year the DAC intends to explore the possibilities which exist for bilateral donors to cooperate among themselves and with others active in the field (OECD 1967:149)." The 1968 review contains a short description of research activities but little about cooperation (OECD 1968:165-168). The last sentence in Moseman's statement, by the way, casts further doubt on the allegation discussed earlier that donors cut back their support of national programs in the developing countries in favor of the international centers.

38. This section is based on "World Food--USDA's Commitment to Development Assistance and Research?" (USDA 1975:11-14). Data provided by J. Flaim, Agricultural Research Service, June 10, 1976.

39. Estimates provided by Helen Wilson, Office of Program Planning and Utilization, Technical Assistance Bureau, AID, November 15, 1976.
40. In addition to the projects listed in Table 7, three comprehensive agricultural sector analyses have been carried out by American universities for three countries. Funding came from both central and regional sources. The projects were: Nigeria, $1.9 million, 1967-1971, Michigan State University; Korea, $1 million, 1974-1977, Michigan State University; and Thailand, $2.1 million, 1974-1978, Iowa State University.
41. The actual proportion contributed by AID has, for a variety of reasons (including availability of funds from other sources), generally run less than 25 percent. The actual proportions have been: 1972, 17.7 percent; 1973, 21 percent; 1974, 20.4 percent; 1975, 22.6 percent; and 1976, 23.6 percent.
42. While the U.S. contribution is large on an absolute basis, it is not so striking on a per capita basis. In 1976, the U.S. per capita pledge ranked eleventh among the 18 CGIAR national donors. Norway and Sweden were first and second with a per capita contribution nearly four times as high as that of the United States.
43. This ceiling was contained in Section 113 of the Foreign Assistance Appropriations Act for FY 1970, Section 107 in FY 1971 and FY 1972, and Section 106 in FY 1974 and FY 1975.
44. Dr. Clifton R. Wharton is chairman of the board. Members include: Orville G. Bentley, Anson R. Bertrand, Charles Krause, James J. O'Connor, M. Peter McPherson, and Gerald W. Thomas.
45. This section is based on "World Food--USDA's Commitment to Development Assistance and Research?" (USDA 1975:13-14); E. Imle 1976, personal communication, International Programs Division, Agricultural Research Service, USDA; and data provided by J. Flaim, Agricultural Research Service, USDA.
46. One less-developed region under American supervision that has received virtually no research assistance lies in the western Pacific, the trust territory of the Pacific Islands, Guam, and American Samoa. See McDougall, et al. (1975). Guam has received some Hatch Act funds.
47. One product from this program was a recent report on "Tropical Agriculture Research Needs" (Western Regional Planning Committee 1975).
48. For further discussion of this point, see Schuh (1976:16).
49. See, for example, Fischer (1976:16). In addition, large areas are planted with short-stemmed

varieties of wheat descended from the Norin 10 types of wheat introduced from Japan. Perhaps 35 percent of the U.S. wheat area is planted with semidwarf and short-stem wheat. See Dalrymple (1975:34-35).

50. The legislation establishing USDA specified the collection and distribution of new and valuable seeds and plants as one major task (USDA 1963:13). This led to many foreign missions, an activity that is still carried out (early activities are summarized by Ryerson [1933]). Plant collection also was carried out prior to the establishment of USDA (see Rasmussen [1955]).
51. But to the extent that individual states eventually benefit from the process (e.g., the ability to capitalize on a new technology developed elsewhere), they might be expected to share in the costs.
52. From 1970 to 1974 the total funding for public food and food-related research in the United States increased by only 1.9 percent in real (deflated) terms while the number of scientist-years decreased 0.1 percent (U.S. Congress, House of Representatives 1976:1032).
53. Federal agencies are allowed only a certain number of positions. If some of these individuals are used for international activities, it reduces the human resources available for domestic needs. Agencies have had little luck in getting ceilings raised to reflect international activities.
54. These problems also exist at the university level. See Whitaker and Wennergren (1976:498-499).
55. Whitaker and Wennergren (1976:499-500) view "the failure of Congress to directly and clearly define the method for funding university involvement" as a "serious weakness." They also are concerned that "Board recommendations for implementing Title XII will be in direct competition with traditional USAID programs."
56. Presumably the program would build around the international strength of the institution. Work would be monitored at the federal level and institutions could be dropped if they did not appear to be using the funds efficiently and effectively.
57. In some cases, such as Florida, there is concern among certain groups that international activities may lead to competition for local products, as, for example, cited by Borroff (1976).
58. For years the United States has maintained that FAO should not use any of its regular funds for agricultural research (it does, as noted earlier, administer research under other funds). This

position was reiterated, despite an initial difference of views by AID, at the meeting of the FAO conference in November 1975. See U.S. Congress, Senate (1976:36, 58).

59. The new director general of FAO has been reducing rather than expanding the number of publications issued by that agency. Presumably, however, FAO would be responsive to a positive expression of interest in a research journal by member nations.

60. It is commonly thought that there is some statutory basis behind this policy, but despite an extensive search none has yet been found except for the phrasing on the use of the SFCRP funds (E. Hawker, E. R. Niemier, and S. Gillette 1976, personal communications, Agricultural Research Service, USDA).

61. We are hesitant to suggest formal earmarking, although it may prove necessary. The main limitation is that it would be applied to all agencies or states whether or not they had an interest or capability in international research. One variation might be to indicate that up to a certain proportion (say, 25 percent) could be used for international activities; this step, however, would not protect the research director from pressures for local uses.

62. In this calculation no funds have been allocated to regional programs; these might well be included. Also, the administrative funds have been carried at the present CSRS level of 4 percent. This might be much too low for a program of this type. Possibly 10 percent would be more appropriate.

63. Some groups, for example, are quite critical of the formula concept. Certainly the distribution under current research formulas would have little to do with interest or ability in the international research area (this also would be true of the allocation of any increased federal research funds under the Hatch Act). Some federal administrators feel they do not have sufficient control over the funds. Others recall a rather unsatisfactory experience with a special domestic program started in 1972. On the other hand, states that do relatively well may be more favorably inclined. It is doubtful that a fully satisfactory formula can be found.

64. While work is done in the developing countries by their own scientists, there is a cooperating Agricultural Research Service scientist for each project.

65. To be more specific, Section 205 of the International Development and Food Assistance Act of 1975 (P.L. 94-161) amended Section 106(b) of the

Agricultural Trade Development and Assistance Act of 1954 to permit the local currency proceeds from the sale of Title I agricultural commodities that are used for specific activities to be considered an advance payment of the equivalent amount owed to the United States under the Title I agreement.

66. This program has been evaluated by Cordaro (1972). Also see Ledogar (1975:99-110).
67. While this bill passed the House by an overwhelming margin (373 to 7), it died in the Senate Agriculture Committee. The Senate subsequently provided a counterpart in Title VIII--Food and Agricultural Research of the proposed Food and Agriculture Act of 1977 (Section 275), introduced on January 17, 1977. It would include a Federal Food and Agricultural Research Policy Council, a Federal Food and Agricultural Research Operations and Advisory Committee, and a Users Advisory Board for Food and Agricultural Research.
68. In addition to seeking efficient organization, the group might wish to see that a certain pluralism occurs in funding so that different points of view can find support. A monopoly in research funding, like other monopolies, should be avoided if possible.
69. Principally based on a publication of the same title as the organization (GERDAT 1971).
70. Principally based on: a letter from P. Silvestre, Direction Technique & Documentation, IRAT, Paris, May 5, 1976; IRAT, A Research Institute Working for the Promotion of Agricultural Development (IRAT 1970); and Rapport Annual 1974 de l'IRAT (IRAT 1975).
71. Based on TARC, General Information, 1975, Tropical Agricultural Research Center, Japan.
72. Adapted from the model for the participant training cycle for AID-USDA trainees.
73. Prepared for the annual meeting of AUSUDIAP held at Michigan State University, June 1976.
74. This bibliography is for Subgroup C only.

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