Report of a Conference

PNAAQ438
IAN: 35425

Selected Issues in Agricultural Research in Latin America

Madrid, Spain
September 26-
October 1, 1982

Sponsors

International Federation of Agricultural Research Systems for Development
Inter-American Institute for Cooperation on Agriculture
Government of Spain
International Service for National Agricultural Research

Barry Nestel and Eduardo J. Trigo, Editors

March 1984

Published for the sponsors by

isnar

International Service for
National Agricultural Research
The Hague, Netherlands

Preface

Selected Issues in Agricultural Research in Latin America is the second publication in a series of conference proceedings which document regional meetings of agricultural research directors. The meetings were organized by The International Service for National Agricultural Research (ISNAR) in collaboration with The International Federation of Agricultural Research Systems for Development (IFARD).

The first publication, **Agricultural Research for Development: Potentials and Challenges in Asia,** is the record of a conference held in Jakarta, Indonesia, in October 1982. It was arranged jointly by ISNAR and IFARD and sponsored by the German Foundation for International Development.

The present volume is derived from a similar meeting in Madrid, Spain, September 26-October 1, 1982. It was sponsored by the Spanish Government and organized by ISNAR and IFARD in conjunction with The Inter-American Institute for Cooperation on Agriculture (IICA). During the first two and a half days of the meeting, leading issues in agricultural research in Latin America were introduced and discussed. The third afternoon was devoted to a business session of the Latin American chapter of IFARD. Participants then visited cattle and viniculture research facilities of the Instituto Nacional de Investigación Agrícola (INIA) near Madrid, prior to traveling to Valencia to tour additional INIA research facilities.

The organizers of this conference express their appreciation to their Spanish hosts for generous support and hospitality and to INIA for logistical backup during conference and field visits.

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List of Participants

Aguila, Jorge Alberto del
Director Nacional
Instituto Nacional de Tecnología Agropecuaria, INTA
Rivadavia 1439
Buenos Aires
Argentina

Alvarez-Luna, Eduardo
Vice President for Latin America and the Caribbean
IFARD
A. Postal 20-577
01820 México D.F.
México

Arjona, Orlando
Director Técnico
Instituto Ciencia y Tecnología Agrícolas, ICTA
Avda. Reforma 8-60 Zona 9
Guatemala, C. A.

Barney, Gustavo
Instituto Colombiano Agropecuario, ICA
Calle 37 No. 8-43
Bogotá
Colombia

Blair, Enrique
Subdirector General para Asuntos Externos
Instituto Interamericano de Cooperación para la Agricultura, IICA
Ap. 55 - Coronado
San José
Costa Rica

Bustamante B., Alfredo
Fondo Nacional Investigación Agropecuaria, FONAIAP
Torre Norte - Piso 14
CSB - El Silencio - Caracas
Venezuela

Cal, Jerome P.
Director of Agriculture
Box 75,
26 Nargusta
Belmopan
Belize

Castronovo, Alfonso J. P.
Consultant
Uruguay 1267, 4o. A
1016 Buenos Aires
Argentina

Curotto, Juan Antonio
Director General
Centro Investigaciones Agrícolas 'Alberto Boerger'
Treinta-y-tres 1374 - 4o. piso
Montevideo
Uruguay

Fonseca Martínez, Santiago
Senior Research Fellow
International Service for National Agricultural Research, ISNAR
P. O. Box 93375
2509 AJ The Hague
Netherlands

Fonseca Souza, Raymundo
Director Ejecutivo
Empresa Brasileira de Perquisas Agropecuarias, EMBRAPA
Edificio Venancio 2000 Sala 908
70.000 Brasilia D.F.
Brasil

Gastal, Edmundo
Director Programa IICA-Cono Sur/BID
Juncal 1305 - Piso 14
Montevideo
Uruguay

Gobbee, Enrique
Director
Instituto Estudios Económicos
Soc. Rural Argentina
Lavalle 442 - 3o.
Buenos Aires
Argentina

Grobman, Alexander
Jefe
Instituto Nacional de Investigación y Promoción Agropecuaria, INIPA
Avda. Guzmán Blanco 309
Lima
Perú

Hobbs, Huntington
Senior Research Fellow
International Service for National Agricultural
Research, ISNAR
P. O. Box 93375
2509 AJ The Hague
Netherlands

Jeffers, J. Percival W.
Deputy Chief Agricultural Officer
Ministry of Agriculture, Food and Consumer Affairs
P. O. Box 505
Graeme Hall, Christ Church
Barbados

López, César
Director
Departamento Investigaciones Agropecuarias
Secretaria de Estado de Agricultura
Centro de los Herves
Santo Domingo
República Dominicana

Madamba, Joseph C.
Director
Southeast Asian Regional Center for Graduate Study and
Research in Agriculture, SEARCA
College
Laguna
Filipinas

Madrid Cerda, Emilio
Presidente Ejecutivo
Instituto Investigaciones Agropecuarias, INIA
Casilla 5427
Santiago
Chile

Marcano, Luis
Presidente
Fundación Servicio Agricultor, Fusagri
Apartado 2224
Caracas
Venezuela

McDonald, Frank D.
Head, Crop Science (Research)
Central Agricultural Station
Mon Repos, E.C.
Demerara
Guyana

Moncada de la Fuente, Jesús
Director General
Instituto Nacional de Investigaciones Agrarias, INIA
Arcos de Belen 79-9
México 1, D.F.
México

Monge, Fernando
Office for Latin America and The Caribbean
International Development Research Center, IDRC
Calle 72 No. 5-83, 8o. piso
Bogotá, Colombia

Morillo Andrade, Francisco
Director General
Instituto Interamericano de Cooperación para la
Agricultura, IICA
Ap. 55 - Coronado 2200
San José
Costa Rica

Muller-Haye, Berndt
Oficial Superior Investigaciones Agrícolas
Internacionales
Organizacion de las Naciones Quidas para la Agricultura
y la Alimentacion, FAO
Via delle Terme di Caracalla
00100 Roma
Italia

Nestel, Barry
P. O. Box 93375
2509 AJ, The Hague
Netherlands

Nores, Gustavo A.
Director Investigación Recursos Tierra
Centro Internacional de Agricultura Tropica, CIAT
Apto. Aéreo 6713
Cali, Valle
Colombia

Obando Espinoza, José Miguel
Director Investigación Regional
DGTA-MIDINRA Km. 12 C. Ap. 592
Norte Managua
Nicaragua

Osler, Robert D.
Director Asociado
Centro Internacional para la Mejoramiento de Maiz y Trigo, CIMMYT
Londres 40
06700 México D.F.
México

Osten, Alexander von der
Executive Officer
International Service for National Agricultural Research, ISNAR
P. O. Box 93375
2509 AJ The Hague
Netherlands

Parasram, Samsundar
Director Research and Development
Caribbean Agricultural Research and Development Institute, CARDI
University Campus
St. Augustine
Trinidad

Pereira Irahola, Francisco
Director Ejecutivo del IBTA
Instituto Bolivano de Tecnología Agropecuaria, IBTA
Avda. Camacho
La Paz
Bolivia

Piñeiro, Martín
Jefe Proqueto Protaal
Instituto Interamericano de Cooperación para la Agricultura, IICA
Ap. 55
Coronado
Costa Rica

Quezada S., Norberto Antonio
Director
Instituto Superior Agricultura, ISA
Apartado 166
Santiago
República Dominicana

Ramalho, José
Director
Empresa Brasileira de Pesquisas Agropecuarias, EMBRAPA
Edificio Venncio 2000 Sala 910
70.000 Brasilia D.F.
Brasil

Rodriguez Voigt, Abelardo
Gerente General
Fondo Nacional de Investigaciones Agropecuarias, FONAIAP
Torre Norte Centro Simón Bolívar
Piso 14
Ap. 5562
Caracas
Venezuela

Rojas M., Basilio A.
Director
Instituto Mejoramiento Producción Azúcar
Yucatán 23-3
Colonia Rourz
México D.F.
México

Ruiz Corvea, Eliodoro
Director Ciencia y Técnica
Ministerio Agricultura
Calle 16, No. 102 esq. Miramar-Playa
C. Habana
Cuba

Sahtoe, J.
Director Agriculture Experiment Station
Paramaribo
Suriname

Samper, Armando
Director General
Centro Investigación Caña Azúcar, CENICANA
Ap. 9138
Cali, Valle
Colombia

Sawyer, Richard
Director General
Centro Internacional de la Papa, CIP
Apartado 5069
Lima
Perú

Segura, Mariano
Director
Oficina en Venezuela
Instituto Interamericano de Cooperacion para las Agricultura, IICA
Ap. 5345
Caracas
Venezuela

Silva, Antonio
Jefe Programa Nacional Investigación Agropecuaria
Ap. 239
Cancayaguela D.C.
Honduras

Tarte, Rodrigo
Director General
Instituto Investigaciones Agropecuarias
Ap. 6288
Panamá 5
Panamá

Trigo, Eduardo J.
Coordinador Proyecto PROTAAL
Instituto Interameri no de Cooperacion para la Agricultura, IICA
Ap. 55
2200 Coronado
San José
Costa Rica

Van Wherwin, L. Walter
Department of Research and Development
Ministry of Agriculture
Hope Gardens
Kingston
Jamaica

Vargas, Alberto
Subdirector Investigaciones
Ministerio de Agricultura
San José
Costa Rica

Venezian Leigh, Eduardo
Director
Departamento Economía Agraria
Universidad Católica de Chile
Casilla 114-D
Santiago
Chile

CHAPTER ONE: Introduction

Agricultural research has a long history of development in Latin America and the Caribbean. National research efforts date back to the early decades of this century. In a number of countries, massive efforts to build relevant institutions have been launched during the past 25 years.

Such national efforts, with important support from international sources, have led to the emergence of what can be called a regional agricultural research system, a system composed of both national and international research institutions. This system represents an important resource for the agricultural development of the region. Its proper functioning and ongoing improvement have become subjects of concern at both national and international levels.

As might be expected in as diverse a region as Latin America, national agricultural research systems, however similar, have not followed identical paths of development. Although in most countries an institutional model has evolved with the same basic conceptual elements, that is a decentralized major public research body which supplies technological knowledge for the whole of the agricultural sector, different historical backgrounds, ecological conditions, and economic possibilities in various countries have given distinctive national characteristics to the model. Differences have also materialized as a result of the particular problems which each system has had to face during maturation. Nevertheless, national institutions in the region have shared certain experiences in common, struggling to overcome related difficulties through similar solutions.

In general the evolution of national research systems in Latin America and the Caribbean over the past decade has been characterized by an initial period of sustained expansion and institutional consolidation, fueled by external funds, and followed by lean years during which budgetary support for agricultural research has ceased to grow and, in a number of countries, has even declined. In addition, many national institutions have not been able to retain scientific personnel trained during the 1960s and early 1970s. This loss of manpower is a highly sensitive issue, given the vital role that highly trained scientists play in a productive research system and the considerable cost involved in their training.

Agricultural research in Latin America has a rich and varied history of international cooperation, particularly between countries in the region.

It was with an awareness of past events and current difficulties that the regional chapter of the International Federation of Agricultural Research Systems for Development (IFARD) selected topics for discussion at its second meeting of director of national agricultural research systems of Latin America and the Caribbean, convened in Madrid. Themes chosen concerned personnel, financial and information management, and international cooperation. *

This publication includes the five keynote papers of the Madrid conference plus the resumé delivered at the closing session of the meeting by Eduardo Alvarez-Luna, IFARD's Vice President for Latin America and the Caribbean. In the first paper, Alfonso Castronovo, from Argentina, discusses the management of human resources used for agricultural research. Skilful human resource development and management are basic to the success of an agricultural research institution. The quality of institutional output will depend largely on the scientific creativity of its research personnel; priorities may be set in accordance with policies and needs, but only a motivated body of well-qualified scientists can translate goal statements into appropriate and viable research questions and projects.

The productivity of researchers is a function not only of their level of training but also of their experience. Consequently, the productivity of any given stock of human resources will depend on whether the research institution in question is able to provide a work environment with enough stability and continuity for its scientists to accumulate needed experience. Towards this end, it is essential that appropriate conditions of service exist; and that there be a salary structure geared to long-term career development. Since agricultural research is basically an interdisciplinary effort — moreover, one which requires the contributions and interaction of scientific personnel with different training and points of view — it is important that the staffing of a research institution should provide for a carefully planned disciplinary balance. Once again, continuity is needed to allow for the development of productive, complementary work styles.

* The first meeting of national agricultural research systems directors was held at the headquarters of the InterAmerican Institute of Cooperation for Agriculture in San José, Costa Rica, in March 1981.

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Although experience is often invaluable in research ventures, it is also a fact that scientific skills have a way of growing outdated. Ongoing study and training for staff is bound to yield profit. Indeed, as new research topics acquire priority, an entire research division or institution may require intensive instruction to enable it to achieve necessary reorientation. Carefully designed evaluation procedures are, therefore, necessary to identify key research personnel for in-career training and retraining.

Successful management of a research institution's scientific personnel is crucial, irrespective of the size of the institution. The norms and organizational structures needed may vary with size, but the basic functions to be performed remain the same in all cases. Castronovo organizes these functions under five headings: human resources planning, personnel recruitment and selection, training, salaries and other benefits, and evaluation. His paper deals with these subjects sequentially.

The second paper, prepared by Eduardo Trigo and Martin Piñeiro from the Inter-American Institute of Cooperation for Agriculture (IICA), deals with issues concerning the financing of agricultural research activities. In their analysis of agricultural research funding, the authors emphasize three interrelated subjects: the level of funding and profitability; the origin of funds and the issues involved in public versus private financing; and institutional mechanisms for channeling funds to research institutions.

Funds allocated to agricultural research in Latin America rose significantly during the sixties and early seventies. Towards the end of the decade, however, cutsback began. Funding levels have increasingly lost stability. The fiscal crisis that most countries in the region are now confronting suggests that, despite widely available evidence establishing the high social profitability of agricultural research, funding shortages will continue for some years, perhaps growing even more acute in time.

Changes in the level of funding have also been associated with changes in the origin of funds and in the procedures through which funds are assigned to research activities. Private funding of research has increased over the past few years. There has also been an accelerating shift towards project funding, as opposed to more traditional, institutional-funding mechanisms. Project funding, although it may foster closer relationships between researchers and technology-users, is likely to bias research efforts in favor of applied and short-run problems with low levels of risk. Certain products and clientele will be benefited at the expense of others.

This is not to say that private participation and competitive allocation schemes, such as project funding, do not offer valuable alternatives to public funding. Nevertheless, it is unlikely that these innovations will be of sufficient magnitude to dislodge the traditional system of institutional support using public funds. According to authors Trigo and Piñeiro, the crux of the challenge is to design an institutional proposal able to exploit the potential of each scheme for improving the levels and stability of funding and, at the same time, to ensure a properly balanced research program.

The third paper, presented by Alexander von der Osten of ISNAR (on behalf of ISNAR's Director General William K. Gamble), raises an issue closely related to the funding of agricultural research: how to achieve an improved global support system for national agricultural research in developing countries. After the paper highlights shortcomings of present approaches to international and bilateral support it proposes a new approach, one which places principal responsibility for planning and implementation squarely on the shoulders of developing countries themselves.

It is Gamble's central contention that, although foreign aid may be essential for strengthening national research capacities, the way in which such aid is given at present may well be counterproductive in terms of realizing the ultimate goal of more effective national research systems. Externally funded projects may lead to an over-reliance on the project approach, which in turn is likely to encourage national research managers to cultivate the favor of external agencies rather than national research constituencies (policy-makers, producer groups, exporters, consumers, suppliers). The frequent end result of this approach is that research programs are more sensitive to donor agency priorities than to the problems and needs of the country for which they are ostensibly drafted. As a consequence of the project approach to funding, many research efforts have been developed in isolation of adequate political and grassroot support, with their long-term survival seriously threatened. Recent history has shown that many projects, even whole research institutions, no longer prove viable once foreign assistance ends.

At the operational level a major problem associated with reliance on foreign aid is having to cope with a multitude of different and often conflicting administrative and reporting procedures and methodologies, each of which has been designed to fit the needs of a particular donor agency. The burden of complex paperwork has overtaxed the management — which is usually a scarce development resource — in a number of national agricultural research organizations.

These diverse factors limit the effectiveness of available resources for agricultural research. In general, results todate have fallen short of the expectations of both donors and developing countries themselves. The alternative funding strategy outlined in the ISNAR paper derives from ideas implicit in the support system established by the Consultative Group on International Agricultural Research (CGIAR). The core of this support system is development of a coordinating mechanism to align the interests and perspectives of host countries and donor agencies. Such a support system, it is argued, will improve collaboration among donors and provide incentives to relevant ministries in developing countries to build local constituencies for agricultural research. By so doing, the system will make it possible in the future to base foreign assistance on an overall agricultural research program rather than on fragmentary projects. In this way it will facilitate the management of resources made available to national systems.

In the fourth paper of the conference, Brasilio Rojas, a Mexican, addresses issues related to the design and management of information systems for agricultural research. He concentrates on information needs relevant to the three main phases of the agricultural research process. The first phase involves research program planning and development: at this stage, a satisfactory information system must be able to handle agroecological and socioeconomic data, policy guidelines, previous research results and their impact on production processes, as well as background information about the scientific state of various relevant arts. The second phase is program execution: here the contribution of an information system is to enable researchers to monitor implementation of their research designs. The third and final phase of agricultural research entails dissemination of research results and the study of their impact. During this phase, an information system is entrusted with the essential task of processing feedback and provides the basic input for final program evaluation.

Rojas fleshes out his theoretical discussion with references to the experiences of the Mexican agricultural research system in the development and implementation of its current agricultural research information system SINIAGEC (Sistema de Información de Investigaciones Agricolas en Curso). He provides a brief description of the steps followed in implementing the system, pointing out the cost advantages of basing its design on elements already in existence, emphasizing the wisdom of potentially relevant to technology development are two examples which he specifically mentions.

In the fifth paper, Eduardo Venezian, from Chile, examines international cooperation in agricultural research. He puts forward the view that agricultural research at the national level should not be considered in isolation, but rather be regarded as one component in a world complex of research activities. This complex comprises the research activities of specialized institutions in developed countries and also the activities of regional and national organizations in the developing world. The product of this complex is a vast pool of information to be drawn on in trying to solve national production problems

Venezian maintains that international cooperation in agricultural research should facilitate the exchange of information already available. Without undue delay, results from national research efforts should be continually incorporated into the international pool of information. Through this process, duplications of effort can be avoided. Information resources available at the national level, usually scarce, might thus be utilized more productively.

Against this background, Venezian discusses present alternatives for international cooperation in agricultural research. He identifies two approaches. The first, touched on only briefly in the paper, involves direct action through multilateral organizations, such as UNDP, FAO, World Bank, OAS, and IICA; through the aid agencies of developed countries such as USAID, IDRC, CIDA; through foundations such as the Rockefeller, Ford, or Kellogg foundations; or through CGIAR. Venezian's second approach consists of various "horizontal" cooperation schemes now in operation in the region. These he refers to generally as "international associations." He further divides them into nine subgroups, depending on the degree of their involvement in agricultural research and their style of operation. The analysis emphasizes which of these different subgroups may have the most to offer to agricultural research activities, considering the costs involved and the benefits that can be expected from each distinct form of cooperation. Venezian's paper concludes that recent experiences, especially the IICA-Southern Cone IDB program and the PRECODEPA program in Central America and Panama, clearly indicate that considerable potential exists for horizontal cooperation and for a high level of commitment by participating countries. The importance of the catalytic role of developed countries and of multilateral organizations, however, is also acknowledged.

The final paper in this volume is the presentation made at the close of the meeting by Eduardo Alvarez-Luna, IFARD's Vice President for Latin America and the Caribbean. Alvarez-Luna summarizes the different topics discussed during the conference, placing them within the context of the challenge which awaits agricultural research in the coming decades: to achieve the agricultural production and productivity levels required by an expanding world population, which by the year 2000 will exceed 11 billion people. He calls for an approach to agricultural research based on humanistic principles, with fulfillment of the needs of rural people as the guiding objective. For this to be achieved, Alvarez-Luna states clearly, it will be necessary for researchers and extension personnel alike to develop more credibility among farmers and to recognize the value of traditional technologies as a base on which to build for improving production conditions. Only by working in close contact with farmers, are scientists likely to develop needed breakthrough technologies. At the same time, Alvarez-Luna makes a plea to developed countries for generous assistance, stressing how small and insignificant current resources allocated for agricultural research appear when compared to their expenditures on armaments.

IFARD's role in the region should be considered against this background. Alvarez-Luna suggests that IFARD should stimulate governments to a fuller awareness of the potentialities and needs of agricultural research. At the same time, IFARD should serve as a forum to help establish the participation of scientists and research institutions in the planning and implementation of agricultural development programs.

CHAPTER TWO: The Organization and Management of Human Resources

Alfonso Castronovo
Consultant, Buenos Aires, Argentina

Introduction

The Need to Organize Research

In 1921, 85% of the papers published in the journal **Science** appeared under the name of a single researcher; the remaining 15% had co-authors. Thirty years later single author papers accounted for only 35% of the total; articles by two authors had risen to 38%; and the remaining 27% were the work of three to eight persons (Siu, 1957).

Multiple authorship, that is collective effort, has become even more marked in the last few years. Single author papers are now rare, except where individual work is mandatory, such as for a doctorate. Apparently, external factors have overcome researchers' reluctance to work with others. They are prepared to share honors, rather than work independently and in secret in order to take sole credit for their findings (Gaston, 1973).

In the course of the past half century, moreover, the total number of researchers, including those in agricultural science, has grown considerably. In mid-1963, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, one of the world's finest governmental research organizations, had a staff of more than 5,000 persons, approximately 1,500 of whom had a bachelor's or a master's degree. In 1971 there were approximately 3,500 agricultural researchers in Japan. India had over 20,000 in 1979; some 5,000 of these were associated with the Indian Council of Agricultural Research (ICAR), and 15,000 with India's 21 agricultural universities.

In Latin America the number of agricultural researchers varies from a few hundred in smaller countries to several thousand in larger ones. In 1980 EMBRAPA in Brazil had a staff of 1,553 scientists. In the same year INTA in Argentina had 1,065 researchers and 560 extension workers.

The isolated researcher who works on his own, or with a few pupils and helpers in a laboratory which he funds personally or with contributions from a rich benefactor, has practically disappeared from the scene; the solitary figure has been replaced by teams, frequently large, interdisciplinary teams, which use complicated and expensive equipment and which need an organization to orient, direct, and coordinate their efforts.

Essential Functions of the Organization

According to Parsons (1960), organizations — including those involved in research — are social units or human groupings deliberately constructed or reconstructed to accomplish specific goals. For this purpose, they must be able to perform three essential functions: (a) to execute the tasks and transactions which lead to the accomplishment of their goals; (b) to indicate the objectives and determine the norms which the organization must follow; and (c) to coordinate and direct the resources that the organization has at its disposal to execute its planned tasks and transactions.

When an organization is no larger than the kind of personal research laboratory referred to above, these three functions, combined in one or a few persons may be performed almost unconsciously. As an organization grows, however, the first function is likely to be divided between two or more categories of participants. Specific units will almost certainly be established to perform functions (b) and (c). These units, in turn, may be further subdivided as the need to differentiate staff according to rank and task arises.

Thus, to perform its operational function (a) a research organization of relatively modest size may have several ranks of researchers (senior, assistant, etc.) and various categories of support personnel (engineers, manual workers, etc.). For leadership, it may have a director and several area or program managers, all of whom may also have advisory bodies. In addition the organization will have financial and personnel administration to control and coordinate allocation of resources. Nowadays there is also likely to be a public relations division for the "new" task of communication.

Indeed with added size, the complexity of an organization also grows; it can easily lose its effectiveness and efficiency unless appropriately structured and managed.

Scientific Administration, a Contemporary Problem

The large growth which has taken place in research institutes in the last half century has created relatively new problems in administration (Castronovo, 1969). In Europe, the cradle of modern science, collective research work in research institutes is a relatively recent phenomenon (OEEC, 1961). Even in the United States which has, perhaps, more experience than any other country with research teams and large research organizations, problems of research administration were reputed to be responsible, as late as 1963, for delays in the national space research program which enabled the Soviet Union to gain ascendancy (Paterson, 1963). In India, with its much more recent modern development, Rangaswami (1979) has pointed out major problems impeding agricultural research programs: the poor administrative or management capacity of medium and high level scientific personnel; obsolete administrative procedures which obstruct execution of programs; numerical lack and inadequate training level of specialized personnel.

Individuals in many capacities have made contributions towards solving organizational problems, including scientists, sociologists, economists, psychologists, specialists in business administration, public administration, industrial management, and finance. Their contributions range from advice which comes from personal experience, often intuitive, but informed with a lot of common sense, to elaborate studies. Specific research, for example, has investigated the effect on researchers' productivity of such factors as his age, or the time which he spends on different tasks, or the sort of leadership to which he responds.

The outcome of these studies, many of which are deficient in the critical analysis of collected data, is a vast set of theories and an abundant literature full of fragmentary knowledge of the most diverse type, frequently contradictory.

Focus of the Work

Research in different disciplines may well require different kinds of administrative organization. Since, there is no single standard approach, it is useful to consider proven alternatives and to examine situations which may serve as a sound basis for discussion. To a certain extent this was attempted, some years ago at a seminar in Uruguay, where it emerged that a number of Latin American countries had already adopted some of the newest ideas in research organization and administration (Arnon, 1978).

Human Resources in Research

Restrictions of the Concept

The human resource pool of an agricultural research organization comprises all personnel on its staff. This paper will confine itself to discussing scientific personnel, however, because these researchers constitute the productive element of the research system, the element that requires special forms of administration. To a lesser extent, when directed to specific issues such as training and education, discussion will also include research managers, for their leadership affects the productivity of the researchers. In addition, many managers were formerly researchers who received their training from the research organization; in effect, thus, the organization has assumed responsibility for management training.

The Value of the Research Scientist

One of the few points on which there is general agreement among persons and institutions with an interest in research management is that the value of a research organization is related to the personnel on its staff, an idea which has been expressed in various ways, (Marull, 1967; Rigney, 1968; Oropeza, 1971; USAID, 1972; Molero, 1975; and Araujo, 1979).

General statements of this form, however, frequently involve the introduction of descriptive phrases in referring to research personnel, for example, "adequately prepared" or "qualified". This raises suspicions of circular reasoning: "the best" organizations are those which have "the best" personnel, and "the best" personnel are those who work in "the best" organizations.

Nevertheless, if a research organization is seen as a productive system whose object is to generate new knowledge and new technologies — or solutions to scientific and technological problems — and if researchers are considered to be the productive element of this system, then a direct, irreversible relationship must be acknowledged between the productivity of this element and the productivity of the whole. After all,

"research results are obtained by the **researchers,** not by their administrators" (Rigney, 1971).

While admitting that the productivity of a researcher may vary, among other reasons, because of the environment in which he works and that a person who is productive in one organization may not do as well in another, the point about the relationship between individuals and institution remains valid, at least in the sense that the yield of a crop cannot exceed the potential of its germplasm. This may seem self-evident but, as Kluckhohn (1963) states, "only what is important and interesting becomes obvious."

In fact, a researcher may be respected by his colleagues for his achievements, by his subordinates for his leadership, and by the ambitious for the position that he holds or the honors he has received. But his commercial or market value, which must — or should be — taken into account by the organization which employs him, depends on his productivity.

A Policy for Human Resources

Scientific productivity varies from one researcher to another. Variation may also exist during different phases in the career of the same individual. Were it possible to obtain, over a period of time, a numerical or linear measure of the productivity of researchers as a function of the objects of the organizations for which they work, a frequency curve could be prepared by placing different values of productivity on a horizontal axis and the number of researchers performing at each level of efficiency along a vertical axis.

By integrating the values in such a curve, the overall production of an organization could be calculated over time; this total would equal the sum of the average productivity per worker multiplied by the number of researchers. The major objective of any effective organization must be to maximize this value. The most efficient way to accomplish such maximization — the only way without major changes in personnel — is to prevent average individual productivity from declining and, wherever possible, to boost it. This paper will review how best to obtain these desired results.

Mechanisms for Implementing Personnel Policy

It is obvious that discussion in previous paragraphs is an over-simplification. Other variables remain to be taken into account. Individual productivity, for example, might be measured as a function of investment rather than of time. This would facilitate an economic or financial analysis of the organization. Nevertheless, the object of this paper is not to elaborate or discuss mathematical models, but rather to present a rational view of the management of human resources, a view to be illustrated by considering the mechanisms available for implementing personnel policy. For this purpose, a frequency curve enabling us to calculate overall production suffices; this model will be referred to whenever necessary, incorporating new details as discussion requires.

As a growing organization becomes more complex, alternatives for managing its human resources may multiply. This will be reflected in both the functions and the organogram of the institution. In the last resort, however, manpower administration boils down to a question of personal relationships.

Five management issues will be raised in the following sections of this paper:

Planning,
Recruitment and Selection,
Education,
Salaries and Other Benefits,
Evaluation.

These issues are interdependent. Thus, a rigorous personnel selection procedure may reduce subsequent educational needs; the complementation of selection and education permits a reduction in the need for evaluation; a sound level of salaries and attractive benefits simplify recruitment and selection.

Although it is recognized that other elements, such as physical conditions, the general working environment and style of leadership, also influence the productivity of personnel, such elements have not really been scrutinized separately in this paper. Instead they are incorporated, where relevant, in discussion of the five principal headings given above.

Before examining techniques of personnel management in detail, it is perhaps worth stressing the general truth that a research organization is unlikely to maintain an acceptable level of long-term productivity unless it achieves an effective system of organizing and managing personnel. The laws of institutional life are likely to mean that, through natural causes or migration, an organization gradually loses its more productive elements, at the same time it acquires young scientists without experience and retains those who, lacking external motivation or innate drive, rest content with a comfortable mediocrity. Should this situation endure undisturbed the productivity of the organization will inevitably decline.

Planning

Organization of the Demand to Labor

It is a difficult and time-consuming task to staff a research team and put its program into operation. This cannot be left to chance, trusting the required specialists will turn up just when they are needed, having been attracted to participate in the proposed program. Such rare good fortune is only possible for small teams and in a labor market where the supply of specialists is both plentiful and varied. It is true that many Latin American agricultural research organizations already have attained considerable size; only a limited number of their staff, however, have had postgraduate training (Table 1).

Common sense dictates, moreover, that the composition of a research team should be based upon the needs of the program, rather than on the availability of scientists.

Although a number of different criteria and options have been proposed, little substantial data exist to enable us to formulate demand for scientists in a rational way.
A number of recent global estimates have been made of the demand for specialized agricultural research personnel. Oram (1977), on the basis of published information and his own work, tentatively concluded that during the next 10 years developing countries would need 55,000 new M.Sc. graduates in agricultural research. Projections like this and other detailed information in Oram's paper are useful indicators of the magnitude of the problem. They help stimulate the search for adequate solutions and generate estimates of cost and feasibility. Yet, more specific analyses of high-level human resource requirements need to be carried out at the national level.

There are few Latin American countries, however, in which meaningful national science and technology plans have ever existed. Argentina is an exception but unfortunately neither its 1971 nor 1973 plans were approved or implemented. The 1976 Mexican PNICYT (Plant Nacional Indicativo de Ciencia y Tecnología), also contained a target for training human resources, disaggregating the total into various sectors.

As far as agriculture and forestry are concerned, the details of the Mexican plan are specific. Essential topics are raised such as the likely beneficiaries of research, priority ecological zones for its application, and ways in which plentiful resources, such as labor, might be utilized. From the national plan, however, it is impossible to draw accurate conclusions about the demand for scientists and technicians trained in specific disciplines or fields.

Table 1. Percentage of postgraduate researchers in selected institutions and countries in Latin America.

Institution and Country	Year	% Post-graduate researchers	Source
GNTA (Argentina)	1980	11.1	Castronovo (1980)
DIEAF (Paraguay)	1980	10.7	Castronovo (1980)
CIAAB (Uruguay)	1980	14.1	Castronovo (1980)
DNPEA (Brazil)	1972	11.0	Coqueiro (1981)
Mexico (equiv. full-time)[1]	1974	29.7	Anon (1976)
INIA (Chile)	1980	42.0	Castronovo (1980)
EMBRAPA (Brazil)[2]	1980	56.5	Coqueiro (1981)
EMBRAPA (Brazil)	proj.	79.0	Coqueiro (1981)

[1] Mexico is the only country for which the figures refer to the whole agricultural sector. For all others, statistics pertain only to the institution noted.

[2] It can be seen that the percentage of postgraduate personnel is for the most part low. INIA, it should be mentioned, is a relatively small institution. The glaring exception to the rule, however, is EMBRAPA, the successor of DNPEA. Since 1974 EMBRAPA has mounted a sustained, massive educational effort, sponsoring each year between 46% (1975) and 24% (1980) of its technical scientific personnel to obtain M.Sc. and Ph.D. degrees. By May 1981, EMPBRAPA had awarded over 2,000 scholarships to researchers belonging to state organizations and to prospective staff members. During the period 1974 to 1980, EMBRAPA spent more than Cr$473 million, plus about US$1.5 million on educational grants (IICA, 1981).

Nor in Latin America are studies plentiful of the supply of agricultural scientists at the national level. In Argentina, one such study, made in 1971-1972 (Castronovo et al., 1974) offers incomplete estimates of manpower divided into 3 levels of education, 12 types of profession and 5 types of employer. Currently a more extensive study is underway under the aegis of the FECIC. In Brazil, Abreu et al. (1974), on the basis of data collected during 1968-72, provided estimates of the demand for both agricultural engineers and veterinary surgeons for the period 1974-80. The researchers listed the total number of postgraduates required in these fields (M.Sc. and Ph.D.) and broke the total down by occupational sector (governmental, academic, business).

Studies of this sort undoubtedly are useful for setting postgraduate training targets and as a stimulus for additional studies along similar lines. It must be recognized, however, that to date they have had little impact.

A number of suggestions have been made about how a research organization can best predict its future manpower needs. Actually many of these suggestions concern the personal attributes desired in researchers, such as their level of education, creativity, administrative ability, and other characteristics. To be sure, these are interesting issues in relation to recruitment and selection, and will be discussed later. As far as manpower planning is concerned, however, while an awareness of the importance of such criteria may improve the quality of staff recruited, (second-rate researchers, for example, only produce second-rate research results (Moseman, 1970), such thinking does not help much when trying to determine the number of personnel needed for a certain research project or when deciding whether it is more appropriate to recruit a phytogeneticist or a phytopathologist to do the work.

Manpower targets based on multiple criteria may be more useful. Oram (1977) has suggested that manpower targets in agricultural research should take into account (a) parameters such as the gross national product or the agricultural sector product; (b) the land area dedicated to leading crops; and (c) types and numbers of producers.

Rigney (1968) has stressed the need for a "critical mass" of scientific personnel. He insists it is better to concentrate efforts on a limited number of well-manned projects than to disperse research resources as a result of diffuse social or political demands. Marull (1967) also spoke of the need for a critical mass, using the term differently, however, when he stated that four researchers in related fields were the minimum number required in any endeavor to avoid intellectual stagnation. He offered a set of practical guidelines for planning human resource requirements. Marull's guidelines relate: to the need to keep an adequate part of the total research budget available for operational expenses; to the level of fixed assets required for each researcher (which, like operational expenses, are not necessarily the same for a social scientist and an animal scientist); to the age distribution of the labor force; and to the balance between different categories and levels of personnel.

Although these guidelines may be useful, they do not provide the post identifications and descriptions required for an operational manpower plan at the national level. This can only be accomplished through first defining research objectives and then designing programs and projects to achieve them.

Even once objectives have been clearly defined, however, the task of the research manager in identifying the staff required to meet those objectives is not an easy one.

Suppose, for example, that in a given research project organized by commodities there is a maize component which aims at increasing the yield in region X by 15%, without increasing production costs. Only someone with a thorough knowledge of the region and of the production conditions which prevail there, complemented by a knowledge of the production potential of maize, can determine whether the problem must be tackled primarily from the viewpoint of genetics, economics, rural engineering, or pedology, to mention only a few of the numerous possibilities.

Few executives or managers, unless they work in an organization with a very limited range of activities, are likely to be equipped to answer such questions without some study or constitution. Even if initial questions can be handled readily, it is difficult to imagine finding senior managers who, without being directly involved in the research, are able to make decisions as to when and for what reasons an expert in genetic engineering or in cost accounting, phytopathology, or statistics should be added to the team; whether such additional scientists should be part-time or full-time; whether they should be employed for a limited period of time or indefinitely. Decisions of this nature really lie within the domain of a project manager or program coordinator.

In essence, the organization of demand for scientific labor is a two-way process: senior management, in accordance with their own criteria, supply budgetary outlines and relevant constraints; project managers and coordinators, in turn, also applying criteria of their own, identify, without foreseeable time spans, specific manpower needs. Integration of the perspectives of the two parties has then to be achieved by a process of iteration.

In Latin America project managers or coordinators, as such, are customarily removed from any direct line of command. It may be that "most technical specialists do not want to become administrators" (Etzioni, 1965), or that most prefer to keep to the field of science (Villegas, 1968) because they have not received an education in administration (Brothers, 1977). It does indeed appear that successful specialization may to some extent be incompatible with the broad experience required for effective administration (Holden, 1963). And reluctance on the part of technicians to become involved in management may have, on occasion, lessened administrators' confidence in recovering them for managerial responsibilities (Fenley, 1961).

For these and other reasons in Latin American agricultural research organizations, technical managers are frequently separate from and subordinate to administrative managers. This has been an obstacle to the planning of human resource requirements along the lines of the two-way system referred to earlier. In practice, such a system is rarely found.

Migration

At the time of the creation or the reorganization of a research institution, special opportunities arise for influencing its staffing. Such opportunities occur more frequently in Latin America than in developed countries, but they are exceptional even there. Under ordinary circumstances, opportunities for intervention are limited to routine turnover in personnel, customarily quite modest. During an earlier study of this topic, I derived a turnover index based on an average working life for a scientist of 30 years (Castronovo, 1972). A loss of one-thirtieth of the scientific staff in any given year for reasons other than retirement would thus represent a negligible turnover. According to Oram (1977), a turnover of 5% (derived from equating active professional life with 20 years) has been frequently used in research and development studies. Oram considers 5% acceptable for a static situation but 10% more accurate for a dynamic and expanding program. It is not clear whether this figure includes personnel increments in a growing organization. The number of technical scientific employees at EMBRAPA, for example, rose from 1,037 in 1975 to 1,553 in 1980, an increase of 49.8% in five years (Coqueiro, 1981). In INTA (Argentina), total personnel in research and development rose from 728 to 1,007 between 1959 and 1964, an increase of 38.3%, in five years (Castronovo, 1980).

Both of these growth figures refer to years during which the organizations concerned were undergoing rapid growth immediately following their founding. Taking deaths, resignations, and retirements into account, the statistics represent an annual turnover of 10%. In an established research institution, a turnover on this order is only to be expected as the consequence of special situations which favor or stimulate the voluntary retirement of personnel, a phenomenon also referred to as "migration."

Its well-known irregularity (United Nations, 1956) makes such "migration" difficult to predict. There is a type of migration, however, which causes especially acute concern to many countries in Latin America: the departure of trained personnel for destinations outside the region. This is part of the phenomenon described as the "negative skill flow" or the "inverse transfer of technology" from developing countries towards more developed ones (Araújo, 1979).

The worldwide magnitude of this problem was signalled in UNCTAD by the representative of the Group of 77 who stated that, according to an UNCTAD study, between 1961 and 1972, 230,000 skilled persons emigrated from developing countries to the United States of America, Canada, and the United Kingdom alone. This flux represented an estimated capital of US$50 billion. In reply the representative of the industrialized countries cited the limited capacity of countries of origin to absorb their own skilled personnel, referring to various factors which bear on this problem, including differences in wages and living standards, work environment, and prestige (United Nations, 1978).

Baldwin (1970) attributed the "brain drain" to the pull exercised by developing countries. He quoted a study on education and world affairs, according to which the authors argue it would be an error for receiving countries to try to reduce international migration, since this would

relieve countries who are "losing brains" from the critical task of improving the conditions in which their critical elite are supposed to work.

The problem, however, is not specific to north-south or development-underdevelopment relationships. In one recent year, the United Kingdom lost 160 university professors of the highest caliber; new British Ph.D.s are emigrating at the rate of 140 a year (12% of total production). It is feared that if this flow continues, national technological progress will slow down appreciably. Regions within a country may similarly be weakened. Of the 200 scientists who recently graduated in the Chicago area, only three remained there to work; of 100 aeronautical M.Sc. graduates from the University of Michigan, not one accepted employment in that state. On the other hand, in a recent year enterprises in California, New York, and Massachusetts were awarded almost 60% of government contracts for military research. These states are considered centers of knowledge. This has prompted the prediction that — as factories crowded close to iron and carbon deposits during the time of the industrial revolution — enterprises in the future will locate near centers of knowledge in order to capture their main resource, intellectual talent.

It is not the intention here to enter into the debate between advocates of "attraction factors" (pull factors) and "repulsion factors" (push factors). Migration exists. What is important and interesting for us is to evaluate its impact on the agricultural research institutions of Latin America and to determine whether there are means of combating its negative effects.

The longest available chronological series of statistics related to labor migration in agricultural research in Latin America is reproduced in Table 2. This table shows the variation, in percentages, of the number of engineers at INTA (Argentina) during the first 22 years of INTA's operation.

In four different years (1963, 1966, 1973 and 1976) losses exceeded 10%, reaching 37.5% in 1973. Net increases exceeded 10% on five different occasions: the first and the second of these (1959 and 1961), however, occurred during the initial growth period; the third (1964) and fourth (1967) follow immediately upon years of high loss, and the fifth, (1972), when the highest value of 70% was attained, preceded a record loss in the following year. Only the loss of 1976 (11.1%) is sandwiched between normal years in which the variation did not exceed 5%.

Table 2. INTA (Argentina): Percentage change over the previous year in total number of scientists working in agricultural research and development (1959 to 1980).

Year	Percentage Change	Year	Percentage Change	Year	Percentage Change
1959	13.7	1966	-17.4	1973	-37.5
1960	5.1	1967	35.2	1974	4.7
1961	12.8	1968	5.3	1975	3.0
1962	.6	1969	1.5	1976	-11.1
1963	-11.8	1970	7.7	1977	4.8
1964	22.8	1971	6.3	1978	.9
1965	3.8	1972	70.0	1980	10.8*

* in 2 years

Source: Castronovo 1980: 34

Another such time series is available from INIA in Chile (Table 3). This institution, re-organized in 1964, thereafter behaved with comparative regularity until 1970. Subsequently it started to show sudden large variations in staff numbers, with net losses of 24.3% and 19.5% in 1973-74 and 1979-80, respectively.

Table 3. INIA (Chile): Percentage change over previous period in total number of scientists working in agricultural research development (1964 to 1980).

Period	Percentage change	Period	Percentage change
1964-65	37.0	1970-73	20.1 *
1965-66	11.1	1973-74	—24.3 **
1966-67	5.0	1974-78	46.4 ***
1967-68	4.8	1979-80	—19.5 **
1968-69	0		
1969-70	0		

* in 3 years
** in a few months
*** in 4 years.

Sources: Until 1970, computed from Elgueta (1978) p 91; 1970-73 to 1979-80, from Castronovo (1980) p 87.

CIAAB (Uruguay), after re-organization in 1962, also exhibited sudden variations in number of staff members, including a massive loss of almost 100% in 1967 and substantial gains in 1965, 1968, 1971 and 1973. From 1973, except for minor respite in 1975, scientific staff at CIAAB fell steadily in numbers until 1980 (Allegri and Grierson, 1981).

The percentages of change mentioned incorporate both entries and exits. Consequently, only in the improbable event that there was no recruitment during a whole year are negative values equal to total loss. Taking the figures above and reducing them by 5% -- to account for "normal" turnover – the remaining losses, which can be attributed to voluntary or enforced migration, some time still reach 25% or more of the total personnel. In CIA (Venezuela), for example, by 1971 89.3% of the agronomists who had undergone training between 1942 and 1960 and 15.6% of those who had been trained between 1961 and 1970, no longer worked at the institution (Orpeza, 1971). A limited analysis of all postgraduate specialists (M.Sc. and Ph.D. and equivalent degrees) in the same country yielded similar results.

In INTA (Argentina) 29.7% of those who completed their postgraduate training abroad after 1960 (29% of the M.Sc.s; 32% of the Ph.D.s) had resigned by 1981, as had 25% (all M.Sc.s) of those who had done postgraduate training at home since 1955 (Marzocca, 1981). It should be noted that of the total who left, 39% did so in a single year, 1976.

In INIA (Chile), 43.2% of the postgraduates once employed (40% of the M.Sc.s and 51.5% of the Ph.D.s) had left the institute by 1981 (Cubillos Plaza, 1981). The bulk of the losses were a result of the political crisis of 1973-74.

As far as CIAAB (Uruguay) is concerned, Allegri and Grierson pointed out that "Only a fourth of the postgraduates who had attended CIAAB were with the institution in 1981. The professionals who retired from the CIAAB averaged three years in service after graduating; nearly one-fifth of postgraduates did not re-enter the service. As to current occupation of these professionals, a survey showed 52% abroad, mainly with international organizations, and 34% employed in the private sector in Uruguay."

Ardila et al. (1980 a,b,c.) studying migration in Argentina, Colombia, and Peru, found the annual turnover index for those with M.Sc. varied from 0 to 15.3%; for the Ph.D., from 0 to 31.3%; and for a combination of the two, from 0 to 16.5%.

Some of their findings are summarized in Table 4. It may be deduced that on the average heavy losses through migration (turnover index of 10% and over) were suffered approximately once every 10 years; medians occurred (turnover index 5.0 to 9.9%) twice; and during 7 out of every 10 years "normal" averages were registered (turnover index 0 to 4.9%).

Table 4. Number of years in which the annual turnover index of post-graduate personnel (M.Sc. and Ph.D.) attained certain indices in selected institutions (1960 to 1973).

Turnover Index (%)	ICA (Colombia)	INTA (Argentina)	UNA (Peru)	Total	%
0 to 4.9	11	16	13	40	70.2
5.0 to 9.9	5	2	4	11	19.3
10.0 and over	3	1	2	6	10.5
Total	19	19	19	57	100.0

Sources: Ardila et al., 1980a, p 86; 1980b, p 54; 1980c, p 60.

A more detailed analysis of the work of Ardila and his team shows that, in terms of the period since the establishment or the latest reorganization of research institutions, turnover indices of over 10% occur: for ICA (Colombia), in years 12, 15, and 16; for INTA (Argentina), in year 19; for UNA (Peru), in years 15 and 19; for INIA (Chile), in years 10 and 15; and for CIAAB (Uruguay), in year 5 only (when there was a temporary conflict, the resolution of which led to the return of many researchers who had left previously).

The pattern of turnover indices suggests that internal institutional factors are one reason, perhaps the main one, for migration. Ardila and his colleagues tried to analyze the causes of migration by making inquiries among retired research personnel. Although the low percentage of responses received, particularly from scientists in Argentina and Peru, limits the validity of conclusions, it is notable that in both these countries, as well as Colombia, dissatisfaction with salary levels is invariably cited as the most important motivation for retirement. Nevertheless, if this was a universal explanation, migration would be distributed more uniformly over time and not be concentrated in a few years, or even months. Indeed, a study by Gutierrez and Riquelme (1965) casts doubt on the primacy of salary

considerations. They found that only 24% of the professionals questioned mentioned pay problems as a reason for emigrating, while 55% cited the opportunity to prove themselves in their professional or academic work. It is possible that factors of a general nature are also involved, such as the desire for social status.

The sporadic and intense character of "migration crises" suggests that occasional events, those of a political nature included, may also be significant underlying causes. In this context, Yopo (1975) states: "Everyone knows that most countries, particularly Latin American ones, undergo radical and substantial changes in their administration, even at lower levels, whenever a new government comes into office. These changes are so much part of the system that many professionals and engineers find it difficult to retain any job in their own country of origin. In such circumstances, the only option (sic) is for them to move to other countries, usually to the most developed ones, thus the brain drain is generated."

Yet the fact that migration crises nearly always occur after an agricultural research organization has operated for 10 or more years suggests that migration has something to do with the aging of an institution and with its mode of operations becoming obsolete. The time may be ripe, therefore, to consider changing the prevalent type of agricultural research system in Latin America. At present such systems usually consist of large, central public institutions which carry out agricultural research and, sometimes, perform other functions.

This suggestion apart, it is evident that if no method is found to control sporadic, massive migration of qualified personnel, efforts to organize labor demand rationally — and also to plan research — will necessarily fail.

Problems of Supply

A seminar in Quito (IICA, 1971) identified apparently contradictory problems: although on the one hand, "In most developing countries, there is a shortage of personnel conveniently trained for agricultural research. . .," on the other, "agricultural faculties produce a larger number of graduates than can be absorbed by existing research institutions."

In Moseman's opinion (1970), an undersupply of personnel is the main constraint to improvement of agriculture in developing countries. Oram (1977) supports this viewpoint with documentation from meetings of TAC, CGIAR, the World Nutrition Conference, and the Indicative World Plan of FAO. In 1979 the problem of a shortage of national scientific manpower was addressed in the background (IADS, 1979: 11) and working papers of a workshop at Bellagio (Wright, 1979); it was returned to again in 1981 at a conference on research and training held at CIAT (CIAT, 1981). In every instance thinking ran along lines similar to the opinions expressed at the Quito seminar.

Agricultural education in Latin America started in 1854, with the foundation of a specialized college in Chapingo, Mexico. Few new institutes of higher education in agriculture were established during the nineteenth century. From 1900 to the end of World War II, however, 26 were created. Since 1945, the growth of such institutes has accelerated; approximately 90 were functioning in 1967 (Schlottfeldt, 1967), a figure which had doubled by 1973 (ALEAS, 1973)) and is still increasing. Consequently it is hardly surprising that the production of agricultural professionals numerically exceeds the demand of research institutions and also governmental, academic, and private commercial activities.

Graciarena (1972) offers an explanation for the situation: ". . . when the expansion of advanced education is left to the pressures of social forces, which manifest themselves primarily in what has been called 'social demand,' a chaotic situation arises leading, among other things, to an excessive multiplication of institutional units."

What demand is satisfied by the veritable multitude of Latin American agricultural educational institutes? According to Bouvier (1972), in Argentina only 10% of trained agricultural engineers work in agriculture; and in Brazil, in 1959, 97% of certified agronomists and veterinary surgeons were employed by federal or state public services. Nor is the problem unique to agriculture: In Colombia, according to Graciarena (1967), of 52,070 professionals with university degrees in 1964, 18,207 were not active in the field of their training. While this represented 35% of the total, in certain professions "desertion" was even higher.

In reality, Latin America's universities face problems as grave or even graver than those encountered by her research organizations. "The Faculties of Agricultural Sciences," says Hernán Caballero (1978), "generally suffer from a chronic and profound shortage of teaching,

scientific and technical leadership. There is a scarcity of human, physical and financial resources. The field, its production and operational systems are partly unknown. The majority of the farmers and their real needs and worries are neither known nor fully understood. Generally universities work in the dark, offering a series of isolated disciplinary training which in the end provides a great mosaic of unrelated pieces of information which supposedly equips the student to contribute to the improvement of agricultural production and productivity. Unfortunately, this does not always occur, and in most cases a professional is produced who, though he may possess an adequate academic education, lacks the necessary practical knowledge with which to translate his efforts and abilities into useful actions which will have a real impact on the rural environment."

Indeed, as I have had occasion to remark elsewhere (1981), notwithstanding all good wishes and good will, our universities, in general, do not educate students to carry out research. But how can they be expected to, contending as they do with reduced means and inadequate facilities? What use are such institutions if their teachers do not conduct research themselves; if, to state the matter bluntly, they lack any essential connection with the medium which might enable them to give a correct orientation to the applied research which students should undertake?

This view has also been advanced by the National Council for Science and Technology of Mexico (1976:67): "Education at university level, in spite of some efforts, basically rests on systems which assume a passive assimilation of information and do not stimulate an inquisitive attitude in the pupil which would encourage him to question hypotheses, to investigate and to experiment. This problem originates with the complex set of factors which influence the task of teaching: academic background, methodology, study plans and programs, etc.; all of these favor theoretical education, which is not associated with either the application or the use of knowledge. There are some indications that the educational and professional level of university graduates is deteriorating. This phenomenon is associated with a fall in the quality of university teachers and the accelerated growth of demand for university-level education . . . Many universities have at their disposal only a small number of full-time professors.

"In 1971, the total number of professors in Mexico was 24,000, of whom only some 3,500 or 14% had a full-time teaching job, an even smaller percentage divided their time between research and teaching. Postgraduate studies were relatively new. There are reasons to believe that in many cases the expansion of postgraduate studies is the answer to the need for supplementing the deficiencies of university education. Most higher training for scientific and technological research has, until recently, been carried out either abroad, or in the trainees own research institute, under the supervision and guidance of more experienced scientists and technologists."

In Latin America, formal postgraduate education in agricultural sciences began in 1946 at the Graduate School of IICA, in Turrialba. By 1966 there were no fewer than eight graduate schools, which among them offered specialization at the M.Sc. level in 26 different areas (Castronovo, 1966). The number has continued to grow and some schools now offer a Ph.D. program. Nevertheless, the optimistic predictions of the late 1960s and the early 1970s are still far from fulfillment. With few commendable exceptions, postgraduate education has not succeeded in becoming integrated into the university system. It is frequently regarded as a nuisance, maintained by noninstitutional mechanisms under the pressure of outside forces through the interests and efforts of a small number of teachers concentrated in specific academic units. In Argentina wide-ranging and patient deliberations to institutionalize the Graduate School in Agricultural Sciences floundered when the outside force which sustained the school lost its credibility. The limited graduate training activities still depend on financing from outside the university.

At the opposite end of the region, in Mexico, the National School for Agriculture and the Post-Graduate College at Chapingo, despite extensive discussions and negotiations, were unable to agree on any form of structural integration. Currently, the college is an autonomous entity whose relationship with INIA is possibly closer than it is with the school. In smaller Latin American countries, initiatives to consolidate postgraduate education institutionally are being debated. Those concerned are searching for a formula that would permit continuity and, at the same time, satisfy a demand which is no less diversified for being small. Even in Brazil, the country where postgraduate agricultural education has undergone the greatest development,

difficulties may be pending because of reductions in the training program of EMBRAPA, which is linked to the postgraduate schools and faculties of a large number of academic entities.

To summarize, the number of agricultural educational institutes in the region may deceive us into underestimating manpower supply difficulties. It seems certain that for some time to come a scarcity of local specialized personnel will continue to be a problem for agricultural research organizations in Latin America.

Discussion Theme

Planning, although it may have important influence for staffing, is not really a mechanism for personnel management as long as it depends on demand and has little influence on supply. Consideration should be given, therefore, to measures which might eliminate or reduce the frequency and gravity of the periodical crises which affect research institutions in Latin America. These crises lead to expansion or reductions of staffing on a scale sufficient to impede the efficiency of the research institutions. Steps also need to be taken to enlarge the regional pool of specialized research personnel with scientists of a high quality.

Possibilities for restructuring agricultural research systems and higher education also need to be explored. If linked more closely to each other and to the production sector, they might prove more effective than when, as at present, research is controlled by the state, and education by the universities.

Recruitment and Selection

The Role of Recruitment and Selection in Personnel Management

It was noted earlier that to maximize the output of a research organization it is necessary to maintain or raise the average productivity of its member researchers. Once this has been recognized, it is easy to see that the role, or the goal, of recruitment and selection is to ensure that only new employees are accepted whose productivity is likely to be at least equal to, and preferably higher than, the average of the organization. Expressed in another way, this same principle emerges in the conclusions and recommendations of an IICA Seminar in Lima (IICA, 1973); ". . . it is necessary to develop adequate selection systems . . . based on criteria of efficiency."

To convert this concept into an operational norm, it is first necessary to define its parameters: the first parameter refers to the product unit (or units) in which the total production of the employees, as well as of the organization, is expressed; the second refers to the unit, as a function of which productivity will be determined.

For a research organization, the basic product is always knowledge. In addition one may assume that the knowledge sought is to have practical applications which will prove economical. First, however, knowledge has to be obtained in order to be tested. Selection and recruitment of staff for carrying out original research will need different criteria, however, from the selection and recruitment of staff for applied research. "Any activity through which somebody learns something he did not know previously" (Macklup, 1962:7) imposes the extra tasks of communication and transfer of knowledge to an organization's personnel.

As for applied research, productivity may be measured in various ways; as a function of time, or of expenditure. For example both criteria may be used on specific occasions, for the duration of a project, say, or a specific program. Any organization, depending on its circumstances, will define its output in such a way as to ensure its growth and survival. Thus it will be disposed to measure productivity as a function of its scarcest resource.

It has been noted that, "Apart from their main researchers, a research institute must recruit, in variable proportions depending on the circumstances, a certain number of M.Sc. and of researchers at the bachelor's level. Without detracting from the former, there is reason for reflection in the following observation of a Soviet scientist: 'scientific research must have its infantry; the brilliant individual provides the spark, but only the masses can exploit the results" (OEEC,1961). The need for dependable rank-and-file researchers may make it necessary to be flexible in categorizing personnel, not only individuals but also work teams.

In addition, selection should be directed to finding individuals who will adapt well to the working conditions which the organization has to offer them. This is particularly important in Latin America, where only too frequently working conditions leave something to be desired. Indeed Borlaug (1964:112) has stated: "When

you deal with problems of food production in underdeveloped areas, there is no substitute for the trained mind that can improvise to meet difficult conditions with inadequate facilities."

Specific Selection Criteria

To select effective staff entails attempting to predict the future productivity of individuals as a function of their personal characteristics and/or their past performance. For this purpose, the use of diverse criteria has been suggested, based generally on the individual applicant's intrinsic qualities. Because these qualities often cannot be assessed directly, other attributes or facts which may be indicative of character are frequently reviewed in their place during the selection process.

Creativity is perhaps the quality most frequently mentioned as desirable in researchers. Development of a new idea, or of a new application for a known idea both basically involve creative work (Dunk, 1964). According to Hertz (1953), a creative mind is characterized by receptivity to new information, flexibility, intellectual curiosity, and an ability to formulate problems and use new information to solve them. For some, creativity is expressed not only in coming up with new ideas but also in devising the means to test, communicate and propagate them (Stein, 1963). Molero (1975) is among many who cite creativity as an essential trait in any productive researcher. This judgment, however, suggestive and possibly accurate, nevertheless remains a matter of a posteriori celebration. The question is how accurately we can predict creativity in ways which help simplify selection. Certainly there are cases, particularly among biologists, where creativity is slow to manifest itself. Charles Darwin, was already 50 years old when he published the **Origin of the Species by Means of Natural Selection.**

Expertise, experience, professional title, recognition, and honors received in the course of a career are criteria frequently used for staff selection. In 1973 at the Peruvian Regional Center of Agricultural Research, La Molina, selection was based on scientific qualifications, research experience, and an evaluation during a trial period, of the applicant's initiative, wish to learn, perseverance, creativity, flexibility of judgment, spirit of cooperation, intellectual honesty, and ability to communicate (Quevedo Iturri, 1973). Many of these characteristics can only be appraised subjectively and over a relatively long period of time. In Venezuela most selection criteria mentioned by Oropeza (1971) correspond to requirements set by the public administration (the absence of a criminal record, for example, and clearance by the income tax authorities); only two criteria, professional title and qualifications obtained in the course of the job seeker's career, relate clearly to expected performance in the field of research. A personal interview has now been added to the selection process, as well as a probationary period of 45 to 90 days during which work performance, levels of interest, personal knowledge, and the ability to establish sound personal relations, can be observed (Montilla, 1973). Nevertheless, objective reliable criteria for selection still remain to be identified. Some postulated that to offer low wages would guarantee that job applicants were motivated by an authentic scientific vocation. Montilla disagrees.

The value of certain selection criteria has been questioned in various studies. The assimilation of knowledge produced by others, for example, has been shown to involve a different mental process from the one which leads to the generation of fresh knowledge (Taylor 1964). As a consequence, the ability to assimilate has limited predictive value as far as creativity is concerned. In the selection of candidates for research posts less importance should also apparently be attached than is true at present to certificates acquired in the course of a scientific career (Taylor et al., 1963).

It has been suggested that eligibility for research posts be restricted to persons who have completed postgraduate studies. This policy, however, assumes a positive correlation between attainment of an advanced degree and the future performance of the researcher. Rigney (1971), for one, stresses the need to stay in close contact with postgraduate programs to facilitate observation of M.Sc. or Ph.D. candidates so that careful selection from them will later be possible. Arnon (1978), while conceding there are no objective criteria of equivalent value to the observation of on-the-job performance, recommends recruitment of well-trained M.Sc.s to give them an opportunity to prove their worth. He also notes that it is an advantage for a job candidate to be familiar at first hand with agricultural problems and that training in basic research techniques is indispensable. Unlike Montilla, Arnon is of the opinion that low initial wages do stimulate self-selection. Coqueiro (1981) states that since 1979 EMBRAPA has given highest priority to the education of Ph.D.s, considering such persons to be the best qualified to study relevant foreign technologies critically and adapt them to solve the problems of Brazil.

Nevertheless, there is no confirmation that an academic degree is a safe criterion for the selection of productive agricultural researchers. Higher levels of education and the wish to carry out basic research apparently correlate positively with each other and negatively with the needs of an applied research organization (Abrahamson, 1964).

Diaz Bordenave (1968a) found that, as far as number of publications is concerned, M.Sc.s are more prolific than either Ph.D.s or agricultural engineers. Similarly, those who studied abroad between two and three years publish more than those who carried on for four or five years; those who studied abroad for two to three years also outpublish colleagues whose education outside the country was limited to a year at most. Caiueiro (1981) mentions an analogous phenomenon he observed at a large university in Brazil. His explanation for the current state of affairs is that on one hand, in the past a master's degree in Brazil was no prerequisite for a doctorate and, on the other hand, candidates today for a doctorate must commit themselves to a time-consuming period of research. Unfortunately, there are few objective studies in Latin America which analyze differences in income among researchers who hold different levels of academic degrees. One such study which might have helped clarify the problem, proposed almost 20 years ago by the author of this paper was never carried out for lack of financing.

The purpose of personnel selection and contracting is to achieve an adjustment between the requirements of a position and the characteristics of the person hired to do the job. For this reason the Quito Seminar (IICA, 1971) recommended that "research institutions should have at their disposal an analysis and description of each function or job which the holder of a given position within the organic structure is expected to carry out." Although laborious this method of comparing the desirable and previously defined with the obtainable, may well be the most effective one, at least where sound selection criteria are available.

In Latin America, partly because of difficulties inherent in the application — either separately or in combination — of criteria referred to above, and partly because research organizations have limited access to the labor market, recruitment and selection of personnel for agricultural research have to date received slight attention.

Forms of Recruitment and Access to the Labor Market

For selection criteria to yield positive results, it is necessary that the population from which selection is to be made be sufficiently large and contain enough variety of skills and aptitudes to ensure a high probability that individuals with specially designated characteristics can be found.

Research organizations in Latin America have not always taken this necessity into account. They generally restrict their search for personnel to the poorly supplied local market, all too frequently to no more than a fraction of it.

Several reasons may account for such behavior. On the one hand, it is easier to apply selection procedures when the number of candidates is small and they are of relatively homogeneous origin. Oropeza (1971: 273) states: "Sometime ago, when the only Faculty of Agronomy in the country was the one at Maracay, it was relatively easy to select research personnel. This was facilitated by the fact that a large number of C.I.A. researchers at that time were also part of the teaching personnel of the Faculty. On the other hand, there were jobs available for students in their final years, who were chosen through competition in accordance with rules laid down for that purpose." In a tightly knit unit, however, it is difficult to avoid recruitments becoming heavily biased by "personal recommendations from reliable individuals." Elements of nepotism easily creep in. Marull (1967) has referred to personal recommendations as counterproductive in many countries where politicians use such recommendations to drive an incumbent out of his post, regardless of his technical capabilities. Such actions are on the whole aimed at mature, experienced scientists, rather than at recent graduates.

Such situations can occur while formal recruitment is taking place by means of public competition in accordance with established norms, (Castedo, 1973), or with "the law of the administrative career" (Montilla, 1973). Vacancy announcements generally receive limited or belated publication so that many potential candidates never learn about suitable job openings, or only do so when it is already too late to apply. This holds true particularly for those who reside abroad. Announcements about research positions in national organizations are rarely published worldwide, the way they are for international organizations or highly selective national organizations, such as CSIRO.

There are reasons why vacancy announcements for national research enterprises are not often published internationally. To start with, international publication prolongs the selection procedure. If an organization keeps a vacancy open for too long, it may find when the selection process is finished, that funds to finance the position have been reduced or lost. Another deterrent is that advertising abroad is expensive and requires foreign exchange which may not be available. Salary and working conditions offered, moreover, may not strike recruiters as attractive enough to appeal to candidates abroad. Their assumption may be correct in some cases, but certainly not in all. Furthermore, they may be overlooking the wish of certain expatriate scientists to return to their home country. Nevertheless, the main reason for exclusively domestic circulation of job notices, appears to stem from the fact that research organizations in Latin America, however little or much autonomy they may enjoy, are state organizations; as such they are not permitted to include foreigners on their permanent staff.

It is curious to note that such exclusion, which may or may not be justified in other fields, continues in the agricultural sciences with total disregard for the role expatriates have played in agricultural development. Only consider Deneumostier and Berisel in Colombia, Lefebre and Renard in Chile, Daller and Brieger in Brazil, Spegazzini and Hauman Merck in Argentina, Boerger in Uruguay, Pittier in Costa Rica and Venezuela, Popenoe in Central America and many more. Or, take note of the more recent programs of the Rockefeller Foundation through their Special Study Workshops in Mexico, Colombia, and Chile (see, for example, Ardila et al. 1980d, Elgueta 1978, Marzocca 1967, Stakman et al. 1967).

Finally, the rigidity of this salary system, as we will observe later in more detail, also reduces the access of national research organizations to the labor market. This has the same unfortunate aspect as other recruitment problems to which we have already referred: it principally affects highly qualified personnel.

Given the present labor market situation, it is perhaps not so surprising that already in their final years of study many students try to associate themselves with research organizations and seek to major or to specialize in fields where either they can identify a concrete job opportunity (Peñalosa, 1968) or where there appear to be clear prospects for further study (Marzocca, 1981). The Quito Seminar was of the opinion that the training of undergraduates at experimental sites is "... a very adequate system for the selection of initial personnel who later might be assigned to the research services. Nevertheless, for this to be effective researchers must be convinced that the time which they devote to training young scientists working on their experimental station will be justified (IICA, 1971)."

In the past most graduates joining a research organization were trained in this way or similarly. With their unproven abilities and limited experience, however, their initial productivity, if not zero, certainly is below average. At the same time, personnel leaving the organization are, to a large degree, established scientists. These facts together suggest that in-house training of students leads to a decline in average productivity and to a fall in the efficiency of the research system.

Intensive training programs, as we will note later, may compensate for this negative effect, at least in part. The cost of such programs, however, is considerable. Rapid calculations indicate it would be beneficial to devote part of these funds instead to the perfection and expansion of current recruitment and selection systems then a larger proportion of entering personnel will have productive contributions to make from the moment of their employment.

Discussion Themes

Problems relating to the recruitment and selection of human resources fall into two main categories: those whose solution lies within and those whose solution lies beyond the realm of direct action by research organizations.

As far as external solutions are concerned, each organization will have to analyze and decide where and to what extent they might exert constructive influence. With respect to internal recruitment and selection issues, two essential discussion points arise.

Over the past 20 years, considerable experience has been amassed in Latin America regarding personnel management in agricultural research. The number of active researchers, with and without postgraduate qualifications, has grown considerably. It is possible to classify these workers into relatively homogeneous groups of known productivity. Thus, data necessary for the identification of effective selection criteria might well

be obtained through the sharing of available information and through the formulation and empirical testing of relevant hypotheses.

Concurrently, information processing has also undergone impressive progress. Thus, it is now feasible to assemble a file of information on the human resources available for agricultural research in Latin America and to make this file accessible throughout the region. Such a data bank could even be extended to include those from other areas who are willing to serve in Latin America.

Should these suggestions be deemed promising, ways and means to put them into practice could be discussed during this workshop.

Training

The Role of Training in Personnel Management

In accordance with ideas which we discussed earlier concerning generation of knowledge as the goal of research organizations, training should be devised to maintain, or if possible, to increase the productivity of member researchers.

This statement may be simple; putting it into practice, however, is not. Many factors influence the productivity of individual scientists. These factors prominently include cognitive issues, technical skills, and motivation.

It is widely recognized that increasing the knowledge of researchers is equivalent to raising their value as human capital. Yet, it is not always understood that through disregard and obsolescence of acquired knowledge, human capital is subject to rates of depreciation which at times can be high (Alvez, 1980). When the knowledge of a large proportion of research organization's personnel has gone out-of-date, the organization itself ages and becomes ossified (Seifert, 1964). To prevent this from happening, it has been suggested that researchers should spend at least one third of their time keeping abreast of new developments in their field of activity (Raudsepp, 1963). Still, and despite the emphasis on cognitive issues in the training programs of Latin American agricultural research organizations, relatively little is being done about updating knowledge. Instead, enormous efforts are devoted to formal training, especially at higher levels.

There is also an unhealthy disposition to neglect the acquisition of new technical skills, possibly because the educational and social environment of Latin America does not accord prestige to manual tasks. In research organizations such tasks are currently assigned to personnel of lesser rank, such as laboratory workers, assistants, and helpers. Many research teams lack support staff possessing these skills. It is, in fact, not uncommon in Latin America to find a researcher whose career has been dictated by the techniques which he learned in his formative years. Large teams sometimes function at but a fraction of their potential capacity, for neither the researchers nor technicians on the team are skilled in handling complex equipment. It is also not unusual for a researcher to claim he has found improved ways to use a piece of equipment without his even knowing, completely and fully, the techniques recommended by the manufacturers.

The importance of motivation to productivity is based on the fact that "the attitude of staff . . . towards the objectives of the organization and with respect to their own cooperation influences their ultimate behavior within the organization . . . For example, it frequently happens in professional life that a person is indifferent to the specific goals of the organization where he finds a post, although he accepts that post for materialistic reasons" (Mayntz 1972; 160).

Training with respect to motivation rarely occurs, except sporadically, during induction courses and, more frequently, through the personal influence of charismatic leaders. It is often suggested that vocational challenge should compensate for lack of training in motivation. It is difficult to reconcile this point, however, with the fact that large organizations may have goals so general that they no longer seem highly relevant to the personal objectives of the researcher.

Few individuals have a spontaneous vocational urge. In a restricted labor market, it is wishful thinking to assume it is impossible to recruit personnel exclusively endowed with this characteristic. This realization suggests that greater attention to motivation would significantly increase the contribution of training programs towards achieving the overall goals of the organization.

Training programs also customarily have specific goals which vary from organization to organization. One such goal is the training of future leaders. In research organizations, management positions are frequently

attained by promotion, which "brings many problems along with it; for example, how does a candidate for promotion learn his new task?" (Mayntz, 1972: 159). In Latin America, this problem has to a large extent been solved by evaluating the leadership potential of researchers prior to promotion; to some extent this may compensate for and replace training but leadership potential will not invariably blossom into leadership on its own.

Conversely, training programs have frequently been used either as a complement to or as a tool of, personnel selection. As complement, training permits expansion of the organization's work program through granting scholarships to advanced students or recent graduates, or through consolidating cooperation with universities in mounting postgraduate courses. As a selection tool, training programs enable the behavior and performance of trainees to be observed over time so the best candidates to fill vacancies can be identified. Because these types of interaction are possible, it is difficult to isolate training from other aspects of personnel management and to treat it systematically on its own.

Training Programs

Training is the aspect of personnel management in Latin American agricultural research about which the most has been said, written and done. The subject has been covered extensively in publications, meetings, and seminars, as well as in materials related to the organization and administration of research projects.

Among leading reasons for such a strong interest in training programs, the following may be mentioned:

1. A need to increase the limited pool of existing specialized researchers by the addition of well-trained personnel;
2. The need to keep up-to-date in fields where knowledge is increasing continuously and rapidly;
3. Given the development of technology, the need for acquiring new skills not always available on the labor market, making it necessary to re-adapt existing personnel so that new programs can be established and implemented;
4. The growth and evolution of research organizations, as well as the high turnover of their personnel, often means an exchange of functions among staff who remain, and therefore a need for supplementary training.

In the first half of this century, agricultural research training needs in Latin America were often met by assigning personnel to work closely with distinguished scientists. Shortly after the end of World War II, with the intensification of foreign aid, the first training programs with an institutional goal or orientation appeared. These programs in most instances followed a standard format. Priority was given to in-service training. Candidates learned on the job, released from the limitations of an almost exclusively theoretical education. Such practical training made it possible to transfer or adapt advanced technology created in developed countries. Subsequently it became clear this approach was in itself insufficient. Training scholarships gained in importance, enabling recipients to attend formal postgraduate courses, first at the M.Sc. level and finally at the Ph.D. level.

In some instances, training programs were built up to the point where they acquired a stable institutional basis, for example, the Specialization Department of INTA (Argentina) (Marzocca, 1981) or the Department of Human Resources of EMBRAPA (Coqueiro, 1981), where diverse types of training were possible. Elsewhere it has been necessary to follow the sometimes round-about roads opened by foreign aid; such aid unfortunately does not always make it possible to offer training to meet the real needs of an organization (IBTA, 1981; Urbieta, 1981). In general, however, each country in the region now has a whole series of training opportunities available for agricultural researchers — at home and abroad — ranging from conferences, meetings, seminars, and short courses, to formal postgraduate and postdoctorate programs.

The Rockefeller Foundation has significantly promoted the development of advanced agricultural training, particularly, although not exclusively, in Mexico, Colombia, and Chile. Generous assistance has been offered as well by other sources, including the Ford and Kellogg foundations, government agencies such as USAID and CIDA, and international organizations such as OEA, IICA, and FAO.

More recently, CGIAR centers have applied considerable effort to the training of personnel from national organizations. These centers, which initially featured in-service training, later switched to more diversified programs which may even involve formal courses at the postgraduate level (CIAT, 1981; Nickel, 1979; Vega, 1979).

National efforts, abetted by foreign aid, have made it possible for the countries of Latin America to begin to acquire rich and varied technical skills. In Uruguay, for example, 120 scholarships have enabled sending trainees to more than 16 countries for training in no less than 14 different agricultural fields (Allegri and Grierson, 1981).

One aspect of training which has barely been touched upon in Latin America, however, is training for research management. Indeed, whether or not research should be administered by scientists is still a point of controversy. To review this controversy here is not of pressing importance; to look squarely at reality is. "Although administrative authority is adequate for the main activities in private business," says Etzioni (1965: 146), "in professional organizations the administrators are charged with secondary activities; they administrate means for the main activity performed by the professionals. In other words: To the extent that there is a relationship between team and line, the professionals should keep the main authority and the administrators should retain a secondary role." Such a split is also to be considered in private businesses as companies grow and become more technical. Whereas in Latin America a little over half a century ago, only 7% of senior executives in the private sector had a technical education, today, over 30% are graduates or M.Sc.s, a proportion which is growing annually. This is not to suggest that a scientific enterprise be successfully administered without any knowledge or experience whatsoever in administration, but rather to indicate that scientists who assume administrative responsibilities should undergo specific training in management skills.

Participants in the Bellagio Workshop (IADS, 1979) closely considered the administration of agricultural research and development. Metz (1979) described courses offered at Cornell University concerning the administration of agricultural and rural development; Vyas (1979) reviewed the experiences of the Indian Institute of Management, which gives courses in the same field, at various levels and from different viewpoints; the South-East Asian Research Center of Agriculture reported on the Project on the Administration of Research which has research and training components (SEARCA, 1978).

Of the three work groups which participated in the Bellagio workshop, two devoted themselves exclusively to the theme of administration. In its final report, one of these groups addressed itself specifically to the training of leaders for agricultural research organizations. It stressed that the importance of this issue does not depend on the degree of development attained by a country. The group identified an urgent need to provide leadership training in this field to a target group of 6,000 persons, indicating that a high priority should be given to making an early start with one third of the total number. It mentioned some ten organizations and agencies which offered some sort of training in this area and recommended specific initiatives (IADS, 1979:87-94). The third work group concentrated on in-service training for middle-level administrators (IADS, 1979:95-98).

Costs, Benefits, and Sources of Funds for Training

Until the late 1950s and early 1960s, external grants were the principal source of agricultural research scholarships in Latin America, nearly all of them for students to study abroad, because within the region few postgraduate courses in the agricultural sciences existed. Individuals were the beneficiaries of these grants, not the institutions to which they belonged. These institutions restricted their contribution to awarding grantees leave of absence. Sometimes they also continued to pay the national salary of grantees while away studying. Scholars, who were designated by donor agencies on a basis of academic ability and vocation, made relatively heavy sacrifices in exchange for the opportunity to study and the prestige associated with having been selected.

Under these circumstances, it is perhaps predictable that results, scientifically speaking, were excellent. There were few failures. Those who finished usually achieved commendable records.

Nowadays the situation is different. Although scholarships are still available, many more than previously, the degree to which individuals are the direct recipients of grants is limited. Instead scholarships are for the most part coupled to loans or to specific projects in such a way that a restricted area of specialization is designated beforehand, one which it is believed will reinforce the scientific capabilities of the national institution charged with carrying the project out. Thus conditions immediately narrow the options and eligibility of scholarship candidates. Research institutions select trainees from their current or aspirant personnel. To be sure there will be researchers studying certain disciplines, and candidates of lower quality of motivation may be selected.

Under such conditions we might well anticipate an inferior level of scientific achievement. Because their scholarship would be oriented more to their organization's goals than to their own, grantees could be expected to fail more frequently in their studies, to take more time to finish, and to feel less loyalty towards their own organization. Yet this approach should help research organizations to meet their broad, planned objectives

This said, however, it still remains to be seen whether the new approach is preferable to the previous one in terms of advancing the overall interests of the organization. In other words, does today's grant system yield greater benefits than the preceding one? It is tempting to maintain that the previous situation was preferable because it entailed almost no expenses for research organizations so that benefits were practically net gains. Yet the fact of the matter is that in most Latin American countries a return to the system of personal grants would simply be unacceptable (see Cubillos Plaza, 1981). In reality current training programs consume considerable funds which, for the most part, come ultimately from taxpayers and the treasury. If the flow of these funds is not to be interrupted, it is indispensable to demonstrate they are being well spent.

Such demonstration is not easy, however, because data on costs is incomplete, and there is no data relating to benefits. All we know is that costs are considerable. Reference has already been made to EMBRAPA's training outlay (see Table 1). Ardila, Trigo and Piñeiro (1980d) report training program expenditures for INTA (Argentina), ICA (Colombia) and UNA (Peru) over the period from 1960 to 1978: in 1977 US dollars total costs amounted to $5.2 million for INTA, $19.6 million for ICA and $2.9 million for UNA. Dividing each of these amounts by the number of organization scholars who obtained higher degrees (M.Sc. or Ph.D.), the average degree cost amounted to US$16,571 for INTA; US$31,145 for ICA; and US$11,344 for UNA. In computations for UNA, the sum does not include the national salaries of the scholars, for these were not paid during their studies. The average degree cost figures are slightly misleading, for the total costs include grants to those who did not finish their studies (not taken into account) as well as to recipients of more than one scholarship, for example, first a grant for an M.Sc. and then for a Ph.D.

The sequence of activities which a researcher pursues during the course of his studies can also influence the costs and benefits to his employer of his advanced training. Cajueiro (1981), for example, describes three different situations. In each case, the candidate has a scholarship during two years of university studies, before entering the research organization. In the first case once he is admitted, he works for three years, studies for one and a half years in order to obtain his M.Sc., returns to work for three more years and finally goes back again to study, this time for three and a half years, to finish his Ph.D. This case corresponds closely to one described by Elgueta (1978) for the initial period of INIA (Chile).

In Cajueiro's second case, the moment the candidate joins the research institute, he leaves to study for an M.Sc.; he then returns to work for three years before he leaves again to study for a Ph.D. In the third case, the researcher's leave starts immediately after he joins the institute; but this time he stays away for five years to complete his master's degree and doctorate in succession. Obviously there are many other variations possible in which time spans and levels of preparation differ, alternatives where researchers break off their education with an M.Sc. or push on beyond a doctorate or rest content with merely on-the-job training.

Table 5: Duration in years of study and work stages in the career of researchers who follow alternative training sequences[1].

Stage	Alternatives I	II	III	IV	V	VI
	Years					
Study, with scholarship, prior to being admitted to the organization	2	2	5	2	3	2
Work as Agr. Eng. or Lic.	3	-	-	3	-	40
M.Sc. program	2	2	-	2	-	-
Work as M.Sc.	3	-	-	35	39	-
Ph.D. program	3	3	-	-	-	-
Work as Ph.D.	29	35	37	-	-	-
Total	42	42	42	42	42	42

Source: Author.

[1] A career is considered to begin with completion of studies for Agr. Eng. or Lic. (theoretically at age 23) and to end with retirement (normally at 65), which gives an active professional life of 42 years.

[2] Alternatives I and II correspond to the Cajueiro's situations A and C except for slight variations in the duration of the M.Sc. and Ph.D. programs which here together last for five years.

In Table 5, six alternative sequences are presented. I and II correspond respectively to Cajueiro's first and the third cases; VI represents the study-work history of someone who finishes university without formal or informal postgraduate training.

By applying the cost and production indices in Appendices 1 and 2 to these cases (indices which, while arbitrary, are plausible), we obtain the data presented in Table 6, which shows costs and benefits for various postgraduate training strategies. The lowest cost alternative is, as was to be expected, VI (agricultural engineer or Lic.) The strategy yielding the largest benefit is III (Ph.D. before starting work). If we consider the influence of different training sequences on average productivity, then the most favorable alternative is III, followed by V (M.Sc. before employment) and VI. All alternatives in which postgraduate study commenced after a period of work for the research organization are clearly inferior. If on the other hand, we wish to maximize the number of years in which the production index exceeds the cost index (annual productivity greater than 100), then alternatives V and VI are clearly preferable to all strategies which include the obtaining of a doctorate.

Table 6. Total costs and benefits, until 65, of researchers following alternative training sequences (based on cost and benefit indices estimated in Appendices 1 and 2).

Alternative	Accumulated Cost[2]	Accumulated Production[3]	Productivity Average[4]	Productivity Annual[5]
I	239	218	91	26
II	267	252	94	23
III	254	270	106	30
IV	196	179	91	24
V	199	209	105	35
VI	157	161	103	35

[1] Table 6 is derived from Table 5 data to which have been applied the arbitrary cost and production indices set out in Appendices 1 and 2. It is illustrative, not a reflection of reality.

[2] $\text{Accumulated cost} = \frac{\text{year n}}{\text{year 1}} \text{ (annual cost)}$

[3] $\text{Accumulated production} = \frac{\text{year n}}{\text{year 1}} \text{ (annual production)}$

[4] $\text{Average productivity} = \frac{(3)}{(2)} \times 100$

[5] $\text{Annual productivity} = \frac{\text{production year 1, 2...n}}{\text{cost year 1,2...n}} \times 100.$

The table gives the number of years, in the entire career, in which this value was greater than 100.

Table 6 shows clearly that if work to be done is within the reach of an agricultural engineer or Lic. with experience, it is not necessary to have it performed by an M.Sc. or Ph.D.

In Table 7 total training costs are shown as the researcher's total income. Highest in alternative II, this represents the least favorable choice for the research organization in terms of annual productivity (Table 6 column 5).

If this analysis had been limited to the first 10, 15, or 20 years of active service, instead of to the researcher's entire career, results might differ. They might have differed still more if the indices used, particularly those of Appendix 2, portrayed different behavior. It is, therefore not worth our trouble to embark on further analysis lacking an empirical basis. The example has been included simply

Table 7: Differences in total income[1], until the age of 65, of researchers who have followed alternate training sequences[2].

Alternatives	Alternative II	III	I	V	IV	VI
Index[3]	267	254	239	199	196	157
II	–	13	28	68	71	110
III		–	15	55	58	97
I			–	40	43	82
V				–	3	42
IV					–	39

[1] Total income is taken as the accumulated cost in Table 6; it includes benefits received through study grants before and after the researcher has entered the organization.

[2] This table is a recasting of column 2 of Table 6; it should be interpreted as an illustration, not necessarily as reality.

[3] See Appendices 1 and 2 for derivation of cost and benefit indices.

to show that, if a research organization keeps good records of the costs and performance of its scientists, it will have at its disposal the necessary data with which to choose suitable programs for training and also, perhaps, for planning and financing the education of human resources at different levels.

Discussion Theme

Conflicting opinions have been expressed about the best way to train researchers to maximize institutional productivity: at home or abroad; as a simple specialization, with emphasis on actual practices, or in a formal degree program at the M.Sc. or Ph.D. level; at the time the individual joins the research organization or later, after he has worked there for a few years; by selecting the most talented, competent candidates for training, or choosing those whose intellectual interests appear best to serve the goals of the organization; or by financing studies through guarantees, by contract, or by bonding the candidate to continue employment for a number of years after completion of his studies. Frequently, the approach most suitable for the research organization does not satisfy the aspirations of its scientists. Similarly, were scientists to pursue their personal priorities, these would clash with the objectives of their research organizations. In the only case which came to my attention in which agricultural research scientists were consulted about their training wishes (INTA, 1971), it appeared the views they expressed were not translated into practical action.

No doubt exchanges of views on training should be encouraged but by themselves they cannot overcome what is for most organizations the main problem: a lack of regular funds to finance a rationally conceived training program. A considerable part of currently available training funds, both internal and external, are mis-spent on candidates who either do not finish their studies or who, if they do, leave the organization a short time later, even if this means breaking their contract. Huge sums invested in training in the past have not provided the agricultural research organizations of Latin America with the competent personnel they need. It seems neither possible nor reasonable to expect more funds to be earmarked for training, or even for present funding levels for training to be maintained, unless waste can be eliminated and training benefits for sponsoring organizations improved.

Under these circumstances, it would appear high time — using an adequate empirical base — to review the concepts, policies, and practices, which agricultural research organizations throughout the region adhere to for training human resources.

Salaries and Benefits

The Role of Salaries and Benefits in Personnel Management

A research organization, like any artificial social entity wishing to perpetuate itself and to attain certain goals, must admit new researchers with a certain regularity and succeed in retaining their services. Furthermore, it must find ways to induce them to carry out tasks which require a major intellectual input. To obtain compliance from researchers, the organization has a system of rewards and sanctions. Rewards take the form of salaries and other benefits for those who show acceptable behaviour (average productivity); additional bonuses may be awarded those demonstrating exceptional behavior (above average productivity).

Yet, such a description of the role of salaries and other benefits in personnel management is both static and incomplete: static in that it does not necessarily imply any displacement of the productivity curve; incomplete because it does not recognize that the participation of researchers in the organization is voluntary and their work has a strong intellectual component. Indeed no element of coercion would be tolerable. Instead organizations may resort to various forms of stimulus, motivation, inducement, and involvement. When such elements are included in the total employee benefit package, they stimulate individual behavior (increasing individual productivity) and, at the same time, promote a positive displacement in the productivity curve.

To obtain this result, the system of benefits must be based on a clear description of desired behavior and of methods for measuring it.

"The output of a company . . . can be measured by the quality and quantity of their products and by the benefits obtained from them. The measure of output for . . . a research organization . . . is more difficult to determine.

The search for an output measure becomes particularly problematic when an organization has not defined its goals in a clear and unambiguous way or when it pursues several goals at the same time without having established clear priorities among them" (Mayntz, 1972: 174)

Researchers, however, do not invariably share the goals of the organization to which they belong. Their personal interests and goals are likely to diverge from institutional objectives. In the preceeding section, for example, we observed how training alternatives most attractive to researchers may well be least attractive for their organizations.

Perhaps a measure of alienation or even conflict between staff and organization is inevitable. When the staff includes eminent researchers, conflict may acquire major, more or less permanent proportions, constituting, in Steele's phrase (1957), the "schizophrenia" of the organization.

To alleviate or eliminate internal tension, it is not enough to enhance or diversify the organization's system of rewards to conform more closely with researcher's goals. This merely "exaggerates things to the point of overlooking the fact that the idea of employing somebody is to obtain certain services from him" (Marull, 1967: 18.11). Even without falling into this trap, "the exercise of power . . . keeps the subject alienated for as long as he conforms. He conforms for ulterior motives. His conformity is probably limited to subjects explicitly endorsed by the management. It is unlikely that he ventures information, shows initiative or cooperates, except when he is explicitly forced to do so. In addition, in moments of crises, when the power structure of the organization is weakened, he will tend to prefer other norms which he favors over those of the organization" (Etzioni, 1965).

It is clear then that the system of rewards will influence researchers and their behavior differently under different styles of leadership, autocratic, democratic, or permissive (Peltz, 1956). This suggests a need for appropriate adjustments between the system of rewards and leadership style.

It seems hardly necessary to add that the rewards referred to here are not only monetary or material. They include other incentives which strengthen motivation as well (Maslow, 1954; Mendoza, 1973).

In the interests of clarity, the system of rewards and sanctions discussed here is confined to the three P's; pay, power, and prestige, which satisfy three kinds of human needs. Pay satisfies material needs; power is related to man's need to occupy a recognized place within society, with recognized perogatives, often related to his status. Presitge involves the value assigned to an individual by persons whom he himself values, particularly his peers; prestige assures man's need for esteem.

Even contemplation of the simplified three P's suffices to show that it is not easy to establish and operate a satisfactory system of rewards within a research organization. To do so requires an institutional maturity rarely attained in Latin America.

Possibly for this reason, Etzioni (1965:105) finds "The granting of part of the rewards by an organization without first considering performance is commoner in the more backward areas of a country than in more advanced areas, and is also more common in the least developed countries than in the developed ones; one of the reasons for this is that the management of research organizations is less effective in less developed countries." Although in Latin America agricultural research organizations are certainly not free from this managerial shortcoming, the nature of the rewards which they offer is probably a more important problem in sustaining motivation. Basically, rewards boil down to a balancing, in one form or another, of the services which a researcher provides and the services an organization has to offer in return. This balancing must take place in such a way that the individual feels reasonably satisfied, while the organization can attain its goals effectively. It is not easy to achieve such a balance in any country, however developed; after all, both parties are inclined to assess services and returns subjectively. In Latin America, however, the problem is especially acute because researchers' salaries are so low.

Salaries and Other Benefits

The most straightforward benefit which a researcher enjoys is his salary. Salaries should be capable of attracting workers to an organization and retaining them. The services a researcher has to offer, theoretically at least, are equivalent to merchandise subject to quotations on the labor market, the international labor market included. To set salary levels, one must first determine the going market rate for a researcher with certain characteristics, such as training, experience, age, family

responsibilities, etc., and then offer candidates this amount or slightly more. Of course, the salary flexibility of a research organization is finite. Furthermore, there are relatively well-differentiated categories of researchers. System can be introduced simply enough, however, with a salary schedule or table, subdivided into ranges or grades, each with a number of steps or positions. Generally, the upper steps of one range coincide with the lower ones of the next, making it possible to differentiate salaries according to characteristics, such as previous income or years of service. Frequently, the scale is designed in such a way that researchers, who, according to many authors, are reluctant to assume administrative responsibilities can finish their career and attain a top salary without having to occupy middle-management positions. Such a system, widely used in developed countries, has been adopted in Latin America by nearly all agricultural research organizations of a certain size.

Nevertheless, as we described earlier, individual research organizations, and the region as a whole, continue to suffer considerable losses of scientific personnel. These losses cannot be ascribed to a single cause.

Indeed, the dissatisfaction with salaries, mentioned by Ardila and his co-workers in all their papers (1980 a,b,c,d), has various origins.

The restrictions of the labor market have already been mentioned. Sometimes, one scientist represents the total supply in a certain speciality. Yet, two or three scientists may mean a surplus. Demand, for its part, is customarily dominated by one large public sector organization (the research organization). This may represent 50% to 80% of the total demand, complemented by the manpower needs of various smaller organizations (universities) and a few private companies. Under such circumstances, oscillations in the labor market are of such magnitude that it is virtually impossible to staff an institution while adhering to categories established in the salary scale.

Exceptional situations arise during the phase of establishment and reorganization through which agricultural research organizations of the region pass with a certain regularity. During such periods, the organization usually can count on substantial political and, as a consequence, budgetary support. All at once funds made available enable it to offer exceptionally high salaries, with a sufficient variation of vacant positions to preclude competition and to assure a satisfactory niche for every applicant researcher, almost without exception. Such prosperity usually lasts for a limited number of years. Ultimately, however, there is a reversal, usually for economic (mainly inflationary) or for bureaucratic reasons. Often state bureaucracies resent the existence of organizations that have some autonomy or salary regimes superior to public service norms. "You have an army with more officers of high rank than soldiers," is a comment budget managers commonly let fall when reviewing the budget proposals of an agricultural research organization.

A clear example of what may happen in such circumstances is presented in the work of Ardila et al. (1980 a:124). The year after ICA (Colombia) was founded, the average salaries of its post-graduate scientists in constant terms, started to decline. Migration commenced when average salaries sank to 73% of their initial value, and it became rampant when pay levels fell below the mark of 60%. Unfortunately, parallel studies on INTA (Argentina) and UNA (Peru) (Ardila et al., 1980 b,c) do not include comparable data. Both these studies, however, demonstrate that in most instances researchers who change organizations receive a significantly higher salary in their new post.

Abrupt migration associated with a decline in relative salary levels can be alleviated by creating new demand through increasing remuneration in other organizations, by the dawning of new prosperity in business, or by the opening up of fresh opportunities on the international labor market (see, for example, Arnon, 1982).

Another source of dissatisfaction and impetus for migration is the political instability which, although at times disguised, is nearly always characteristic of governments in Latin America. No reference will be made here to the dismissal of scientists on political grounds, which is known to occur; note should be taken, however, that researchers who find themselves in a minority, because of their social opinions, may be isolated and rejected by their colleagues, becoming victims of the political opposition endemic to nearly all Latin American societies.

Although a researcher's allegiances in a volatile political climate may well reduce the possibilities of his promotion, his views are unlikely to mean any direct salary reduction. Awareness of political unrest, however, does affect scientists psychologically, eroding their sense of security in ongoing employment, counteracting the stability necessary to research.

Erroneous or arbitrary application of the salary scale also provokes dissatisfaction, especially in scientists with post-graduate training. Unjustified promotions, moreover, will be resented by scientists at all levels.

Motivation

Numerous systematic studies of a quantitative nature have demonstrated a positive relationship between motivation and the quality of scientific work (Gollembiewski, 1964). This relationship has long been recognized by Latin American agricultural research organizations:

"The administration of agricultural research personnel should be directed towards creating a climate which stimulates and motivates the researchers, because this is as important as providing them with incentives of an economic nature.

"It is recommended that those who direct scientific research should give special attention to the use of all types of incentives for their scientists so that they are continuously motivated and oriented with the purpose of maintaining a constant self-improvement in their work. The product of research comes from a stimulated mind and, therefore, the administrator must do everything in his power to keep that mind fertile and productive" (Quito Seminar, IICA, 1971).

A variety of incentives have been used to sustain researchers' motivation: training; differential rewards, promotions and annual bonuses based on evaluation; trips abroad to attend conferences and give work presentations; subsidies for learning foreign languages; loans for acquiring homes and vehicles; and, in addition, the organization of social, sporting, artistic, and cultural activities.

These incentives do not appear to have served their purpose particularly well. Without doubt, under certain circumstances, some are welcome supplements to salaries which are admittedly low or which have diminished purchasing power. Sometimes such incentives are preferable to a raise in pay because they are not subject to tax or social security deductions. Thus they increase the researcher's monthly income at relatively little cost to the organization. Whenever they consist of material benefits, such as the use of a car, their value is automatically readjusted with inflation. Yet their motivating effect, even at best, is modest. Such an effect, when it occurs is rather apt to be the achievement of a charismatic superior who carries out his supervisory function skillfully, providing the sort of leadership which can contribute so much towards boosting productivity (Arnon, 1978:231).

Nevertheless, according to available literature, material incentives do seem to bolster motivation in countries elsewhere. The question remains, why they are ineffectual in Latin America? To try to find the answer, let us return to the 3Ps: Pay, Power, and Prestige. Pay, as we have seen, exercises only circumstantial motivating influence, if any; and even then this is frequently of short duration. It remains to examine how agricultural research organizations in the region attempt to meet researchers' needs which can be satisfied by power and prestige.

Power or status -- appeasing the need to occupy a recognized place within society -- can be conferred by an organization itself. Research organizations in Latin America, however, appear to confuse power with administrative authority.

Efforts to avoid overloading researchers with bookkeeping checks and bureaucratic paperwork have clearly screened them from the main line of authority. Such authority remains vested in the hands of "researchers" who do little, if any, real research. In certain organizations, eminent researchers have been rewarded with the function of "program coordinator," supposedly carrying out the technical management of a specific program, while free from responsibility for its general administration. It is not uncommon for program coordinators to earn as much as the director of the organization where they work, or even more. It is the director, however, who wields all the symbols of power: the executive title, the largest and best-furnished office, the direct telephone line, the private secretary. In addition the director exercises real power: he is the organization's decision-maker. It is always the coordinator who must ask authorization for one thing or another from the director, never the other way around. As a result, regardless of all compensation, leading researchers are prey to dissatisfaction. Herein lies the origins of an organization's "schizophrenia."

In contrast to power, a research organization cannot directly bestow prestige upon a researcher. What the organization can do is give him the opportunity to achieve it by himself. In general the great motivating force of prestige is widely recognized. Etzioni (1965: 87) relates, for example, that "there are lawyers who have refused six-figure incomes to become judges with five-figure salaries, compensated for by the higher prestige of the bench."

Deliberately or not, agricultural research organizations of Latin America have made considerable efforts, within the scope available to them, to give their researchers the opportunity to gain prestige. At times, however, it seems that the commitment of the organization to this third P (prestige) stops short at this point, as if management is preoccupied with raising the potential productivity of researchers so that, at its own convenience, the organization itself can benefit. It is all too common for a researcher who returns cloaked in glamor from his Ph.D. studies, to find himself obliged to assume responsibility for work which corresponds poorly, if at all, with his field of specialization. He seldom has the personnel and supplies at his command to permit him to conduct meaningful research. He must conform to the pursuit of goals for the achievement of which his level of training may be incongruous.

Even when an organization decides to provide a researcher with an appropriate team, it too often economizes falsely by delaying the recruitment of support staff and purchase of equipment. Apparent savings are negated, however, by the cost of leaving an expensive researcher dangling under-employed — to say nothing of the risk of frustrating a major investment in human resources. Extensive, rigorous studies demonstrate that scientific output increases considerably where researchers share in the decision-making process (Peltz, 1964). Nevertheless, researchers are seldom permitted by their organizations to participate in this process.

We should not forget that researchers are only human. They may interpret obstacles to personal career progress as a barrier deliberately erected to exclude them from competition for management positions. Where this occurs, in addition to signs of schizophrenia, a research organization may break out in symptoms of "paranoia."

One way in which it is customary for research organizations to afford their researchers an opportunity to garner prestige, beyond that which they have achieved during their formal training, is to encourage them to present their research findings at professional meetings or congresses. This will usually entail international travel, an occasion to mix with specialists from other countries. Representation at such events contributes to the prestige of both the individual researcher and his parent organization. The stimulus of contact with others at work in the same field can be invaluable. Intellectual cross-fertilization may accelerate completion of a research project by years, or lead to the formulation of new and revolutionary discoveries. Such results, at least potentially, are of benefit to the research organizations with which the inspired researchers are affiliated. Of course, to be realistic, to the extent that a scientist achieves eminence, he gains prestige; and the more he excels, the easier it becomes for him, in the end, to migrate to a more attractive research position.

For organization and researcher alike, it is convenient and necessary for the individual to add to his prestige in his own country, too. Organizations have various means to combat the anonymity of their research staffs, making it possible for scientists to gain public attention and, perhaps of even more importance, the notice of their peers. One rather direct approach to this end consists of endorsing professional and specialist associations, supporting them in their conferences at the national level or when they host international meetings. These groups generally have a precarious, faltering life. Regular seminars, as well as active participation in specialist associations and in the planning and decision-making procedures of their own organization, constitute other opportunities for researchers to enhance their local prestige. To become known within and beyond his own immediate professional environment enables a scientist to develop a sense of belonging, which reinforces his loyalty and counteracts any inclination to migrate.

Discussion Themes

In Latin America, agricultural research organizations are generally state institutions which do not enjoy broad autonomy. Salary policy is out of their hands. They conform to guidelines laid down for the whole of the public sector. It is conceivable that one day, within this context, an exception will be made for research activities. At that time, certain current recruitment problems will be solved. Such a result, however, is unlikely to be achieved

by agricultural research organizations on their own. Indeed organizations involved in medical science, nuclear physics, or defense, to name a few highly influential research areas, are more likely to be the first to make any breakthroughs regarding the salary structure of research workers. At this conference, extensive discussion of the pay question is not justifiable, therefore, unless we consider the possibility of restructuring agricultural research as suggested in the earlier section of this paper on planning. If participants wish to go so far, then we might weigh the advantages and disadvantages of a private company system more or less linked to the state, one similar to the systems now being tested in Brazil and Chile or, alternatively the merits of the research foundation, learning from the experiences of the Technological and University Studies Institute of Monterrey (Mexico).

Motivation of research organizations is far more than merely an internal resource in Latin America. In the past such organizations relied largely on salary adjustments or supplements to keep staff working contentedly. It is possible that nowadays, because research organizations have difficulties in offering attractive, competitive salaries, they will be obliged to use alternate forms of benefits to acquire and retain able researchers. What kinds of benefits might best provide the desired inducements is something for this conference to discuss, including ways to direct available funds or at least part of them to achieve maximum motivational effect. There also remains the possibility of considering how to devise rewards of a social, non-material nature which, without entailing more than minor costs, might stimulate researchers to an all-out effort on the job.

Evaluation

The Role of Evaluation in Personnel Management

Within a research organization, the evaluation of personnel fulfills several functions: it analyzes the professional background and characteristics of employees seeking admittance, simplifying selection and placement within the salary scale; it allows management to exercise control over the organization, ensuring that it operates in the way planned and that it remains directed towards its goals; it serves as a basis for the application of the rewards and sanctions system, justifying promotions and bonuses to those who show desired behavior, as well as penalties or the transfer or dismissal of those who fail to contribute as expected to the organization.

The effects of evaluation, then, are mostly indirect, accomplished by means of mechanisms referred to earlier (e.g., selection, rewards and sanctions). Evaluation supports and reinforces these mechanisms and, in turn, is supported and reinforced by them. Evaluation as an independent process becomes less necessary as other mechanisms operate satisfactorily. Intensive selection and training programs make it possible to employ able personnel who embrace the goals of the organization and facilitate achieving desired staff conduct without strict supervision.

Nevertheless, the goals of an organization evolve. The work of researchers, whatever their intrinsic merit, must not remain unrelated, but rather be "aimed towards solving the fundamental problems of each country" (Samper, 1964). Without coordination, the products of staff efforts may prove only marginally relevant to the organization's goals, barely contributing to its total productivity.

For this reason, it is essential to exercise a certain degree of control over the organization. In reality, even if all personnel management factors operate smoothly, it is almost impossible to prevent a small proportion of unproductive, or uncooperative researchers from being recruited. Dismissal of these employees is necessary to maintain a viable organization. Here evaluation has a direct role to play: by identifying sub-standard performance it can help eliminate deadwood and thereby prevent the regression and possibly the demise of the organization.

Forms of Evaluation

The form of evaluation will be a function of its purpose. When evaluation relates to selection and recruitment, for example, and its task is to estimate the probable output of a candidate, given his personal characteristics and prior performance, it will take the form of a prediction. When evaluation appraises ongoing actions to determine how well they correspond to plans, to reveal possible deviation in order to correct or to justify them, then it is tantamount to operational control. But it is when evaluation turns to productivity that it acquires its most specific character.

Paez (1979), who describes these three forms of evaluation which refer to the future, the present and the past, as evaluation ex-ante, concomitant and ex-post, respectively, offers an elaborate methodology for their application.

Many other methods of classifying different forms of evaluation exist. These may be pyramidal, when following a hierarchic scaling; parallel, when carried out by the peers of the person evaluated; or special, when confined to committees or persons appointed for this specific purpose. Evaluation can be internal or external, depending on whether or not it is performed by members of the same organization. It can be subjective, when based on personal criteria; comparative, when persons are measured against each other and distributed over ranks of merit; or normative, when staff performance is rated according to an elaborate table describing behavior.

Whatever technique is adopted, evaluation requires paperwork: notes, forms, or reports which must be elaborated and treated according to procedures regulated in a more or less formal manner. It is obvious that these documents and procedures are not themselves the goals of the organization, but only an indirect means to achieve these goals. It is counterproductive to over-utilize resources for evaluation, especially human resources whose main task it is to deliver research results. "In professional organizations, the excessive influence of the administration, which takes on the form of ritualized means, undermines the goals for which the organization has been established and endangers the conditions in which science can be created and institutionalized" (Etzioni, 1965:148). In extreme instances, researchers may translate a detailed description of desired behavior into a guideline to which they blindly conform renouncing all personal initiative, turning oblivious to the organization's true goals. In this way the possibility of a researcher making any genuine scientific and creative contribution sadly vanishes.

It is probably to prevent this from happening that major prestigious research organizations, without losing sight of the recognition due to merit, have reduced the administrative work required by evaluation to a minimum. In so doing, they have especially limited the participation in evaluation which they require from their researchers themselves.

CSIRO (Australia), for example, considers it neither necessary nor desirable to establish formal evaluation procedures. Department managers submit proposals for promotion or other relevant actions annually. The nine-member body which controls the organization, known as the Executive, reviews these proposals; in addition it may consult with relevant managers and consider researchers' publications and other accomplishments. When necessary, the Executive solicits advice from eminent scientists within or outside Australia. It compares candidates for advancement with other members of CSIRO and with outside researchers. As a consequence, it may come up with researchers to promote or to reward otherwise not included in the original proposals. Finally, decisions are made in consultation with the department managers.

Of particular note is that no special report is required from the researchers themselves. They do no more than carry on with their work, disseminating results through publications or other suitable media. Once they reach a certain level of special merit, and this is decided on an ad hoc basis, their names are included among the limited number placed before The Executive for special promotion or reward. INRA (France) achieves comparable results by means of radically different procedures. Whenever a vacancy occurs, an internal competition is announced; personnel may participate who consider themselves eligible. The selection process thus involves a genuine comparative evaluation of the candidates.

In Latin America, two extremes of evaluation procedures may be observed. In some agricultural research organizations, especially smaller ones, evaluation of personnel is customarily left to the subjective judgment of the head of the organization. This process can all too easily become arbitrary and, therefore, is not to be encouraged.

Elaborate and complex evaluation systems also have been instituted; these generally require such a quantity of paperwork and procedures that they effectively paralyze the organization annually for a period of two weeks up to a month. After a few years, evaluation becomes a hollow ritual, the sole result of which is the cramming of nearly all staff researchers into few categories at the extreme upper end of the organization's qualification scale. This placement entitles them to a salary supplement, but one which has lost all motivational effect because the reward does not reflect real productivity differences.

Specific Evaluation Criteria

At the outset of this paper, we discussed criteria for personnel selection and recruitment. The following section will be devoted specifically to criteria employed in the evaluation of performance, a topic which is comparatively simple, since it does not involve predictions — which are always a risky business. Evaluation of performance means the appraisal of how work advances the goals of the organization. Yet, this also entails difficulties; not only is it seldom easy to define the output expected by an organization precisely, but it is usually difficult to measure this output objectively.

As said earlier, the products of a research organization invariably fall into the category of knowledge. The discovery and description of new facts are involved, together with the formulation and testing of new ideas or theories, or the elaboration and empirical assessment of new technological resources. But how can these be measured or appraised? How do we compare, for example, in terms of organizational productivity, the botanical identification of three new species of fodder grasses with the selection of a rhizobium capable of entering into symbiosis with a certain variety of soya or with determination of optimal fertilizer treatment for a given soil and crop?

Ultimately, research results are as a matter of course converted into publications. If these could be appraised, one would have an indirect, but valid, means to measure researchers' productivity. Much has been written on this subject, but nothing resembling a consensus has been reached. Klopsteg (1945) has stated: "Nobody has yet encountered a formula to translate the number of pages published into a factor which describes the merit of the work published." Shaw, who should be able to speak from experience, for he served as director of the Agricultural Research Service of the U. S. Department of Agriculture for many years, worked out a method which, (according to its originator) without pretending to be exact, makes it possible, to obtain an acceptable numerical appreciation (Shaw, 1967). According to Krohn (1971), publications are "unfortunately" the only possibility for quantifying the production of researchers. Meltzer (1956) maintains that frequent publication is considered representative of a high degree of performance in scientific circles.

Others maintain that the measure of quality is not so much the fact of publication itself but the number of times a paper is cited by other researchers (Cajueiro, 1981; De Solla, 1965). One might argue, however, that frequency of citation simply indicates that an active or controversial scientific area is involved, one in which many authors are publishing and quoting each other. Indeed, major seminal works like those of Mendel can continue in obscurity for years.

On the other hand, researchers do not always hurry to publish their findings. They may hold them back for a long time, restrained by perfectionist zeal, or by lack of time to write, or because they are primarily interested in satisfying their own curiosity. Whatever the cause, the urgency to publish does not appear deeply felt among Latin American researchers. Diaz Bordenave (1968b) held a survey among the participants of the VII Conference of ALAF (today ALCA) about how they perceived the career significance of publishing; 75% of the respondents indicated "it is not necessary to publish" or "publishing helps, but it is not necessary." He concluded, "It is clear that in Latin America the policy of 'publish or perish' does not reign."

When all has been said and done, the most reliable measure of a researcher's productivity is the quality and quantity of his publications, evaluated by his peers. A researcher, however, may also contribute to the goals of an organization in other ways: by training young scientists, for example, or cooperating in the planning of workteams, or helping the internal harmony of his research group. During evaluation it is desirable, therefore, to use a number of criteria which, though not very reliable or perhaps subjective singly, together may yield a more secure and objective appreciation.

Arnon (1978), citing systems which use 9 to 14 different criteria, gives a brief description and comparison of evaluation methods used in Israel, France, and Great Britain. There is no proof though that the sum or combination of ten not very reliable criteria should be trusted. Would anyone suppose that ten burglars together would behave like an honest person? As a consequence, the solution to designing valid evaluation techniques is not to accumulate criteria indiscriminately, more by imitation than by reflection; the challenge is to examine performance in ways genuinely related to the person to be evaluated and to avoid unnecessary complexities by confusing the means with the end.

Discussion Theme

While it may be said that evaluation is necessary and even indispensable for personnel control, the process does consume time and funds. Poor evaluation systems may be wasteful and ultimately prejudicial, even to the point where they distort the operations of an organization. Where researchers are evaluated purely on a basis of their successes and failures, for example, those who work on topics with minimal risks however minor their importance, may end up being favored, while imaginative scientists with initiative and courage may be discriminated against (Stearns, 1978).

There is considerable experience of personnel evaluation in Latin America. Some highly sophisticated approaches have been utilized. It should therefore be possible to test whether complex methods really interfere with researchers' work, are not entirely reliable, or even may have counterproductive effects. Should such a negative picture emerge, it would be appropriate to discuss how to simplify the evaluation of scientific personnel and make it more efficient.

Research is increasingly being organized according to specific projects or programs which fall under the responsibility of work teams. From outside the team, it is difficult to appreciate which of its members contribute most – in terms of knowledge, industry, and attitude – to overall team results. Under such conditions it may be more understanding to evaluate team performance as a whole rather than the achievements of individuals. One might assign a certain number of merit points to a team which could then be divided in keeping with the merits which the group itself allocates to each member. At first conflicts may arise from egotistical claims. Egotism, however, is not favorable for teamwork. Presumably, under such a system the rest of the group will correct those whose claims are extravagant or even eliminate them from their midst.

Perhaps, up to now in deriving evaluation systems, so much effort has gone into details that we no longer "can see the forest for the trees." It may be worthwhile to stand back, to reconsider the subject from a point where the panorama can be better appreciated. Possibly, Louis de Broglie (1974) was right when he asked, "Could it not be universally true that the concepts produced by the human mind, when they are formulated in a slightly vague form, are on the whole valid for reality, but that, when an extreme precision is looked for, they are converted into ideal forms, whose real content tends to vanish? In my opinion, that is the way it is; and I think that a great number of examples from all fields can be quoted, above all in the fields of psychology and ethics, as well as in daily life." After all, for a genuine man of science no human trait is alien.

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Appendices

Table 1. Arbitrary annual cost indices in the course of the career of researchers who follow alternative training programs[1].

Age (in years)	Annual cost indices for the alternatives indicated[2]					
	I	II	III	IV	V	VI
24	(1)	(1)	(1)	(1)	(1)	(1)
25	(1)	(1)	(1)	(1)	(1)	(1)
26	1	(4)	(1)	1	(1)	13
27	1	(4)	(2)	1	2	1
28	2	(6)	(2)	2	2	1
29	(4)	(6)	3	(4)	2	1
30	(4)	(6)	3	(4)	2	1
31	2	3	3	2	2	2
32	3	3	3	2	3	2
33	3	4	4	3	3	2
34	(6)	4	4	3	3	2
35	(6)	4	4	3	3	2
36	(6)	4	4	3	3	2
37	3	5	4	3	3	3
38	4	5	5	3	4	3
39	4	5	5	4	4	3
40	4	5	5	4	4	3
41	4	5	5	4	4	3
42	5	6	5	4	4	3
43	5	6	6	4	4	4
44	5	6	6	4	5	4
45	5	6	6	5	5	4
46	6	6	6	5	5	4
47	6	6	7	5	5	4
48	6	7	7	5	5	4
49	6	7	7	5	5	5
50	7	7	7	5	6	5
51	7	7	8	6	6	5
52	7	8	8	6	6	5
53	7	8	8	6	6	5
54	8	8	8	6	6	5
55	8	8	9	6	7	6
56	8	9	9	7	7	6
57	8	9	9	7	7	6
58	9	9	9	7	7	6
59	9	9	10	7	8	6
60	9	10	10	8	8	6
61	9	10	10	8	8	6
62	10	10	10	8	8	6
63	10	10	10	8	8	6
64	10	10	10	8	8	6
65	10	10	10	8	8	6

[1] See the description of alternatives in text, Table 5. Cost indices in brackets correspond to number of years of study prior to admittance to the organization (1) and (2), or after admittance, (4) for M.Sc. and (6) for Ph.D.

[2] The annual cost indices have been estimated based on the following assumptions:

1. The annual cost of an agricultural engineer, agronomist or Lic. gradually rises from 1 to 6 as he accumulates years of service and experience.
2. The cost of an M.Sc. rises from 2 (no previous work experience) to 8, depending on years of service and experience.
3. The cost of a Ph.D. varies from 3 to 10, depending on the same criteria.
4. The cost of apprentices is equal to the minimum cost of an agricultural engineer or Lic. (1) for scholarships prior to admittance, but doubles (2) during the last 2 years of a doctorate program. Once the candidate has been admitted to the organization, his cost covers all scholarship expenses in addition to salary and other benefits, and becomes (4) for M.Sc. and (6) for Ph.D. aspirants.

Table 2. Arbitrary annual production indices in the course of the career of researchers who follow alternative training programs[1].

Age (in Years)	Annual Production Indices for the Alternatives Indicated[2]					
	I	II	III	IV	V	VI
24	(0)	(0)	(0)	(0)	(0)	(0)
25	(0)	(0)	(0)	(0)	(0)	(0)
26	1	(1)	(1)	1	(1)	1
27	1	(1)	(1)	1	2	1
28	2	(1)	(1)	2	2	1
29	(1)	(1)	2	(1)	2	1
30	(1)	(1)	2	(1)	2	2
31	2	2	3	2	3	2
32	2	2	3	2	3	2
33	2	3	3	2	3	2
34	(1)	3	4	2	3	2
35	(1)	3	4	2	3	3
36	(1)	4	4	2	4	3
37	3	4	5	3	4	3
38	3	4	5	3	4	3
39	3	5	5	3	4	3
40	4	5	6	3	4	4
41	4	5	6	3	5	4
42	4	6	6	4	5	4
43	5	6	7	4	5	4
44	5	6	7	4	5	4
45	5	7	8	4	5	5
46	6	7	8	4	6	5
47	6	8	9	5	6	5
48	6	8	9	5	6	5
49	7	9	10	5	6	5
50	7	9	10	5	7	6
51	8	10	10	6	7	6
52	8	10	10	6	7	6
53	9	10	10	7	8	6
54	9	10	10	7	8	6
55	10	10	10	8	8	6
56	10	10	10	8	8	6
57	10	10	10	8	8	6
58	10	10	10	8	8	6
59	10	10	10	8	8	6
60	10	10	10	8	8	6
61	9	9	9	7	7	5
62	9	9	9	7	7	5
63	8	8	8	6	6	4
64	8	8	8	6	6	4
65	7	7	7	5	5	3

[1] See the description of alternatives in text Table 5. Production indices in brackets correspond to number of years of study.

[2] The annual production indices have been estimated based on the following assumptions:

1. The annual value of production from an agricultural engineer, agronomist, or Lic. varies from 1 to 6, as a function of his contribution to the goals of the institution.
2. The annual production value for an M.Sc. varies from 2 (no previous work experience) to a maximum of 8.
3. The annual production value for a Ph.D. varies from 2-3 to a maximum of 10.
4. Annual production grows with experience to peak in a period which starts between 49 and 55 and ends at 60. Productivity declines slightly throughout the last five years of the research career (60 to 65). If periods of different annual production were displaced in time while maintaining the same duration, total results would not alter, but partial results (at 10, 15 or 20 years of service, for instance) would vary substantially.
5. The production of student apprentices at university level contributes nothing to the goals of the organization (0). The production of those doing postgraduate studies is minimal (1); which implies the writing of a thesis on some theme of interest to the organization. Financing of post-graduate scholarships can be justified as an investment, provided the greater productivity of such personnel at least covers the cost of the training investment.

Table 3-I. Cost, production and productivity, by years of service, of researchers who follow training alternative I[1]

Years of service	Situation	Accum. cost	Production accum.	Production average[2]	Productivity annual[3]	Productivity average[4]
−2	E	1	0	0.0	0	0
−1	E	2	0	0.0	0	0
1	L	3	1	1.0	100	33
2	L	4	2	1.0	100	50
3	L	6	4	1.3	100	67
4	M.Sc.	10	5	1.2	25	50
5	M.Sc.	14	6	1.2	25	49
6	M.Sc.	16	8	1.3	100	50
7	M.Sc.	19	10	1.4	67	53
8	M.Sc.	22	12	1.5	67	55
9	Ph.D.	28	13	1.4	17	46
10	Ph.D.	34	14	1.4	17	41
11	Ph.D.	40	15	1.4	17	37
12	Ph.D.	43	18	1.5	100	42
13	Ph.D	47	21	1.6	75	45
14	Ph.D.	51	24	1.7	75	47
15	Ph.D.	55	28	1.9	100	51
16	Ph.D.	59	32	2.0	100	54
17	Ph.D.	64	36	2.1	80	56
18	Ph.D.	69	41	2.3	100	59
19	Ph.D.	74	46	2.4	100	62
20	Ph.D.	79	51	2.5	100	65
21	Ph.D.	85	57	2.7	100	67
22	Ph.D.	91	63	2.9	100	69
23	Ph.D.	97	69	3.0	100	71
24	Ph.D.	103	76	3.2	117	74
25	Ph.D.	110	83	3.3	100	75
26	Ph.D.	117	91	3.5	114	78
27	Ph.D.	124	99	3.7	114	80
28	Ph.D.	131	108	3.9	129	82
29	Ph.D.	139	117	4.0	112	84
30	Ph.D.	147	127	4.2	125	86
31	Ph.D.	155	137	4.4	125	88
32	Ph.D.	163	147	4.6	125	90
33	Ph.D.	172	157	4.8	111	91
34	Ph.D.	181	167	4.9	111	92
35	Ph.D.	190	177	5.0	111	93
36	Ph.D.	199	186	5.2	100	93
37	Ph.D.	209	195	5.3	90	93
38	Ph.D.	219	203	5.3	80	93
39	Ph.D.	229	211	5.4	80	92
40	Ph.D.	239	218	5.4	70	91

[1] Computed from text Table 5, and Appendix, Tables 1 and 2.
[2] Calculated from: Accumulated production/Years of service
[3] Calculated from: Annual production x 100/Annual cost
[4] Calculated from: Accumulated production x 100/Accumulated cost

Table 3-II. Cost, production and productivity, by years of service, of researcher who follow training alternative II[1].

Years of service	Situation	Accum. cost	Production accum.	Production average[2]	Productivity annual[3]	Productivity average[4]
−2	E	1	0	0.0	0	0
−1	E	2	0	0.0	0	0
1	M.Sc.	6	1	1.0	25	17
2	M.Sc.	10	2	1.0	25	20
3	Ph.D.	16	3	1.0	17	19
4	Ph.D.	22	4	1.0	17	18
5	Ph.D.	28	5	1.0	17	18
6	Ph.D.	31	7	1.2	67	23
7	Ph.D.	34	9	1.3	67	26
8	Ph.D.	38	12	1.5	75	32
9	Ph.D.	42	15	1.7	75	36
10	Ph.D.	46	18	1.8	75	39
11	Ph.D.	50	22	2.0	100	44
12	Ph.D.	55	26	2.2	80	47
13	Ph.D.	60	30	2.3	80	50
14	Ph.D.	65	35	2.5	100	54
15	Ph.D.	70	40	2.7	100	57
16	Ph.D.	75	45	2.8	100	60
17	Ph.D.	81	51	3.0	100	63
18	Ph.D.	87	57	3.2	100	65
19	Ph.D.	93	63	3.3	100	68
20	Ph.D.	99	70	3.5	117	71
21	Ph.D.	105	77	3.7	117	71
22	Ph.D.	111	85	3.9	133	76
23	Ph.D.	118	93	4.0	114	79
24	Ph.D.	125	102	4.2	129	82
25	Ph.D.	132	111	4.4	129	84
26	Ph.D.	139	121	4.6	143	87
27	Ph.D.	147	131	4.8	125	89
28	Ph.D.	155	141	5.0	125	91
29	Ph.D.	163	151	5.2	125	93
30	Ph.D.	171	161	5.4	125	94
31	Ph.D.	180	171	5.5	111	95
32	Ph.D.	189	181	5.7	111	96
33	Ph.D.	198	191	5.8	111	96
34	Ph.D.	207	201	5.9	111	97
35	Ph.D.	217	211	6.0	100	97
36	Ph.D.	227	220	6.1	90	97
37	Ph.D.	237	229	6.2	90	97
38	Ph.D.	247	237	6.2	80	96
39	Ph.D.	257	245	6.3	80	95
40	Ph.D.	267	252	6.3	70	94

[1] Computed from text Table 5, and Appendix, Tables 1 and 2
[2] Accumulated production/Years of service
[3] Annual production x 100/Annual cost
[4] Accumulated production x 100/Accumulated cost

Table 3-III. Cost, production and productivity, by years of service, of researchers who follow training alternative III[1].

Years of service	Situation	Accum. cost	Production accum.	Production average[2]	Productivity annual[3]	Productivity average[4]
−5	E	1	0	0.0	0	0
−4	E	2	0	0.0	0	0
−3	E	3	1	—	100	33
−2	E	5	2	—	50	40
−1	E	7	3	—	50	43
1	Ph.D.	10	5	5.0	67	50
2	Ph.D.	13	7	3.5	67	54
3	Ph.D.	16	10	3.3	100	62
4	Ph.D.	19	13	3.2	100	68
5	Ph.D.	23	16	3.2	75	70
6	Ph.D.	27	20	3.3	100	74
7	Ph.D.	31	24	3.4	100	77
8	Ph.D.	35	28	3.5	100	80
9	Ph.D.	39	33	3.7	125	85
10	Ph.D.	44	38	3.8	100	86
11	Ph.D.	49	43	3.9	100	88
12	Ph.D.	54	49	4.1	120	91
13	Ph.D.	59	55	4.2	120	93
14	Ph.D.	64	61	4.4	120	95
15	Ph.D.	70	68	4.5	117	97
16	Ph.D.	76	75	4.7	117	99
17	Ph.D.	82	83	4.9	133	101
18	Ph.D.	88	91	5.1	133	103
19	Ph.D.	95	100	5.3	129	105
20	Ph.D.	102	109	5.5	129	107
21	Ph.D.	109	119	5.7	143	109
22	Ph.D.	116	129	5.9	143	111
23	Ph.D.	124	139	6.0	125	112
24	Ph.D.	132	149	6.2	125	113
25	Ph.D.	140	159	6.4	125	114
26	Ph.D.	148	169	6.5	125	114
27	Ph.D.	157	179	6.6	111	114
28	Ph.D.	166	189	6.7	111	114
29	Ph.D.	175	199	6.9	111	114
30	Ph.D.	184	209	7.0	111	114
31	Ph.D.	194	219	7.1	100	113
32	Ph.D.	204	229	7.2	100	112
33	Ph.D.	214	238	7.2	90	111
34	Ph.D.	224	247	7.3	90	110
35	Ph.D.	234	255	7.3	80	109
36	Ph.D.	244	263	7.3	80	108
37	Ph.D.	254	270	7.3	70	106

[1] Computed from text, Table 5, and Appendix, Tables 1 and 2.
[2] Accumulated production/Years of service
[3] Annual production x 100/Annual cost
[4] Accumulated production x 100/Accumulated cost

Table 3-IV: Cost, production and productivity, by years of service, of researchers who follow training alternative IV[1].

Years of service	Situation	Accum. cost	Production accum.	Production average[2]	Productivity annual[3]	Productivity average[4]
−2	E	1	0	0.0	0	0
−1	E	2	0	0.0	0	0
1	L	3	1	1.0	100	33
2	L	4	2	1.0	100	50
3	L	6	4	1.3	100	67
4	M.Sc.	10	5	1.2	25	50
5	M.Sc.	14	6	1.2	25	43
6	M.Sc.	16	8	1.3	100	50
7	M.Sc.	18	10	1.4	100	56
8	M.Sc.	21	12	1.5	67	57
9	M.Sc.	24	14	1.6	67	58
10	M.Sc.	27	16	1.6	67	59
11	M.Sc.	30	18	1.6	67	60
12	M.Sc.	33	21	1.7	100	64
13	M.Sc.	36	24	1.8	100	67
14	M.Sc.	40	27	1.9	75	67
15	M.Sc.	44	30	2.0	75	68
16	M.Sc.	48	33	2.1	75	69
17	M.Sc.	52	37	2.2	100	71
18	M.Sc.	56	41	2.3	100	73
19	M.Sc.	60	45	2.4	100	75
20	M.Sc.	65	49	2.4	80	75
21	M.Sc.	70	53	2.5	80	76
22	M.Sc.	75	58	2.6	100	77
23	M.Sc.	80	63	2.7	100	79
24	M.Sc.	85	68	2.8	100	80
25	M.Sc.	90	73	2.9	100	81
26	M.Sc.	96	79	3.0	100	82
27	M.Sc.	102	85	3.1	100	83
28	M.Sc.	108	92	3.3	117	85
29	M.Sc.	114	99	3.4	117	87
30	M.Sc.	120	107	3.6	133	89
31	M.Sc.	127	115	3.7	114	91
32	M.Sc.	134	123	3.8	114	92
33	M.Sc.	141	131	4.0	114	93
34	M.Sc.	148	139	4.1	114	94
35	M.Sc.	156	147	4.2	100	94
36	M.Sc.	164	154	4.3	87	94
37	M.Sc.	172	161	4.4	87	94
38	M.Sc.	180	167	4.4	75	93
39	M.Sc.	188	174	4.5	75	93
40	M.Sc.	196	179	4.5	62	91

[1] Computed from text, Table 5, and Appendix, Tables 1 and 2.
[2] Calculated from: Accumulated production/Years of service
[3] Calculated from: Annual production x 100/Annual cost
[4] Calculated from: Accumulated production x 100/Accumulated cost

Table 3-V: Cost, production and productivity, by years of service, of researchers who follow training alternative V[1].

Years of service	Situation	Accum. cost	Production accum.	Production aver.[2]	Productivity annual[3]	Productivity aver.[4]
−3	E	1	0	–	0	0
−2	E	2	0	–	0	0
−1	E	3	1	–	100	33
1	M.Sc.	5	3	3.0	100	60
2	M.Sc.	7	5	2.5	100	71
3	M.Sc.	9	7	2.3	100	78
4	M.Sc.	11	9	2.2	100	82
5	M.Sc.	13	12	2.4	150	92
6	M.Sc.	16	15	2.5	100	94
7	M.Sc.	19	18	2.6	100	95
8	M.Sc.	22	21	2.6	100	95
9	M.Sc.	25	24	2.7	100	96
10	M.Sc.	28	28	2.8	133	100
11	M.Sc.	31	32	2.9	133	103
12	M.Sc.	35	36	3.0	100	103
13	M.Sc.	39	40	3.1	100	103
14	M.Sc.	43	44	3.1	100	102
15	M.Sc.	47	49	3.3	125	104
16	M.Sc.	51	54	3.4	125	106
17	M.Sc.	55	59	3.5	125	107
18	M.Sc.	60	64	3.6	100	107
19	M.Sc.	65	69	3.6	100	106
20	M.Sc.	70	75	3.7	120	107
21	M.Sc.	75	81	3.9	120	108
22	M.Sc.	80	87	4.0	120	109
23	M.Sc.	85	93	4.0	120	109
24	M.Sc.	91	100	4.2	117	110
25	M.Sc.	97	107	4.3	117	110
26	M.Sc.	103	115	4.4	117	111
27	M.Sc.	109	122	4.5	133	112
28	M.Sc.	115	130	4.6	133	113
29	M.Sc.	122	138	4.8	114	113
30	M.Sc.	129	146	4.9	114	113
31	M.Sc.	136	154	5.0	114	113
32	M.Sc.	143	162	5.1	114	113
33	M.Sc.	151	170	5.2	100	113
34	M.Sc.	159	178	5.2	100	112
35	M.Sc.	167	185	5.3	87	111
36	M.Sc.	175	192	5.3	87	110
37	M.Sc.	183	198	5.4	75	108
38	M.Sc.	191	204	5.4	75	107
39	M.Sc.	199	209	5.4	62	105

[1] Computed from text, Table 5 and Appendix, Tables 1 and 2.
[2] Calculated from: Accumulated production/Years of service
[3] Calculated from: Annual production x 100/Annual cost
[4] Calculated from: Accumulated production x 100/Accumulated cost

Table 3-VI: Cost, production and productivity, by years of service, of researcher who follow training alternative VI[1].

Years of service	Situation	Accum. cost	Production accum.	Production aver.[2]	Productivity annual[3]	Productivity aver.[4]
−2	E	1	0	–	0	0
−1	E	2	0	–	0	0
1	L	3	1	1.0	100	33
2	L	4	2	1.0	100	50
3	L	5	3	1.0	100	60
4	L	6	4	1.0	100	67
5	L	7	6	1.2	200	86
6	L	9	8	1.3	100	89
7	L	11	10	1.4	100	91
8	L	13	12	1.5	100	92
9	L	15	14	1.6	100	93
10	L	17	17	1.7	150	100
11	L	19	20	1.8	150	105
12	L	22	23	1.9	100	105
13	L	25	26	2.0	100	104
14	L	28	29	2.1	100	104
15	L	31	33	2.2	133	106
16	L	34	37	2.3	133	109
17	L	37	41	2.4	133	111
18	L	41	45	2.5	100	110
19	L	45	49	2.6	100	109
20	L	49	54	2.7	125	110
21	L	53	59	2.8	125	111
22	L	57	64	2.9	125	112
23	L	61	69	3.0	125	113
24	L	66	74	3.1	100	112
25	L	71	80	3.2	120	113
26	L	76	86	3.3	120	113
27	L	81	92	3.4	120	114
28	L	86	98	3.5	120	114
29	L	91	104	3.6	120	114
30	L	97	110	3.7	100	113
31	L	103	116	3.7	100	114
32	L	109	122	3.8	100	112
33	L	115	128	3.9	100	111
34	L	121	134	3.9	100	111
35	L	127	140	4.0	100	110
36	L	133	145	4.0	83	109
37	L	139	150	4.1	83	108
38	L	145	154	4.1	67	106
39	L	151	158	4.1	67	105
40	L	157	161	4.0	50	103

[1] Computed from text, Table 5 and Appendix, Tables 1 and 2.
[2] Calculated from: Accumulated production/Years of service
[3] Calculated from: Annual production x 100/Annual cost
[4] Calculated from: Accumulated production x 100/Accumulated cost

CHAPTER THREE: Improving the Global System of Support for National Agricultural Research in Developing Countries

W. K. Gamble
Director General
International Service for National Agricultural Research (ISNAR)

Introduction

The architects of post-World War II international institutions clearly recognized the need for a global effort to reduce hunger and insecurity. Their concern led to the creation of the United Nations Food and Agriculture Organization (FAO), which at present has 152 member nations. During the early years of FAO, there were fewer countries in the world and only a small number of agricultural assistance organizations. An explosion of nation-states during the de-colonization era of the 1950s and 1960s, however, created demands for additional help. As a result, a welter of multilateral, regional, bilateral, and autonomous institutions and programs sprang up in the agricultural sector.

Among multilateral initiatives were international agricultural research centers (IARCs) whose work, since 1972, has been coordinated and supported by the Consultative Group for International Agricultural Research (CGIAR). For the large number of bilateral agencies involved in agricultural research and development, however, no comparable organ at the national level is generally available. In fact, these bilateral and many similar multilateral enterprises are so project-oriented that, in part as a consequence of the mode of support they provide, the viability and productivity of the institutions they exist to help are in no sense assured.

This paper, therefore, is concerned with possible reforms in modes of support for national agricultural research systems in their search for improved products. The reforms proposed seek to exploit lessons learned from the CGIAR experience and to match these lessons with the specific needs of developing countries and of donor organizations. While primarily addressing problems of funding, I am well aware that a support system is but one of many important factors that influence the performance of a research institution. The discussion that follows is predicated on three convictions:

1. Effective agricultural research systems are critical to improving the well-being of people in most developing countries.
2. The accomplishments of agricultural researchers and institutions are materially affected by the support system which provides their backing.
3. Given changes that have taken place in developing countries and within the donor community, reforms in traditional support systems may well be overdue.

Shortcomings of Present Support Systems

Over the past 30 years, the number of people active in agricultural development assistance has increased rapidly. This growth has been largely uncoordinated, with expansion taking place most rapidly at the bilateral level. Assistance has been subject to the ups and downs of political fortune and to the vagaries, often sudden, of the trade cycle in donor country economies. Among poorer countries priorities have too often been determined by the availability of development assistance rather than by domestic needs or comparative advantage. These developments have spawned a situation in which an aggressive scramble for scarce assistance resources among and between aid agencies and their beneficiaries is more typical than cooperation or mutual achievement.

Actual investment in agricultural development and in agricultural research in particular have but recently shown significant growth. For a group of 51 developing countries, it has been estimated that resources invested in national agricultural research have risen from 0.3% of their collective agricultural gross development product (GDP) in 1975 to 0.56% in 1980. These figures translate, for a large number of prominent developing countries, into an annual growth rate exceeding 10% in expenditure or the number of scientists employed in agricultural research (Oram and Bindlish, 1981).

This rise in the level of investment in agricultural research is important. It comes, at least in part, in recognition of the critical function that effective research can perform. Policy-makers are reaching for the high rates of return that have been generated by successful agricultural research programs. Such expenditures embody the belief that development of agricultural research capacity in poor countries may be one of the most effective ways for them to meet their basic needs.

In principle, increased attention to agricultural research is a shift in the right direction. The outcome of this shift depends, however, upon the effectiveness with which increased resources invested in national agricultural research are used. Performance is closely related to the mode and continuity of support provided to a country, from both external and internal sources. Without reform in the support system, there is reason to believe that returns on additional investments in the development of improved agricultural technology will fall short of expectations.

Ruttan (1982) has identified four basic organizational models of agricultural research:

1. The U.S.A. land-grant, research-extension-education model.
2. The research institute model.
3. The department or ministry of agriculture model.
4. The agricultural research council model.

While significant differences among these organizational models exist, the principal source of funding for all is government — national, state, or provincial. Private-sector funding of agricultural research is nominal in most developing countries, though a levy is sometimes collected to support research on particular export commodities (for example, coffee and rubber).

In developing countries, most research institutions augment the funds available from their governments with grants, loans, and technical assistance. Each aid agency (multilateral, regional, bilateral, or private) that provides such assistance has its own priorities, capabilities, and mode of operation. These may or may not mesh well with the needs, priorities, procedures, and absorptive capacities of recipient countries. Donor countries may use foreign aid as an instrument of national foreign policy and diplomacy, an area in which goals are not necessarily compatible with those of development assistance itself. During the 1970s, for example, while there was a decline in USAID resources allocated to countries where technical and institutional needs were most severe, increased allocations were made to countries considered politically sensitive. In recent years over 80% of the Economic Support Fund has been disbursed to three countries — Israel, Egypt, and Jordan.

Clearly, much latitude exists for both disagreement and improvement. Experience over several decades of development assistance, however, backed by studies of what has been done and how, in support of agricultural research, suggests seven major shortcomings to our present system of providing assistance, policy-making and implementation.

Over-reliance on the Project Approach

Most major development assistance agencies rely primarily on the project approach which appeals to them as flexible, and as convenient for:

Assuring donor identity. This may be crucial to the assistance agency in its continuing efforts at home to obtain resources for ongoing work. The project as a discrete unit can be described in presentations to Congress, for example, or to governing councils, boards of trustees, or citizens at large.

Administration and management. The project provides a handy unit for purposes of resource allocation, accounting, implementation, and evaluation.

Leverage. This may be important to the achievement of donor diplomatic or political goals at home, as a means of enforcing 'tied' sales, and in requiring certain performance standards in order to extend a grant or provide continuing technical assistance.

Participation. Because a project has an identity, this increases opportunities for a personal donor-recipient relationship, especially in bilateral arrangements. A project usually involves more than a cold, mechanical, financial transaction. Where technical assistance is involved, both the giver and receiver may benefit. First-hand involvement in and familiarity with international agriculture, as acquired through projects, by donor country professionals, for example, can constitute a distinct gain in human capital development for the donor nation.

Despite these desirable attributes, the project approach has serious drawbacks as it generally functions. Through it, assistance agencies may exert undue influence on the content of national programs. Donors, bilateral as well as multilateral, may dominate programs through their own perceptions of priorities, through efforts to maintain a commitment schedule (e.g., push ahead with facilities even though they cannot be domestically staffed), or through a self-interested desire to market 'tied' inputs (to sustain political support from suppliers, universities, or consulting firms at home). Indeed, selectivity in program

support and donor bias may result in the funding of projects that are inconsistent with national priorities or national program development. Such projects, as a result, are often unproductive because the associated investments required for overall program effectiveness are lacking (Gamble, 1982).

Of even greater concern is the awareness, won from long experience, that in itself project support has rarely contributed effectively to the development of viable national agricultural research institutions. To speak positively for a moment, in a number of countries the project approach has assisted the rapid development of professional capacity and facilities. Unfortunately, such rapid development has too often been followed by the erosion or collapse of overall program capacity once external project support starts to decline (Ardila et al., 1980). In fact, one may speculate that alternating cycles of development and erosion are inherent in the project approach as it now generally is applied.

External Orientation of the Incentive System

External project assistance often provides an alternative to the winning of internal political and financial support for a program or institution. National program directors frequently find that the generation of external support requires less intensive entrepreneurial effort than cultivation of in-country backing. The kind of domestic support for a project commonly required by donors (for example, matching funds, provision of counterpart funding) can often be conjured up through creative manipulation of budget categories or imaginative accounting rather than by doing any real incremental spending. Such 'paper' financing is particularly prevalent when donor representatives are themselves under pressure from the assistance agency management to 'move' resources. Plans drawn up frequently over-extend existing domestic investment capacity (for example, recurrent costs).

As a consequence of the various forces just mentioned, most existing project systems have built-in incentives for national program leadership to direct their entrepreneurial efforts towards the donor community rather than towards the domestic political system. The external rather than internal orientation of the incentive system therefore does little to promote activity towards developing, building, and sustaining a domestic constituency (for example, commodity groups among producers within the country). Over-dependence on foreign support and the associated absence of any politically or economically powerful indigenous constituency contribute significantly to cycles of development and erosion in national agricultural research and extension organizations. Any reforms in support systems should, to be sure, attempt to reverse the perverse orientation of incentives that now characterizes existing modes of research operation.

Inadequate Effort to Build Institutional Support

Another reason why the fortunes of national research ebb as well as flow is that no means of generating understanding and political support are built into operations from the onset. While assumed to be important, the development of institutional viability is seldom made an explicit goal of a project - or of the program of which the project is a part. Actions designed to help assure continuity within the country itself are frequently given low priority, if undertaken at all. Experience suggests, however, that the long-term viability of agricultural research systems depends on the emergence of organized producer interest groups who are willing and able to exert influence on the legislative and executive budgetary processes. This is because the support of agricultural research forthcoming from finance and planning ministries, given the pressures under which these ministries must operate, is not dependable. Their support is likely to fluctuate with perceptions of the severity of temporary food crises and foreign exchange demands.

To assure reasonable domestic levels of fiscal support on a regular basis, national research program leaders and program beneficiaries have to commit themselves to a sustained political development effort. From the inception of any research endeavor, such an effort needs to be planned for and made an integral part of program activities. This means establishing contacts with farmers, exporters, consumers, and decision-makers on a scale and with an intensity unusual for developing countries.

Excessive Diffusion of Resources

The project system lends itself to launching a fragmented set of initiatives. This is especially true when individual projects are independently negotiated with different donors. The temptation is to initiate a multiplicity of small, short-term activities without concern for whether

they are adequately linked to one another. Many of these separate projects or sub-projects may not fit into, or in any tangible sense support, a coherent national strategy or program. If so, diffusion of domestic as well as external resources inevitably occurs.

In the absence of adequate, unrestricted core budget support and, carried to an extreme, narrowly defined and closely restricted project funding, while helpful for accounting and for some monitoring purposes, can ultimately strangle an overall program. Diffusion of support among many short-term projects can also generate excessive administrative costs. Relative to support that remains for productive research, an unduly large proportion of limited available resources is spent bureaucratically, in project formulation, negotiations, and monitoring.

Stop-and-Go Funding

Abrupt adjustments in resource flows, often a consequence of some revision in a donor's political views or even of the individual preferences of different donor representatives, also contribute to the erratic alternating periods of plenty and want which characterize the life of national research institutions. This de-stabilizing force is exacerbated by the inconstancy of domestic support.

Most institutions, to a greater or lesser degree, face funding discontinuities. In newly developing countries with fragile institutions, such financial disruption can be fatal. If vital scientists and administrators are lost (to international organizations or other countries) during a prolonged lean period, years may elapse before replacements can be found, or trained.

Inadequacies in Communication Among Donors

In several countries information exchange is limited among donors about their programs and intentions. This may be the result of policy either on the part of the donors or of national leadership in the developing countries concerned. Poor communication, however, also may occur simply because no appropriate mechanism exists for assembling and exchanging reliable information of this type. Whatever the reason, instances do occur where donors, perhaps unknowingly, compete for what they consider to be attractive individual projects. What is cause for concern here is that for want of more adequate information, projects of one type flourish while other equally critical aspects of the overall program languish or die.

Collectively, shortcomings of the above types impede effective use of available resources. If it were possible to reduce or to eliminate the undesirable effects of these constraints, the support provided could have a far more constructive impact on development.

The Needs of National Programs

A great deal of the foregoing discussion has concentrated on donors and patterns of their cooperation with national programs. The problem for development that national needs may not always coincide with donor priorities has been stated explicitly in some places and alluded to in others. Not everything about the project approach should be condemned. What is absolutely necessary, however, is a well-articulated program developed by the national institution responsible for the work, a program which clearly sets forth overall goals and then establishes procedures so that aid projects will be compatible with them. National institutions should be able to formulate their needs and make clear what assistance will be required to meet these needs. This is already happening in some countries, but more need to follow.

How then might existing support systems be reorganized in order to mitigate or even to eliminate the harmful effects of the present shortcomings which we have identified?

Approaches to Reform

To improve support systems there are at least four possible approaches:

1. Modified project support mode.
2. Multilateral mode.
3. Formula funding.
4. Country-level research support group.

These approaches are not mutually exclusive; they all contain common elements.

Modified Project Support Mode

If we are realistic, the project appears likely to remain the major development support vehicle, because of its many attributes. Because of the rising cost of launching and sustaining development initiatives that make any appreciable difference, however, governments, private voluntary organizations, foundations, and other assistance agencies now increasingly seek partners. Instead of competing among themselves, they are often interested in becoming partners in program support, even in the absence of any formally organized consortium or consultative group. With guidance from national officials in those countries where priorities have been systematically established, individual donors can be encouraged to help underwrite components (projects) within a coherent program. Such support can be structured to include contributions toward essential core or unrestricted budget categories as well.

The shortcomings of the "self-contained" project approach have become increasingly well understood. Modifications are being made. The World Bank now offers project loans within the framework of a program development plan. At the U.S. Agency for International Development, internal discussion is focusing on the use of "common theme" regional approaches to the transfer of technology and the development of institutional capacity. Such developments are to be encouraged and their pace accelerated. What the research support group approach, to be discussed presently, can do that the project mechanism alone cannot is to assure multiple donor participation with the host country in the developing and funding of the overall program of an institution.

Multilateral Mode

This approach would channel all support through multilateral organizations. In theory this appears to be an uncomplicated, straightforward way to improve support systems. Assistance suited to the circumstances of individual countries could be provided on a program rather than a project basis.

The problem here is that donors appear reluctant to adopt this mode as a means of allocating and administering their bilateral assistance. They are not prepared to consign their bilateral funds to a common pot which will be managed by a third party. The reasons for their unwillingness are many, but they boil down to the donors' insistence (quite understandable) that, as the sources of funding, they retain a direct voice in determining where and how their gifts are used.

On the other hand, several bilateral donors are apparently predisposed to join in partnership with multilateral organizations in support of a program, if appropriate arrangements can be made. According to its advocates, the fourth approach to the reform of support systems mentioned earlier, the one which involves a research support group, can be designed to preserve "donor sovereignty" while encouraging joint participation.

Formula Funding

Envisioned here is a move on the part of the donor community towards program funding. In order to induce national program directors to redirect their entrepreneurial efforts towards building domestic political and economic support, a formula needs to be developed which would tie the size of donor contributions to the growth of domestic program support. As domestic support increased, donor contributions would also rise. The formula would adjust the ratio of external to domestic support to take into account differences in fiscal capacity. Donors might agree, for example, to provide as much as 40% of the national agricultural research budget in a country with low fiscal capacity, while the externally provided share might drop to 10% in a country with high fiscal capability.

How could such a system evolve from the multiplicity of existing bilateral and multilateral assistance programs? One possibility would be for the donor community to place into a common fund its resources in support of a national agricultural research system. The formula method of allocation, as agreed upon by the countries involved, would then apply. The common fund, in turn, would be administered by an existing international agency, such as the World Bank, the United Nations Development Programme, or the Food and Agriculture Organization.

There are decided advantages to this approach. Support would go to an integrated program, not be parceled out project by project. The level of support to the program would be determined by taking into account national fiscal capacity, the importance and potential of the

agricultural sector, and the level of domestic resources actually provided. The matching of funds would be real and subject to careful audit. Formula funding would thus be conducive to building national support for agricultural research because of the modified incentive structure.

If, however, donor resources were contributed to a common fund for third-party administration, donor interest and commitment might rapidly fade. The discretionary latitude of foreign affairs ministries in donor countries would be somewhat compromised. Legislatures and administrators in donor countries might view formula funding as an "open checkbook" approach with retention of only limited control over program level or content. Resistance to formula support through a common fund might also be expected from special interest groups: assistance agency staff members, consulting firms, and universities which would foresee less need for their services; developed country exporters of goods and services whose sale of "tied" items might be threatened; multilateral agency staff members who might anticipate a decreasingly important role for their institution if theirs were not the coordinating organization; and the leaders of projects in developing countries who have a proprietary interest in maintaining present modes of funding.

For a reform to be adopted, it must achieve general acceptance at the outset. The formula-funding concept embodying a common fund cannot claim such approval. Resistance is too widespread to becoming a contributor to a common fund administered by another agency.

Country-level Research Support Group

The research support group approach is indebted to experience accumulated with the CGIAR model. To establish and operate a country-level research support group (RSG) will require close working relations between the host country and aid agencies and improved collaboration among donors. An RSG needs at its disposal a relatively long-term program for the development and operation of the national agricultural research system. To draft and keep this program up to date, the national research system may require external assistance, but in general the program should be the product of indigenous experts in agricultural science and development. To help shelter the program from shifting political breezes, emphasis should be placed on long-term agricultural research needs and goals and on the incremental steps required for implementation.

It is expected that long-term program development and the setting of priorities would be undertaken together with members of the RSG. Once an acceptable program has been framed, donor members of the RSG, it is hoped, would collectively agree to help provide the host country with the components essential to the execution of the program as a whole. The host country, in turn, would assume responsibility for moving its national research program along the agreed-upon development path.

Initial commitments might be for three to five years, subject to annual review and course corrections suggested by analysis and feedback from actual experience.

Use of an institution such as an RSG can potentially help a developing country in a variety of ways:

1. To avoid many of the pitfalls of the project mode, while retaining several of its positive attributes. Donor identity could be retained by relating grants to components of the agreed-upon overall program. These could then even be called projects if, for administrative purposes, this was considered desirable. Donor-recipient negotiations, most of which would take place at group level, would become meaningful: the RSG, like CGIAR, would be likely to involve bilateral grants developed in the framework provided by a forum of multiple donors and the host country. The impersonal process of contributing to a common fund is not envisioned. This does not, however, preclude incentive funding of a formula type. At the same time the danger would be kept to a minimum that any single donor dominate the priority-setting process or that essential program components be slighted.

2. To build a national constituency by concentrating right from the start on this essential ingredient for viability. The donors, for example, might agree to increase their contributions by some fraction of the rise that occurs in the real support provided by the nation involved. Alternately, other matching provisions might be agreed upon to provide incentives for nurturing and cultivating national constituencies.

3. To provide reasonable continuity in support. Commitments would be fairly long term, subject to review and extension well in advance of termination dates. This would diminish the risk of program fragmentation frequently associated with narrowly defined project funding.

4. To reduce the administrative and management workload of the host country through the planning and review processes which the RSG would follow

5. To place donors in a position of genuinely complementing and supplementing one another and the national program instead of wastefully competing for "good investment opportunities."

6. To tighten its own priority setting, performance evaluation, and program modification process by systematically meeting RSG requirements, drawing whenever necessary upon the professional expertise of RSG members.

Fundamentally, success in the use of th[illegible]G approach would require all parties involved to be open to learning by doing. Such a support mode is often discussed, but little used, a fact which suggests perhaps that its implementation is no simple matter.

Implementation

The preceding assessment of approaches for reforming support systems indicates that the research support group merits our recommendation. It must be recognized that the RSG procedure is not one that can or should be applied to all countries. Many countries have alternate systems already at work. Elsewhere, however, if there is interest and need, host countries may wish to test the idea in cooperation with donors. No precise pattern for such a funding arrangement exists. Before implementing any such system, however, it would seem that members of the incipient RSG would have to reach agreement on structure, governance, function, and related matters.

Membership

The host country, probably through its national research institution and the appropriate ministry or ministries, would delegate members to the RSG. Each external donor, multilateral or bilateral, prepared to provide a specified minimal level of support would also designate members, presumably professionals familiar with the host country.

Organization

The RSG's chairperson should be named by the host country. In some countries a rotation of the executive position among group members might be preferred. The RSG's secretary would also, in all probability, be provided by the host country. In the initial stages, external technical assistance to the secretariat might be provided by one of the donor members or by an organization such as ISNAR. Leadership responsibility for the management and operation of the group would be vested in the host country.

Functions

1. The RSG would participate in discussions through which a program of development for the agricultural research system is formulated. Such a program, perhaps encompassing the first five years of the RSG's existence, would specify a work plan, priori[illegible]ctivities, elements to be expanded or reduced, and a proposed budget. The program budget would be developed within the framework of the country's needs and expected resource availability. The RSG would not develop the document itself but might provide technical assistance as well as guidelines for internal review (that is, means for determining the local relevance and importance of the problems being addressed and of the research methodologies being used; procedures to establish links with the country's extension and educational institutions).

2. The RSG would work out, within the limits of available resources, how to provide the external support required collectively to sustain components judged essential to the program as a whole. If the procedures evolved by CGIAR were followed, individual donors would make grants in support of identifiable components of the agreed-upon programs (including allocations to core activities of the system). These would be bilateral and negotiated in the multilateral forum of the RSG. Such grants would be subject to rules governing both the grantor and the grantee. Every reasonable effort would be made to simplify the terms of the grants, however, as well as to provide relatively long-term and harmonious time frames, to standardize review and evaluation procedures, and to meet matching requirements.

3. The RSG would develop provisions for integrating existing project or program grants and loans into ongoing budgets. This process would be virtually automatic if the initial donor members of the RSG represent institutions already active in the country.

4. The RSG would formulate operating guidelines for itself, principles to help establish procedures, attitudes, and style of operation. These might include: adoption of relatively informal or consensus modes of decision-making; building in of incentives for developing increased support for and commitment to agricultural research within the country (for example, provisions in fund-matching arrangements for external assistance to rise as real domestic support increases); encouragement of interdisciplinary approaches to problem diagnosis and solution; institution of on-farm research, possibly as a joint effort with extension services; and systematic feedback from representatives of producer groups in the evaluation process.

5. The RSG would establish a meeting schedule and agenda. Initially it might be desirable for the RSG to meet twice per year. The first of the two meetings could well be devoted to an assessment of the program's performance, a review of plans, and discussion of needs for the coming year. Major policy issues would be addressed in this forum. The second meeting would then concern the budgetary process itself — the matching of program requirements with available resources. The productivity of these meetings will be determined, in no small measure, by the adequacy and quality of the materials assembled or prepared in advance by the secretariat.

Budget

While the members of the RSG would underwrite th costs of the participation of their representatives, the secretariat, the program-budget group, and possibly the chairperson will require budgetary support. One of the tests of the RSG concept may be the capacity and willingness of the host country to meet the essential running costs of the new organization. As a gesture at the start, donors might decide to provide technical assistance and/or financial help to the secretariat for the first three to five years. Without a substantial national financial input and commitment, however, the new RSG might come to be viewed as a foreign implant rather than an indigenous organization created to serve local needs.

Next Steps

Before meaningful discussions concerning the establishment of an RSG can be undertaken between a potentially interested developing country and donors, some individual, group, or institution must accept responsibility for elaborating the ideas discussed here, for helping design and implement trials — if an experimental effort is to be made — and for analyzing the results. Then national leaders will have to decide if they wish to pursue the RSG approach further. Should they wish to embark on a field-testing venture, they must:

1. Identify countries and donors interested in exploring and implementing the ideas sketched in this draft paper;

2. Seek ways to assemble information on and simultaneously assess worldwide experience with consortia, consultative groups, or similar institutional arrangements for mobilizing support for the development and operation of research systems;

3. Revise the content of this draft paper in light of comments and suggestions received and insights obtained from research on prior initiatives of this nature;

4. Determine ways to help one or more of the countries and associated donors that desire to do so to develop and operate a RSG or similar system; these efforts would include the formulation of testable hypotheses and goals for evaluation purposes;
5. Establish a means to monitor whatever trial efforts are undertaken, subsequently analyzing performance and reporting the results.

Conclusions

While interest in national agricultural research institutions is increasing, together with available levels of funding, serious shortcomings in their systems of support have become apparent. These have arisen in part from an over-reliance on the project approach and the perverse twist which it gives to research entrepreneurship. Incentives are stacked in favor of cultivating external agencies rather than building up national support. Leadership is preoccupied courting foreign aid, so that no effective constituency (producer groups, exporters, consumers, suppliers) emerges inside the country. As a result, the viability and long-term

productivity of the national research establishment is threatened because it enjoys inadequate political and grassroots support. Often then, the effectiveness with which resources are used falls far short of the expectations of both donors and developing countries themselves.

While the system of support is but one factor influencing research productivity, its improvement can contribute to huge gains in performance. All available information indicates reform is overdue. Otherwise, the transfer of resources to national research may even prove counterproductive.

Identification of the shortcomings of current research support systems facilitates the choice of a preferable approach. A mode that places principal responsibility for planning and implementation squarely on the shoulders of the host country — at the same time providing incentives to build local constituencies holds exciting promise. The innovative system of support developed by the CGIAR contains many elements worth trial and adaptation. Reforms might proceed along other lines as well. In general, however, evidence encourages the belief that the most promising and comprehensive approach to reform involves creation of country-level consultative groups composed of host country and donor members.

This draft paper calls these proposed institutions research support groups (RSGs). It suggests that national leaders consider establishing RSGs in those developing countries where both the national leadership and donors are prepared to experiment with the concept.

Acknowledgments

Much of the impetus for this presentation came from Vernon W. Ruttan's research. His paper, Reforming the Global Agricultural Support System (Minneapolis, Minnesota, University of Minnesota, June 4, 1981), was the subject of an informal meeting in Washington, D.C., on June 30, 1982. In addition to Ruttan, participants included Thomas Arndt, John Coulter, Ralph Cummings, Jr., A. Hankins, Lowell Hardin, Elmer Kiehl, Peter Oram, and Ruth Zagorin. At the suggestion of the group, ISNAR agreed to draft this discussion paper; it draws heavily on Ruttan's own work, on suggestions made by participants in the Washington meeting, and on the experience of ISNAR in cooperation with leaders of national agricultural research systems.

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CHAPTER FOUR: Information Systems for the Scientific Management of Agricultural Research

Basilio A. Rojas
Director Sugar Cane Research Institute (IMPA)
Mexico

Introduction

In the 15th century, printing created a revolution in written information. Scientific knowledge became available to a much wider audience. During the past 30 years, a similar revolution, the full consequences of which we have not yet understood, has taken place in information science. Newly developed information systems and processes represent immense resources whose potential remains to be recognized more widely by agricultural research institutes. Even in developing countries up-to-date scientific documentation can now be made available by the use of new information sources and techniques.

Information is basic for ensuring that researchers exploit the latest technological know-how, that methods are backed up by a large reservoir of modern tests, and that no unnecessary duplication of efforts occurs. Similarly, relevant information facilitates the optimum allocation of human and financial resources in research programs; it monitors progress or setbacks; and allows for judicious decisions at various levels to guide and regulate both strategic actions and scientific and technical tactics.

This paper describes the principles which characterize an information system for scientific management. It discusses the quality, level, and processing of data required to plan, monitor, and make decisions. Several existing information systems are described prior to the discussion and analysis of the proposed new system.

Information

Information means the communication of knowledge about an event or given condition or the spread of knowledge derived from study, experience, or instruction. Information may be stored in many different ways, as language, graphs, books, photographs, diagrams, formulas, records, magnetic tapes, punch cards, etc. Our modern capacity to codify, register, reproduce, and transmit information has brought about a revolution in information processing and an explosion in the dissemination of knowledge.

Today information should be considered a basic resource, every bit as essential as minerals and other natural sources of energy. Indeed, such a resource needs to be exploited globally if our total reservoir of scientific and technological knowledge can be made accessible to developing countries, its intelligent use may shrink the gap separating them from developed countries.

Although information potentially represents a valuable resource, it will prove valueless unless its collection, processing and storage are systematic.

Quality of information. To be of practical value, information should possess the following qualities:

1. Accessibility. This refers to the ease and speed with which the information can be obtained.
2. Comprehensiveness. Information should be complete.
3. Precision. Information should be free from errors.
4. Compatibility. Information should suit its user's needs.
5. Timeliness. Information should be up-to-date.
6. Clarity. Information should not entail ambiguities.
7. Flexibility. Information should be useful to more than one decision-maker.
8. Verifiability. There should be ways to test the accuracy of the information.
9. Free of bias. Information should be objective, presented without favoring any particular viewpoint.
10. Quantifiable. Information should be measurable.

Levels of information. For an agricultural research system, basic information will be required for planning, control, and decision-making. Levels of information will relate directly to strategic, tactical, and technical activities of the research system.

Information at the **strategic** level is that which enables planners to formulate long-term programs and to rank various alternatives and decisions with respect to their anticipated contribution towards desired results.

This type of information may originate from sources outside the research institution: production statistics, trends, yields; descriptions of soil, water, climate; data relevant to production techniques, mechanization, seeds, fertilizers, pests and diseases; population studies including social, economic, nutritional, and economic characteristics; analyses of production costs at home and abroad; supply and demand forecasts. At the strategic level, information should include an account of scientific

and technological advances throughout the world, with assessments of potential implications for national agricultural development.

Information at the **tactical** level serves to implement short-term regional and long-term national goals. Similar to strategic information, tactical information includes the detail and analysis necessary to prepare projects: for example, what combinations of fertilizer should be tested; what type of genetically improved seed is to be used; what agronomic and industrial characteristics are desired of crop varieties under investigation; what irrigation, drainage, and desalinization studies are to be carried out.

The **technical** level of information, basically internal to an institution or organization, refers to experimental procedures, operational schedules, resource requirements, both human and physical (such as agricultural machinery and laboratory equipment), and input costs. It also deals with such subjects as probable cropping dates, types of analyses required, and presentation of research results. Technical information is also essential for establishing supervision, monitoring, and evaluation procedures.

Information classification and codification. Information may vary widely in source and in nature, in descriptive, qualitative, and quantitative features. In addition, the volume of information available on just about any subject is vast. Therefore, before embarking on the costly task of amassing information, it is advisable to order and classify information needs according to clearly defined purposes. Information should be collected and stored systematically according to how it is to be processed and retrieved.

The aim of classification is to identify and place the elements of information into categories relating to future use. The universal procedure for classifying an element of information is to assign it a key — a short group of numeric, alphabetic, or mixed (alphanumeric) characters — for its registration, communication, processing, or retrieval. Keys allow electronic digital computers to be used for information storage, processing, and retrieval.

Classification of scientific knowledge has now become a reality. Keys are assigned to unit concepts (terms, words, or topics) according to certain rules. This permits a specific piece of technical information to be found, providing the book or journal which contains the item is known. Major libraries now catalogue books and journals for location purposes, and index them. Indexing consists of assigning a series of keys to each book or article related to its subject matter.

The indexing of scientific and technical information simplifies classification into broad areas of knowledge and application. The process has spurred creation of specialized centers of documentation or information. It nourishes a massive new information industry, one in which the private sector has become progressively more interested and involved.

Historically, scientific and technical knowledge have for the most part been the heritage, pride, and asset of developed countries. Today, however, data bases or banks are able to place at the disposal of researchers in any country the accumulated wealth of books, journals, and scientific documentation found in the most extensive libraries of the world. What remains is for policy-makers and scientists in developing countries to summon the will, imagination, and audacity to make meaningful use of these resources.

A relevant thesaurus greatly simplifies computer access to data banks of agricultural, scientific, and technical information systems. The thesaurus is an information index stored in the computer which consists of a list of key words or topics included in the data base. Retrieval of desired information is facilitated by using the correct key to designate relevant terms or concepts.

A research institute may set up an index and classification system for its projects; the organization of this system will be a function of the nature and aims of the research envisioned. Indexing may be straightforward or complicated, depending on the availability of human, financial, and computer resources. Any research project can be summarized in a register which contains identification data and keys to a relevant index. Information from a large number of different projects or institute programs can be stored in the form of a group of registers known as an archive.

Data processing methods. The method of choice for processing information, varying with volume and complexity of data, can range from elementary manual techniques to the sophisticated use of electronic computers. Common data processing methods include simple manuals with registers kept as notebooks, manuals with edge-punch cards which facilitate

classification, electromechanical equipment; punch-card equipment, and electromechanical computers. The quality of data processing does not necessarily bear a direct relation to the cost of the equipment involved. Costs indeed, are largely determined instead by class, quality, and relevance of primary information.

Existing Information Systems

From time immemorial man, in his zeal to become acquainted with the physical laws of the world around him, has applied his gifts of reasoning and observation to the dynamics of natural phenomena. He has classified his findings in a handful of sciences which in modern times have sprouted complex, specialized branches. A further characteristic of the current research era is the proliferation of scientific publications. In 1970 alone, 250,000 scientific articles were published by 236,429 authors working for 33,144 institutes in 168 countries. If this staggering volume of information is to contribute to improving man's well-being, it requires both orderly classification and an efficient and rapid system of access.

In addition, research institutes generate new knowledge which is not necessarily published. These findings, too, however, need to be classified, and made available to researchers elsewhere so that advances in science can yield maximum benefit to the common good. Similarly, on a smaller scale, a director needs to be aware of all research projects in his particular institute before he can plan and coordinate activities effectively.

Our cumulative reservoir of scientific knowledge, the ongoing generation of discoveries, and the inventory of research projects in progress, combined with various forms of access to information, have given rise to three principal types of contemporary information systems: library documentation; documentation systems with computer access; and information systems related to research work in progress.

Library documentation. Libraries have existed for more than 2,000 years. Some — specialized agricultural libraries among them — now have large collections. The United States National Agricultural Library, for example, has 1.6 million catalogue entries (microfilms, microfiles, aerial photographs, maps, and audiovisual material); it subscribes to 22,000 journals; and it indexes some 200,000 articles a year. The Central Library of Agriculture in Mexico contains approximately 250,000 books, pamphlets, and other materials. The library of the Colombian Agricultural Institute comprises some 40,000 items.

A number of libraries and documentation centers produce specialized bibliographies and abstracts of publications relevant to their field of interest. Of abstracts important for agricultural research, the following deserve mention: Bibliography of Agriculture, Chemical Abstracts, Biological Abstracts, Animal Science Abstracts, Dairy Science Abstracts, Field Crop Abstracts, Forestry Abstracts, Plant Breeding Abstracts, and Weed Abstracts. Of guides to sources of information and bibliographies (which deal with agroindustrial topics), those produced by the United Nations Agency for Industrial Development are of singular importance. Various Latin American libraries have produced bibliographies on spheres of particular interest within the agricultural sciences. The Inter-American Institute for Cooperation in Agriculture (IICA) has been a pioneer of agricultural information in Latin America: since 1956, IICA has produced more than 120 documents and bibliographies totaling over 15,000 pages.

The United States of America, United Kingdom, France, and Soviet Union have important abstracting services which cover a broad spectrum of contemporary knowledge. These services are available for international use.

Documentation with computer access. In the last 20 years the electronic digital computer has revolutionized the spread of knowledge. Today a computer terminal can instantly connect researchers to masses of the most up-to-date international information available in their field.

Table 1 (De Caldas y Estrada, 1982) lists the data bases with computer access most relevant to agricultural literature.

Table 1. Automated agricultural science documentation systems (De Caldas and Estrada, 1982).

Code Name	Subject	Name	Responsible Body
AGRICOLA	Natural and agricultural resources	AGRICOLA	U.S. National Agricultural Library
AIDS	Forest products	Abstracts information Digest service	Forest product
CRIS	Agricultural research	Current Research Information System	U.S. Department of Agriculture
SSIE	North American research	Smithsonian Science Information Exchange	Smithsonian Institution
BIOSIS PREVIEWS	Bioscience	Biosciences Information Service (Biological Abstracts and Bio Research Index)	Biosciences Information Service (Biological Abstracts and Bio Research Index)
CAB ABSTRACTS	Forestry, crop, and animal	Commonwealth Agricultural Bureaux Abstracts	Commonwealth Agricultural Bureaux Abstracts
FIREBASE	Fires in forestry areas	FIREBASE	U.S. Forest Service
INRSIC	Water	Water Resources Scientific Information Center	U.S. Water Research and Technology Service

We should also cite here AGRIS (Agricultural Information System for the Agricultural Sciences and Technology) and AGRINTER (Inter-American Information System for Agricultural Sciences). AGRIS, set up by FAO in 1971, contains a world bibliography of literature on agriculture, livestock, forestry, fishing, primary forest products, foodstuffs, soils, and other related scientific fields. AGRINTER, founded in 1972 with its headquarters in IICA, Costa Rica, was designed to integrate Latin American and Caribbean literature on agricultural sciences. The AGRINTER/AGRIS systems ultimately rely on the participation of all Latin American and Caribbean countries. It is vital for institutes of agricultural, livestock, and forestry research in the region to give their utmost support. Argentina's cooperative efforts have been particularly outstanding.

Agricultural Research Studies in Progress

Information systems for agricultural research studies in progress have been set up in various countries. These systems all have some of the following purposes:

1. To maintain an up-to-date directory of agricultural research institutes, researchers, and research projects;

2. To promote and improve communication among researchers;

3. To store basic information on major areas of agricultural research and to determine the extent of the effort devoted in particular countries of the region to the scientific and technological problems of agriculture;

4. To identify areas of agricultural research which do not receive sufficient emphasis;

5. To analyze and adjust budgetary allocations to agricultural research activities;

6. To supply directors and administrators of agricultural research organizations with up-to-date information which will enable them to report on the activities of their organizations;

7. To supply information to governments, to the private sector, and to the public at large.

Information systems for research work in progress, as developed in Brazil, the United States, FAO, and the United Kingdom, are described below. Thereafter the information system set up in Mexico is discussed in greater detail.

Bracaris

Bracaris, the Brazilian information system for current agricultural research work, is a nationwide system embracing more than 500 institutions. It gathers information on 17 areas of research, including administration, economics, animal and crop production, animal and crop protection, soils, rural engineering, climatology, fisheries, natural resources, and food technology. Bracaris produces registers of research institutions and of researchers in the agricultural sciences.

Current Research Information Systems (CRIS).

An automated system developed by the United States Department of Agriculture (USDA), CRIS has had computer access since 1977. Its data base includes all USDA agricultural research projects plus those from 56 different state agricultural experimental stations, 19 forestry schools, and other institutions. CRIS maintains a bank of information about 24,000 current projects. Operational guidelines require each project entered in the CRIS data base to be described on four forms, as explained below.

Form 1. Project summary. This form is completed whenever a research project is approved, started, and undergoes review. The following information is elicited:

1. Project identification: key number, title, responsible body, researcher in charge and collaborators, location of the research study.
2. Project status: new, extended, revised, pending, or completed.
3. Financing sources.
4. Objectives. Problems to be resolved and methodology to be used; described in 1,200 characters.
5. Key concepts. Up to 10 to classify the type of research.
6. Starting and completion dates.

Form 2. Classification of research. This form is completed when a project is started or revised. It provides the following information:

1. Project identification: key number.
2. Type of research: basic, applied, or developmental.
3. Activities: A total of 40 possible activities are classified in nine major groups — conservation, development and use of resources; productivity and improvement of quality; marketing; development of human resources; scientific and test methodology; protection of man, products, and resources; etc.
4. Scientific field: This includes a total of 78 scientific fields — biological (48), physical, chemical, and engineering (20), and social and economic (10).
5. The product, resource, or technology under investigation: There are 450 possibilities — soil, water, climate, forest products, fauna, crops, livestock, markets, administration, cooperatives, etc.
6. Area of research: One hundred areas grouped according to nine major goals — stability and productivity in agriculture, phytosanitary protection and other risks, meeting demand, increasing demand, protecting the health and nutritional intake of the consumer, improving the quality of rural life, etc.

Form 3. Financing and scientific personnel. This form, filed annually on December 1, specifies the federal, state, and private funds budgeted for each project. Information is given about the allotment of man-years differentiated by scientific, professional, and technical personnel and support staff.

Form 4. Progress or completion report. A progress report is submitted annually on March 15; a completion report follows whenever a project ends. These reports supply the following information:
1. Identification: Key number, project title, researchers, responsible body, date.

2. Progress report: A maximum of 1,600 characters is available; results are listed, together with an evaluation of the scientific or practical implications of these results.
3. Completion report: Also 1,600 characters; major achievements during the lifespan of the project are summarized.
4. Publications: Reports are listed which present the results of scientific discoveries and advances made during the project; unpublished material is not included.

Current Agricultural Research Information System

Both initiated and operated by FAO, CARIS gathers information on current projects developed in all member countries. It collates the following data:

1. Identification: Country, institution, date of commencement, completion, and information.
2. Project: Title, aims, indication of the nature of the investigation; researchers, principal and collaborators.
3. Budget.

Agricultural Research Current Information System

ARCIS is an automated system developed and operated in the United Kingdom; it registers the following characteristics of agricultural research ventures:

1. Project identification: Key number and institute; department within the institute; person responsible; and collaborators.
2. Project title.
3. Type of research: Strategic — to explain a project in progress; fundamental or basic; applied; development; briefing.
4. Research activity: Sixty possibilities — improvement of crops and livestock; protection of crops and animals; physiology of crops and animals; soil; entomology; biology; economics; engineering; etc.
5. Agricultural area: Twelve alternatives — general agriculture; crop production; animal production; processing of products; by-products; pollution; etc.
6. Product: Crops, livestock, animal and crop products and by-products, animal feed, etc.
7. Key words: This includes 1,926 key concepts comprising agricultural inputs, sciences and technologies, plant and animal cells, physical, chemical and biological phenomena, etc.

The Mexican System of Information for Agricultural Research in Progress

In February 1979, a System of Information for Agricultural Research in Progress (SINIAGEC) was established in the Mexican National Institute of Agricultural Research (Instituto Nacional de Investigaciones Agricolas — INIA). Since then, SINIAGEC has expanded and has corrected its initial defects. The system's importance and value now exceed original expectations.

SINIAGEC was initiated in 1978 at the request and with the full support of Dr. Eduardo Alvarez-Luna, then director general of INIA. Within a few months it was possible to publish an internal SINIAGEC manual and to carry out the first tests on the system.

SINIAGEC was created in answer to concrete needs:

1. To provide an up-to-date inventory of all research carried out by INIA within a given period.
2. To classify INIA research according to scientific, agricultural, geographic, economic, and social criteria.
3. To supply information for budgetary action as well as for monitoring budgetary control.
4. To assess researchers' workloads.
5. To facilitate the planning of a research strategy in accordance with national and regional priorities.
6. To furnish policy-makers with current information on the state of research activities.
7. To promote diffusion of information among the institute's researchers to strengthen their unity of purpose and spirit of collaboration.
8. To avoid unnecessary duplication of research.
9. To secure information about the proportion of research studies which reach planned completion and about the principal factors which account for failures.
10. To specify the number of experiments on land belonging to cooperative farmers.
11. To identify imbalances in national agricultural research strategy.

Operated with these objectives in view, SINIAGEC supplies high-level administrators with data enabling them to control certain research operations and to make informed decisions. From the start, however, it was recognized that SINIAGEC would not be exhaustive. Two supplementary systems were created to facilitate the management, direction, and administration of research

within INIA: (1) a system for evaluating the planning and performance of research activities; (2) a system for disseminating research results.

Organization of SINIAGEC

In 1978 INIA had its headquarters in Mexico City and maintained 11 agricultural research centers and 48 experimental stations throughout the country. By 1981 the number of experiment stations had risen to 55. The director general's office and senior managerial and administrative staff were still located in the capital. Each of the 11 research centers had a director responsible for between 3 and 7 experimental stations, with a staff of from 10 to 50 researchers.

INIA's central office in Mexico City housed the biometry unit, responsible for developing SINIAGEC. This unit prepared all SINIAGEC forms and forwarded them, at the appropriate time, to the heads of experiment stations who acted as regional coordinators. These regional coordinators distributed the forms to researchers who completed and returned them. Via the regional coordinators, the forms were then sent back to the biometry unit, where they were subject to revision, processing, and report publication. To accomplish its task, the biometry unit had access to the IBM 370/145 computer of the post-graduate college at Chapingo.

Because in Mexico crops are planted during both the autumn-to-winter and the spring-to-summer cycles, it was necessary to collect two sets of responses from many research workers. On dry, tropical-type lands, where cereals and beans are the most important crops, planting depends totally on rain and takes place during the spring-to-summer cycle. In humid tropical areas and irrigation districts, however, planting takes place during both cycles.

Definitions

The following definitions, some arbitrary, may be helpful to understanding how SINIAGEC functions.

SINIAGEC collects, verifies, organizes, processes, classifies, and summarizes information from sub-projects, experiments, and surveys carried out by INIA researchers, and it maintains up-to-date archives on current research.

Sub-project. The sub-project, the basic unit of research, is defined as a research activity at an experiment station directed towards the solution of a clearly specified problem. A sub-project may consist of one or more experiments or a survey.

Autumn-winter cycle. Every sub-project, experiment, or survey which starts between the first Friday of September and the first Friday of the following March belongs to the autumn-winter cycle.

Spring-summer cycle. Every sub-project, experiment, or survey which starts between the first Friday of March, and the first Friday of the following September belongs to the spring-summer cycle.

Start of experiment. A crop experiment is considered to start on the day planting takes place or, more generally speaking, on the day when land is ready for planting. A survey starts officially with the initiation of information collection. A laboratory test begins with commencement of experimental work.

End of experiment. A crop experiment is considered to end on the day the crop is harvested or observations terminate. For a survey, the end coincides with final collection of information. A laboratory test concludes when all experimental work has finished.

Start of sub-project. A sub-project is considered to begin with the setting up of the first experiment or survey which is a component of the sub-project, or with commencement of research activities.

End of sub-project. A sub-project is considered to end at the conclusion of the last experiment, survey, or piece of work carried out to achieve the objectives of the sub-project.

New experiment. As part of an updating procedure, new experiments are those initiated during the autumn-winter or spring-summer cycle referred to in the updating, regardless of whether they end during the same cycle.

Current experiment. An experiment is considered "current" in a specific cycle if it was initiated during a previous cycle but has not ended by the time of updating.

Ongoing experiments. In any given cycle, ongoing experiments are the sum of the new experiments in that cycle plus the current ones of previous cycles.

Sub-projects in progress. A sub-project is considered "in progress" with respect to a specific cycle if it contains experiments, surveys, or work actually in progress or planned for the following cycle. It should be noted that a sub-project may be in progress without having experiments actually under way.

SINIAGEC Operation

Each and every researcher responsible for a sub-project completes the questionnaires required in his respective experimental fields annually. Ten weeks later, officials and researchers at INIA have a printed SINIAGEC report showing all research activities grouped and classified in a suitable manner.

SINIAGEC carries out two surveys per year, timed to correspond respectively to the autumn-winter and the spring-summer cycles. At a given moment, a researcher may face one or more of the following conditions:

1. The sub-project which he reported to be current during the previous cycle has now ended, i.e., all experiments planned within the sub-project have now been concluded.
2. The sub-project which he reported during the previous cycle to be current continues to be current, i.e., it still has one or more experiments outstanding, or it is envisaged that, in the present or subsequent cycles, new experiments will be established.
3. He is involved in a new sub-project, one with or without experiments.

To meet its goals, SINIAGEC uses seven forms for the collection of information:

Form 01: New sub-project registration. The researcher in charge of the sub-project completes Form 01.

Form 02: Registration of new experiments or surveys. The researcher in charge of the sub-project, experiment, or survey fills in Form 02.

Form 03: Record of current or completed sub-projects, experiments, or surveys. This computer output from the SINIAGEC archive relates to the sub-project entailing experiments from the immediately preceding cycle. The person in charge of the sub-project, experiment, or survey marks those activities which are current and those which have ended. He also provides explanations for why certain activities have come to a close.

Form 04: Record of information regarding new sub-projects. This computer output relates to sub-projects reported as new in the immediately preceding cycle. It also contains the most salient parameters reported in Form 01. The researcher in charge of each sub-project indicates omissions, errors, or changes.

Form 05: Record of information regarding new experiments or surveys. Similar to Form 04, Form 05 concerns the experiments or surveys that are components of sub-projects.

Form 06: Summary of information per station. Form 06 contains a summary of the accounting for current and completed sub-projects, experiments, and surveys. The regional coordinator completes Form 06 with the aid of Forms 03 and 07.

Form 07: Preceding cycle information summary per station. Form 07 is a computer output giving the names of persons in charge, numbers of sub-projects, experiments, and surveys for the immediately preceding cycle.

Tables 2, 3, and 4 present the timetable of activities for which the biometry unit, regional coordinator, and researchers in charge are responsible respectively.

Description of Forms 01 and 02: Forms 01 and 02, the registration of new sub-projects and experiments, those in progress about which no report has been previously filed, present the system's essential information.

The questions contained in both may be classified as follows:

1. Identification of research: economic and register number; location in the center and experiment station; program; name of person responsible and collaborators; and commencement and completion dates.
2. Scientific and technological definition of the research: title; objectives; research area; crop; animal or product; scientific field; key concepts; experimental design; numbers of treatment applications; and experimental or sample units.
3. Agroecological and social parameters: geographical sector; irrigation or rain-fed agriculture; type of property; location in INIA or with farmers; sector benefited.

Table 2. Biometry unit activities.

Activity	Final Dates	
	Autumn-winter Cycle	Spring-summer Cycle
1. Distribution of forms 01,02,03 ...07 to regional coordinators	First Friday in February	First Friday in August
2. Processing of forms	The end of April	The end of October
3. Preliminary report from SINIAGEC	First Monday in May	First Monday in November
4. Full report from SINIAGEC	Third Monday in May	Third Monday in November

Table 3. Regional coordinator activities.

Activity	Final Dates	
	Autumn-winter Cycle	Spring-summer Cycle
1. Distribution of forms to researchers	Last Friday in February	Last Friday in August
2. Revision of forms 01,02,03, 04 and 05, submitted by researchers	Third Friday in March	Third Friday in September
3. Completion of form 06	Third Friday in March	Third Friday in September
4. Forms 01,02,03,04,05 and 06 sent to Biometry Unit	Third Friday in March	Third Friday in September

Table 4. Researcher-in-charge activities.

Activity	Final Dates	
	Autumn-winter Cycle	Spring-summer Cycle
1. Completion of forms for sub-projects and new experiments (01,02)	First Friday in March	First Friday in September
2. Filling in of completion and correction forms (03,04,05)	First Friday in March	First Friday in September
3. Forms 01,02,03,04 and 05 sent to regional coordinators	Second Friday in March	Second Friday in September

SINIAGEC tables: To automate information provided on Forms 01 and 02 and to expedite the electronic process, replies need to be converted into keys which a computer can interpret. Similarly, it is necessary for information supplied by the researcher to be organized and classified by the system so that it can be identified according to certain characteristics and attributes and in relation to its planned use.

The computer cannot interpret a sub-project title and objectives, but if the descriptions of these are broken down into different categories -- such as research areas, crop, animal or product, scientific field, and key concepts -- then information relating to the title and objectives of the research can be readily retrieved

Description of information produced: SINIAGEC retains information about sub-projects, experiments, and surveys in progress in an archive, which is updated twice a year, corresponding to the spring-summer and autumn-winter cycle surveys. Ten weeks after the final date when researchers submit their information, the biometry unit produces the principal summary tables for sub-projects and classified experiments.

Obviously the number of tables classifying sub-projects or experiments is large, for there are many possible combinations of the parameters recorded. Of the many possibilities, however, only certain ones prove to be valuable. By way of illustration, some results are shown below corresponding to the 1978 and 1979 spring-summer cycles.

Table 5. Number of experiments associated with each regional center (spring-summer cycle, 1978).

Center	At INIA	On producer	Total
CIANO	140	51	191
CIAPAN	205	220	495
CIAPAC	157	415	572
CIAPAS	94	376	470
CIAGON	349	261	610
CIAGOC	36	84	120
CIAPY	96	231	327
CIAN	171	541	712
CIANOC	374	418	792
CIAB	238	352	590
CIAMEC	181	414	595
Total	2041	3363	5404

Tables 5, 6, and 7, taken from the INIA report on the 1978 spring-summer cycle, represent a classification of all 5,404 experiments in progress during that cycle. Table 5 shows both the number of experiments at INIA centers and the number of trials on producers farms. Table 6, the number of irrigation and rain-fed experiments during the cycle; Table 7, the number of trials per crop on both INIA centers and producers' farms. e

In order to make information stored under SINIAGEC known to researchers both in INIA and elsewhere, catalogs of experiments for various crops such as wheat, sesame, and cotton, were published in 1980. The sesame catalog for example was a listing of all sesame experiments in progress at that time, including the 1980 spring-summer cycle. For each experiment the catalog contained the following data: experiment number assigned by SINIAGEC; experiment title; name of researcher in charge; whether irrigated or rain-fed; whether located at INIA or on a farm. Table 8 is an extract from the sesame catalog.

Table 6. Number of experiments per center set up under irrigation and rain-fed conditions (spring-summer, 1978).

Center	Irrigation	Rain-fed	Total
CIANO	168	23	191
CIAPAN	223	202	425
CIAPAC	106	466	572
CIAPAS	43	427	470
CIAGON	487	123	610
CIAGOC	12	108	120
CIAPY	46	281	327
CIAN	492	220	712
CIANOC	277	515	792
CIAB	163	427	590
CIAMEC	12	433	595
Total	2179	3225	5404

Since the respective key numbers do not follow sequentially this catalog is an indirect one. The key numbers do, however, form a link with the crop experiment classification (Table 9) added at the end of the catalog in which experiments are grouped according to research area. This makes it possible to know, for example, which experiments relate to biological pest control for sesame.

Table 7. Number of experiments per crop on INIA stations and producers' farms (spring-summer, 1978)

Crop	At INIA stations	On producers' farms	Total
Maize	486	1,208	1,694
Wheat	38	90	128
Rice	96	117	213
Sorghum	202	260	462
Barley	28	43	71
Oats	12	37	49
Cereals	49	84	133
Beans	164	300	464
Soybeans	95	115	210
Industrial and medicinal crops	15	2	17
Maize-beans	27	95	122
Other associations	25	40	65
Total	2,041	3,363	5,404

Table 8. General catalogue of sesame experiments: Spring-summer 1979.

No.	Person/Body Responsible	Center	Station	Water Use	Location	Title
31	Roberto A. Gallardo Guajordo	CIAPY	CAECHET	Rainfed	Farmer	Batch of sesame for observation.
127 to 129	Ignacio López Gil	CIAPAS	CAECOAX	Rainfed	Farmer	3 Studies on the influence of different dosages of phosphorous and potassium and different planting densities of outstanding sesame varieties
141	Sergio Poot Caamal	CIAPAS	CAECOAX	Rainfed	INIA	Increased quantity of sesame seed of Colorado Tepequeño regional variety.
143	Sergio Poot Caamal	CIAPAS	CAECOAX	Rainfed	INIA	Sesame demonstration batch with Padilla, Cola de Borrego and Colorado Tepequeño regional varieties.
144	Sergio Poot Caamal	CIAPAS	CAECOAX	Rainfed	INIA	Sesame demonstration batch with Blanco Ro Grande, Regional Verde, Instituto 21 y Regionales y Canasto 1.5 varieties.
410	CAEIGUA sesame group	CIAPAC	CAEIGUA	Irrigation	Farmer	Determination of optimum planting time for sesame cultivation.

Table 9. Classification of sesame experiments per research area; Spring-summer.

Genetic resources											
416	417	4585	5031	5368	5369	6006	6007	6008	6693	6694	6695
Conservation and recovery of soil and water											
5035	5370	5371	7140								
Ecosystems and agrosystems											
5375	5376	5736	5737	5738	5739	5740	6707	7079	7080	7081	
Other areas of natural resources											
5370	5371										
Description of pests											
5036	6703	6704	6705	6706							
Inventory of pests											
5036	7136										
Biological pest control											
412	413										
Genetic pest control											
412	413										
Chemical pest control											
6703	6704	6705	6706	7137							

An Information System for National Agricultural Research

Effective management of a national agricultural research institute requires the best use of the human, physical, and financial resources available so the institute may fulfill its mandate. In most countries, this mandate involves the institute in long-term scientific and technical studies to resolve high priority agricultural problems. These priorities will be a reflection of the physical, social, historical, cultural, and economic context within which the national agricultural research institute must function. Managers thus require an understanding of the national political system and of governmental decision-making processes so that not only budgetary support can be obtained, but favorable political patronage as well, influential support which will back up the application of positive research results.

A satisfactory national agricultural research information system will contain the inputs, throughputs, and outputs necessary to enable the national research institutes' various scientists and administrators to carry out planning, control, and decision-making intelligently.

Planning

Most governments have definite agricultural development policies which they attempt to implement through a variety of organizations. There is usually one organization to undertake or coordinate agricultural research. In Mexico this is the task of the Institute of Agricultural Research (INIA). The INIA information system might well be adaptable to the needs of similar institutes elsewhere.

Awareness of the current agricultural situation in Mexico indicates that the following information is required for research planning purposes:

1. Statistics: production, yields, costs, prices.
2. Technologies applied: seeds, fertilizers, pesticides, mechanization.

3. Natural resources: soil, climate, water.
4. Technical constraints: seeds, pests, diseases, frost, salinity, drainage, drought.
5. Economic constraints: profits, commerce, communications, credit.
6. Social constraints: agrarian system, traditionalism, organization, leadership.
7. Institutional constraints: lack or inadequacy of services.

Definition of the goals of a national research plan requires selection from among the following alternatives:

1. Increased food production.
2. Increased export products.
3. Increased agricultural products for domestic industries.
4. Increased productivity of land, labor, and inputs.
5. Ensured agricultural stability.
6. Encouragement of rural employment.
7. Conservation of natural resources.
8. Protection of health.
9. Increased agricultural profitability.
10. Reduced crop losses.
11. Improved product quality.

Generally speaking, these objectives are complementary. Their achievement, however, may require different actions and be constrained by different physical, economic, and social conditions. Lack of scientific and technical knowledge, nationally but also globally, may also obstruct progress. National documentation and computer access to international data bases will increase the probability of success in agricultural research projects. Skilled exploitation of information systems can also increase the likelihood that farmers themselves will adopt research results and innovative techniques.

A directory of research experts, with notation of their various scientific and technical specializations, is also an extremely important research aid, accelerating the possibility of locating proper sources for consultation and advice.

A complete inventory of research assets is a further constructive measure; this listing should include not only laboratory facilities, equipment, instruments, materials, germplasm banks, but also human resources (scientists, technologists, technical experts, assistants, workers). Ultimately, human resources are the driving force behind research work; who they are, where they are, and what experience they have will largely determine an institute's or country's capacity to develop projects of a certain nature, depth, and scope.

Finally, an appreciation of the physical, social, and economic nature of agriculture, of the relative urgency of general development objectives, of the present state of agricultural technology, and of research institutions' scientific capacities and financial resources, are fundamental for determining national agricultural research priorities. Indeed, this decision-making process demands extraordinary powers of intelligence and a firm grasp of all relevant circumstances.

Regional planning, similar to national planning, is bound by regional guidelines. The information needed about human, physical, and financial resources is more detailed. Requirements in terms of land, materials, machinery, equipment, laboratories, and workers must be specified and located. A budget for each project must be calculated, including estimates of probable costs and benefits. The potential users of research results must be identified and the probability assessed that they will adopt new technologies.

Control

One product of the research planning process, whether national, regional, or local, is a list of projects and programs complete with standards, schedules, and costs. Once who will work where and with what is clearly indicated, research activities can be initiated, later to end, it is the hope of all concerned, as originally planned. It is of paramount importance that procedures be established to ensure the quality of project design methods and the use of appropriate and efficient research techniques. Control must also be exercised over the use of experimental designs, plot dimensions, and numbers of replicates; the measurement techniques applied to make experimental observations; the selection of treatments and applications; the selection of appropriate parent stock for cross-breeding; correct dosages for agrochemicals, and appropriate sampling times for quality determinators. Similarly, steps should be taken to confirm that the theoretical basis of research hypotheses is sound and that it is feasible to reach the project's goals in the time specified and with the means proposed.

Once research is operational, there should be periodic comparisons of projected and actual costs and resource consumption. Real progress should regularly be assessed

against the initial planning timetable. Towards these crucial ends, it is advisable to set up a monitoring system. Monitoring can be more cost-effective in a large institute if a mechanism for rotation sampling is adopted. In this way, over time, all researchers in charge of projects are included in the control sample.

It is also important for the management of a healthy agricultural research institute to monitor the progress reports of each project, and assess the results achieved, including publications. Likewise, it is essential to abstract and to analyze the value of the end results of projects and the uses to which they will be put. These results should be classified according to their likely impact. Should they be corroborated by undertaking trials with farmers? Should they be applied immediately? How should they be disseminated? What is the likely cost-benefit to the farmer?

Decision-making

The executive authorities of a national research institution must arrive at a number of fundamental policy and operational decisions, including:

1. How to implement an efficient decision-making process which allows for participation of researchers in determining an overall research plan and budgetary allocations.
2. Whether or not to promote or discharge scientific personnel and administrative officials, contract outside consultants, or conclude inter-institutional agreements.
3. Whether to expand or cut back the institution's human and material resources.
4. How to create administrative standards to improve the working environment.
5. How to facilitate financial transactions and storage operations.

Research coordinators or committees have the following decisions to make:

1. Whether to approve, reject, or modify research proposals.
2. Whether to accept, adjust, or cancel projects as a result of internal or external project reviews.
3. How to use research results once a project is completed.

The researcher in charge of a project is faced with various alternatives in project formulation. He has to choose between different scientific opinions vis-à-vis the physical and social world. Such choices invariably involve weighing uncertainties against each other. Some of the risks inherent in proposed research may be quantifiable; others may not even be apparent.

Management Research

It is particularly important for an agricultural research institute to channel knowledge and action towards maximizing available resources; creating a spirit of scientific excellence; encouraging creativity and discipline; and promoting coordination and cooperation among all the institute's researchers and workers. After the study and analysis of management research topics relevant to the institute's characteristics and conditions, ultimately a set of work guidelines should be established.

The following topics might merit consideration:

1. Evaluation of criteria for assessing research proposals.
2. Evaluation of criteria for assessing the results of research studies.
3. Methods for measuring individual researchers' productivity.
4. Methods for measuring the institute's productivity.
5. Identification of appropriate incentives for researchers.
6. Methods to optimize the use of installations and equipment.
7. Methods for developing researchers' capacities and efficiency.
8. Improvement of communication among researchers.
9. Improvement of relations between researchers and producers; means of transmitting information.
10. Correlations between research and development.
11. Improvement of relations with academic and development institutions.
12. Means for fostering the use of documentation systems.
13. Means to create a favorable disposition towards research among political leaders and public authorities.

For each of the above topics, several answers may occur with varying degrees of feasibility. To rank them will demand a methodical approach based on adequate data.

Scientific Personnel

Assessment of scientific personnel is an essential component of any management information system; for a research institute's human resources constitute its

greatest current and potential asset. Superior scientific management encourages creativity, diligence, and willing participation through some form of incentive system. In this way it heightens job satisfaction and, therefore, extracts excellent job performance.

The evaluation of a researcher should include consideration of the following:

1. Academic degrees, professional honors and citations.
2. Scientific and technological productivity; significance of his contribution.
3. Recognition by peers.
4. Number of published articles, documents, and books; their quality, originality, and theoretical or practical importance.
5. Number of times his work is cited in scientific publications.
6. Analytical and synthesizing abilities.
7. Ability as a research leader.
8. Sense of responsibility and trustworthiness.
9. Health.

Budget

The financial management of a research institute involves the formulation and maintenance of a research budget, its correlation with investment plans, and its breakdown into programs and projects. In its configurations, this breakdown should represent the relative importance ascribed to each area and type of research, each agricultural region, and each kind of agriculture. Analysis of budgetary information may reveal, given institute goals, that particular elements are receiving too little or too much support.

The research institute's structure, its bureaucratic procedures, its salary schedule, the balance between wage and operating costs, and the balance between running and investment costs constitute basic information which decision-makers need to be able to make necessary spending adjustments towards achieving a healthy, strong, and productive organization.

Modern accounting and management techniques do not pose problems in terms of budgetary control.

Management Aids

Scientific management requires written rules for the running of activities and projects. These rules, standardizing procedures, should be known to all relevant personnel. Research institutes would do well to produce a procedural manual covering all routine operations. Although computers are increasingly being used, manual methods are still common for the following procedures:

1. Financial control.
2. Contracting of personnel.
3. Correspondence and communication.
4. Use of vehicles.
5. Maintenance of equipment, machinery, and vehicles.
6. Purchase of materials.
7. Listing of personnel and their job classifications.
8. Inventories and stores.
9. Patent procedures and marketing.
10. Interinstitutional agreements.

Data Processing

Care should be taken not to collect information irrelevant to the purpose for which the data processing is intended. Too often surveys amass large amounts of statistics and great quantities of documents, the profusion of which engenders more confusion than clarity. In general, quantity of information means loss of quality. Objectives become obscure, the mind distracted, and goals more distant. Illusions are created which mislead the institution.

Information selected for processing should be validated and verified (edited). It should be transcribed according to a set structure. The data and its classification, nature, and descriptors form the register of each item, a register composed of a specific number of fields with a character for each one. A group of the same kind of registers forms an archive. The archives together make up the data base. The size of the registers and the number of archives, as well as the frequency of changes to update the archives, and the class and number of arithmetical and logic operations to be applied serve as a basis to decide whether to use manual or electromechanical procedures, a punch-card system, or an electronic computer.

Data processing usually includes listings, classification into frequency tables of one or more entries, rankings

under different criteria, arithmetical operations, decision-making logic operations, and numeric and logical algorithms for the development of certain mathematical models for operational research. These models, for example, may assist with inventory control, budgetary control, or linear programing.

Data processing design should be adaptable to suit the different information and decision levels required. There are filtering and monitoring methods to facilitate such adaption.

Filtering is a process for sifting or extracting redundant information by means of summaries or classifications which eliminate all elements not required for a specific information or decision level. Senior decision-makers need concise reports; area heads and research coordinators generally require more detail.

Monitoring is another method for paring down the amount of detailed information, simplifying it, and reducing the time needed to make decisions. A reduction in information, however, should not diminish the efficiency of the decision-making process. There are three procedures for implementing monitoring: (1) variation reporting, (2) decision-making program, (3) automatic notification.

In variation reporting, only facts or activities involving major deviations are entered. In the decision-making program, qualitative or quantitative condition criteria are established to determine alternative modes of action. In automatic notification at periodic intervals, the computer or system gives information on specific aspects which serve to regulate action criteria.

Information System for the Scientific Management of Agricultural Research

Table 10 is intended as a summary of the explanations, considerations, and recommendations presented in this paper. An information system should be the coherent embodiment of a series of information sub-systems or archives. Information sources may be external or internal, with specific features and aims, and with a strategic, tactical, or technical orientation. These sources of information create sub-systems or archives. As shown in Table 10, activities resulting from study, analysis, and interpretation, lead to decisions which become crystallized as products or actions.

Simple information systems, such as the one we have been discussing and such as the system considered in Table 10, consist of the following sub-systems or data archives:

1. National reference marks.
2. Regional reference marks.
3. Scientific documentation.
4. Scientific human resources.
5. An institute's physical resources.
6. Budget.
7. Current research.
8. Evaluation of current projects.
9. Research study results.
10. Production formulas.

All agricultural research institutes keep registers of the 10 topics listed above. The compilation procedures they use range from the simplest manuals to the most advanced electronic computer systems. The updating of all this information, the timing and ease of access, and the integration for control and decision-making are, in many institutes, a major constraint challenging the management or administration. There is a pressing need for those authorities responsible for the planning, operation, and control of agricultural research to examine their individual situations and take firm actions to improve their information systems.

Table 10. Information system for the scientific management of agricultural research.

Sources	Description	Inputs Levels	Subsystems	Activities	Decisions Level	Products
External	a) Socioeconomic production statistics	Strategic	National reference framework	1. Indicator plans a) Policies b) Production problems c) Socioeconomic problems d) Markets e) Natural resources f) Science and technology	Strategic High government officials Planning Committees Industrial, agricultural and workers' associations	a) Summaries b) Monographs c) Publications d) National science and technology Plan
External and Internal	a) Scientific and technological documentation b) Science and tech.Plan c) Human resources for Science, technology d) Institutional resources e) Physical resources	Strategic	a) Documentation: AGRIS, AGRINTER, AGRICOLA, CAB, etc. b) Institutional resources. c) Human resources d) Budget	2. Programming a. Priorities b. Budget c) Human resources d) Physical resources	Strategic Board of directors Institute board directors	a) Summaries b) Publications c) National program per product and scientific area d) Budget per program
External and Internal	a) Scientific and technological documentation b) Human resources c) Physical resources d) Regional reference framework	Tactical Technical	a) Documentation AGRIS, AGRINTER, AGRICOLA,CAB,etc b) Local reference framework c) Budget	3. Project a) Scientific, techno-logical feasibility b) Physical resources c) Human resources d) Probability of success f) Budget g) Duration h) Probabilities of implementation i) Sphere of adoption j) Cost-benefit	Tactical: 1) Regional projects committee 2) Researches in charge of projects Technical: 1) Scheduling of 2) Human and physical elements	a) Approval, modification or rejection of projects b) Bulletins c) Budget per project d) Budgetary allocation e) Methodology activities
Internal	a) Current research studies b) Research study progress	Tactical Technical	a) Current research study b) Evaluati .	4. Inventory, Control a) Research inventory b) Supervision c) Evaluation	Technical, Tactical: a) Researchers b) Directors	a) Summaries b) Publications c) Cancellation of export by products d) Reconfirmation e) Ramification
External and Internal	a) Evaluation survey	Tactical	a) Results b) Production formulas	5. Completion a) Analysis b) Conclusions c) Recommendations	Tactical: a) Directors b) Researchers	a) Progress of experiment b) Publication c) Extension d) Reconfirmation e) Ramification

Acknowledgment

This paper has been prepared under the auspices of the Centro Internacional de Investigaciones para el Desarrollo and the Comisión Nacional de la Industria Azucarera de México. The author is indebted to the many INIA staff who assisted in the development of SINIAGEC, especially his close collaborators, Carlos Mejía and María Isabel S. de Jasa.

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CHAPTER FIVE: Funding Agricultural Research

Eduardo J. Trigo, Co-coordinator,
Martín E. Piñeiro, Coordinator,
Cooperative Project on Agricultural Technology Research in Latin America
Inter-American Institute for Cooperation in Agriculture (IICA) San José, Costa Rica

Introduction

The organization of agricultural research, conceptualized in terms of the institutional forms and mechanisms through which human, physical, information, and financial resources converge in the operation of research processes, has received growing attention in recent years Concern has focused on the overall features of organization as well as on such crucial components, as training of human resources, development of physical infrastructure, and relationships between national and international research institutes.

At the same time, it is becoming increasingly clear that the productivity of national research systems is not independent of their organizational format. In particular, the effectiveness of these sytems may in large part be determined by the forms and mechanisms through which they obtain their financial resources. This linkage suggests that the nature and structure of research institutions are influenced by the cultural, economic, and political context in which they operate. It also implies that characteristics of this context act as determinants of organizational alternatives that should be considered in designing national research systems (Ruttan, 1982; Rigney, 1981; Trigo, Piñeiro and Ardila, 1982).

These relationships have not been fully recognized in the past. They appear to be a primary reason, however, why national efforts to establish a highly productive research infrastructure have not attained anticipated success.

It is against this background that we will examine the financing of agricultural research. This paper places special emphasis on existing alternative financing mechanisms and on factors that affect the impact of resources on the effectiveness of research organizations. The paper comprises seven sections. The first is this introduction. The second gives a brief description of the organizational and budgetary background of agricultural research in Latin America. The third concerns the magnitude of financing for this type of activity, especially the comparison standards used for measuring resources. The fourth and fifth discuss alternative sources of funding and the real possibility of linking the intended recipients of benefits with the financing of research. The sixth presents several ideas for financing research by institution and by project. The final section contains general comments on all issues raised in the paper.

Background of Agricultural Research and its Funding in Latin America

Historically, agricultural research in Latin America can be divided into two periods. The first began with early research efforts during the second half of the last century, and lasted until the 1950s.

Throughout this stage, activities unfolded in institutional structures which were generally unstable. On the whole, institutional developments were closely allied to meeting crisis situations in specific crops. Examples include tanguis cotton in Peru and sugarcane in the Cauca Valley of Colombia. During this period, experimental stations were built, later to become the cornerstones of modern research institutes (Estanzuela in Uruguay, Pergamino in Argentina, the National Agricultural Association in Chile, the experimental farms in Palmira, Medellín, and Bogotá in Colombia, the Cañete and La Molina experiment stations in Peru, etc.).

The second period of institutional development, the one in which we find ourselves today, began towards the end of the 1940s. It has been characterized by the establishment of more integrated research structures with a national scope. Initially, agricultural research was centered integrally in the ministry of agriculture. After 1960, however, most countries in the region introduced decentralized, independent research organizations with administrative autonomy. This new institutional model, generically known as the National Agricultural Research Institute, provided a basis for the expansion and strengthening of research activities which, until the mid-1970s, received uninterrupted growing financial support from international as well as from domestic sources.

This expansionary period, included a "territorial occupation" phase featuring the establishment of new experimental stations and networks of extension agencies. In addition, broad training programs were initiated, oriented toward developing the critical mass of

human resources needed for meeting the requirements of research processes. These processes received strong impetus from external assistance programs that call on beneficiary nations to assume progressively more financial responsibility for their own research system(s). Such national funding occurred only to a limited extent, however, leading to a dramatic decay of programs once external assistance came to an end (Piñeiro and Trigo, 1983).

Table 1 shows the evolution of budgetary resources for agricultural research from 1960 to 1980 in Latin American countries for which information is available. The table reveals, almost everywhere, a strong growth of resources for research. This general expansion, however, conceals a different pattern which emerges after closer scrutiny. It is true that from 1960 to 1970 budgets rose steadily, but after 1970, the upwards trend faltered throughout the region, and in some countries, research funding even suffered a cutback.

A further observation is that during the 1970s, agricultural research budgetary resources in any given country were extremely mercurial. This is reflected both in differences between peaks and valleys, often surpassing 50%, and in year-to-year variations. Table 2 illustrates these annual variations, showing the frequency with which budgetary allocations dropped off from one year to the next, and the magnitude of these reductions. The problem of budgetary instability is a particularly acute one, given the long-term nature of national research programs and thus their inflexibility for abrupt, short-term adjustments.

Indeed, year-to-year funding variations are particularly drastic for research institutes in view of their budgetary structure. In general, over 70% of total organizational resources are used for personnel costs; these are relatively hard and fast over the short-term. Therefore, any drop in funds must be fully absorbed by the budget post for direct research.

This means that, in practice, a total budgetary variation of 5% has an impact on the organization's operating capacity equivalent to a cut of 20% to 25%.

It should be noted that the countries most affected by budgetary instability include some of those with the oldest research infrastructures: Argentina, Colombia, Ecuador, Uruguay, and Peru.

Financing Models

The funding of agricultural research activities has proceeded by and large on the basis of annual allocations from national budgets. This funding mechanism is characterized primarily by: (a) public nature of the funds, paid out of general revenue, which means that agricultural research competes directly with other public sector activities; and (b) allocation of funds is per institution, leaving decisions concerning specific spending to the research organization itself.

In addition to this general approach, several important alternatives with respect to the origin, means of acquisition, and use of resources continue in use. To give an example at the National Research Institute level: Argentina's INTA has until recently received budgetary resources from a specific tax on agricultural exports. Elsewhere, a tax on exports of a particular commodity has been used to support research on that commodity. Both the Executive Commission of the Plan for Economic Recovery of the Cacao Industry (CEPLAC), in Brazil, and the National Coffee-Growers' Federation (FEDERACAFE), in Colombia, finance their research in this way.

Similarly, the Sugar Cane Research Center of Colombia (CENICAKAPÑA)receives financing through a formula based both on sugar exports and on the differential between domestic and foreign sugar prices. This type of commodity funding for an individual institution may be supplemented by support from additional sources. We might cite, for instance, the resources received by the Colombian Agricultural Institute (ICA) through the Fifth Law of 1974, and specific programs developed with the local brewing industry by the Colombian Rice-Growers Federation; the pasture research programs under way in the National Agricultural Research Institute (INIAP) in Ecuador, which receive funding from the Highlands Livestock Association; and a number of ventures in Brazil such as the programs of the Sugar Producers Cooperative (COPERSUCAR) for sugar cane and the National Association for the Use of Fertilizer (ANDA) for cotton, beans, corn, soybeans, and wheat (López, 1979).

International loans and grants from both the multilateral credit organizations and bilateral aid programs of developed countries have also become important sources of support to national agricultural research budgets in Latin America. The Inter-American Development Bank (IDB) and the International Bank for Reconstruction and

Table 1: Latin America and the Caribbean: Budgetary resources for agricultural research from 1960-1980. Values expressed in constant 1975 currency (in thousands).

	1960	1965	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
North Zone:													
Costa Rica (Colones)	3,565.1	5,210.6	4,637.5	13,521.9	14,387.5	9,235.3	7,081.0	8,972.8	9,937.9	10,839.5	10,329.1	12,525.9	12,143.7
El Salvador (Colones)	1,177.5	1,072.5[1]	1,280.3	1,552.2	1,812.5	2,295.1	2,570.0	2,500.0	4,530.4	4,095.8	5,077.2	4,409.2	3,906.3
Mexico (Pesos)	58,325.0	65,237.0	30,900.0	41,912.5	65,812.5	109,337.5	116,812.5	173,437.5	199,912.5	166,612.5	450,600.0	510,750.0	579,487.5
Nicaragua (Cordobas)	–	5,545.8	7,209.5	7,469.3	7,729.0	6,430.3	6,830.5	7,855.4	6,494.2	9,343.6	7,848.4	8,508.2	9,168.1
Guatamala (Quetzales)	1,840.0[2]		–	–	1,911.0	1,578.9	2,330.7	2,380.0	2,293.7	2,668.8	2,841.2	3,426.7	3,[illegible]4.9
Panama (Balboas)	417.0	–	1,176.0	1,437.0	1,698.0	1,649.0	1,600.0	1,218.0	850.0	989.9	1,014.2	1,709.8	1,622.3
Caribbean Zone:													
Barbados (BB Dollars)	–	480.0	1,179.7	1,258.5	1,100.9	943.3	843.4	747.4	735.3	735.3	850.4	1,149.4	1,012.0
Jamaica (J Dollars)	–	137.5	138.0	769.0	814.0	1,257.3	1,360.7	1,301.3	1,340.9	1,178.1	841.5	504.9	554.4
Guyana (G Dollars)	–	–	–	–	–	1,218.7	1,131.8	1,543.4	1,094.9	583.5	–	–	–
Andean Zone:													
Bolivia (Pesos)	10,820.0[3]	–	30,980.0	31,360.0	25,080.0	25,620.0	26,140.0	24,820.0	23,520.0	41,240.0	46,020.0	42,080.0	36,680.0
Colombia (Pesos)	213,751.2	234,312.0	667,944.0	764,755.0	750,562.0	760,766.0	701,984.0	711,454.0	747,173.0	641,682.0	807,461.0	739,899.0	697,114.0
Ecuador (Sucres)	–	42,850.0	72,628.0	96,552.0	125,806.0	137,143.0	126,025.0	128,825.0	131,600.0	132,880.0	109,321.0	124,156.0	99,666.0
Venezuela (Bolivares)	19,850.6[1]	31,757.6	–	–	–	–	–	–	85,207.7	96,647.0	99,330.8	84,387.4	97,699.8
Peru (Soles)	76,948.8[3]	114,933.6	351,818.0	271,279.2	289,353.6	308,937.6	297,962.4	415,711.2	376,852.0	211,028.0	188,975.0	174,644.0	161,188.0
Southern Zone:													
Argentina (Pesos)	1,099,976.4	1,066,998.8	1,113,000.0	936,000.0	1,028,000.0	1,283,000.0	1,534,000.0	1,222,000.0	1,145,000.0	1,165,000.0	1,218,000.0	1,209,000.0	1,301,000.0
Brazil (Cruzeiros)	67,316.4	–	–	–	196,569.0	237,608.0	–	–	700,307.0	713,405.0	758,027.0	945,240.0	949,561.0
Chile (Pesos)	13,701.7[2]	13,554.4	41,173.8	45,711.6	46,787.1	26,745.3	28,690.1	26,151.1	33,252.4	32,957.7	31,283.1	32,373.3	33,208.2
Paraguay (Guaranies)	–	–	–	68,164.0	75,982.0	–	–		–	208,232.0	205,767.0	213,733.0	441,135.0
Uruguay (Pesos)	215.0	484.5	372.3	399.0	425.7	525.6	584.1	730.2	573.6	663.3	585.3	773.4	817.8

Source: Oram and Bindlish, 1981; Piñero and Trigo 1983.
Notes: A Hyphen (-) signifies that the data was not available.
[1] Corresponds to 1962
[2] Corresponds to 1964
[3] Corresponds to 1966

Table 2. Latin America and the Caribbean: Annual variations in budgetary resources for agricultural research. 1970 – 1980

	1971/1970	1972/1971	1973/1972	1974/1973	1975/1974	1976/1975	1977/1976	1978/1977	1979/1978	1980/1979
Northern Zone										
Costa Rica	2.91	1.06	0.64	0.76	1.27	1.11	1.10	0.95	1.21	0.97
El Salvador	1.21	1.17	1.26	1.12	0.97	1.80	0.90	1.24	0.62	0.88
Mexico	1.36	1.57	1.66	1.07	1.48	1.15	0.83	2.70	1.13	1.13
Nicaragua	1.04	1.03	0.83	1.06	1.15	1.08	1.10	0.84	1.08	1.07
Guatemala	–	–	0.82	1.47	1.02	0.96	1.16	1.06	1.20	1.02
Panama	1.22	1.18	0.97	0.97	0.76	0.70	1.16	1.02	1.69	0.95
Caribbean Zone										
Barbados	1.07	0.87	0.86	0.89	0.88	0.98	1.00	1.16	1.35	0.88
Jamaica	5.57	1.06	1.54	1.08	0.96	1.03	0.88	0.71	0.60	1.09
Guyana	–	–	–	0.93	1.36	0.71	0.35	–	–	–
Andean Zone										
Bolivia	1.01	0.80	1.02	1.02	0.95	0.09	1.75	1.12	0.91	0.87
Colombia	1.14	0.98	1.01	0.92	1.01	1.05	0.86	1.26	0.92	0.94
Ecuador	1.33	1.30	1.09	0.92	1.02	1.02	1.01	0.82	1.13	0.80
Venezuela	–	–	–	–	–	–	1.13	1.03	0.85	1.16
Peru	0.77	1.06	1.07	0.96	1.39	0.91	0.56	0.89	0.92	0.92
Southern Zone										
Argentina	0.84	1.10	1.25	1.20	0.79	0.94	1.02	1.05	0.99	1.08
Brazil	–	–	1.21	–	–	–	1.02	1.06	1.25	1.00
Chile	1.11	1.02	0.57	1.07	0.91	1.27	0.99	0.10	1.03	1.03
Paraguay	–	1.11	–	–	–	–	–	0.99	1.04	2.06
Uruguay	1.07	1.07	1.23	1.11	1.25	0.78	1.16	0.88	1.32	1.06

Source: Table 1
Note: A hyphen (–) means that the data was not available.

Development (World Bank) both have active programs to provide loans and technical assistance to national agricultural research activities. From 1971 to 1980, the IDB granted 13 such loans to eight Latin American countries for a total value of US$137.9 million. It also provided a total of US$25.0 million non-reimbursable grant aid for technical cooperation. This sum was distributed among 20 projects in 13 countries. The World Bank has granted two research loans in Latin America totaling US$96.0 million.

In 1980, the United States, the major single source of bilateral assistance for agricultural research in the region, had 25 projects under way and nearly US$70.0 million committed through 1985.

International loans and grants are channeled primarily toward the development of physical infrastructure and human resources for national research systems. International support has been particularly instrumental in training human resources, not only within research institute training programs, but also through the efforts of some countries to develop postgraduate programs in the agricultural sciences (Trigo, Piñeiro, and Ardila, 1982)

A different approach, with broader implications for the organization and management of research and technology development in the agricultural sector, has recently been put into operation in the National Agricultural Research Institute (INIA) of Chile. This approach formally combines two types of financing: overall institutional funding and specific project funding. It includes basic financing to maintain core personnel, as well as national (public) budget allocations following the traditional model to meet certain operating costs; but it calls for other operations to be covered by contracts and agreements for specific research projects funded by interested parties. This format is a significant institutional innovation for mixed funding (public-private). Its importance lies in its implications for the role of the public sector in the research process. It also has major consequences for administrative and managerial aspects of research.

This mixed-funding mechanism represents but one of several recent initiatives to revamp agricultural research systems. These initiatives, principally involving the organizational structure of research and technology transfer activities, also have implications for the financing of the system through the establishment of National Agricultural Research Funds. These funds complement, through the financing of specific projects, the regular or core funding of research organizations. In general, these initiatives have been developed within the framework of forging closer ties between agricultural research and the overall science and technology sector, including improved coordination and increased complementarity among research programs of national institutes, universities, and private sector research organizations. Together with the establishment of Research Funds, National Agricultural Research Plans are emerging as basic tools to govern the use of available financial resources. Agricultural Research Councils have also been proposed as mechanisms for overall institutional coordination (Anon., 1981).

The systems for financing agricultural research reviewed in the previous paragraphs differ substantially from one another. Each is the expression of a distinct concept of the nature of research and agricultural technology.

Topics for Discussion

Historical analysis of different ways of funding agricultural research in Latin America over the last two decades shows a clear shift away from models based on blanket institutional allocations from the public sector budget. Research has, to an increasing extent, been supported by sources that acknowledged both the participation in research, of interested sectors (research beneficiaries), and the need to forge institutional ties between agricultural sciences and other research and technological development activities in society. This shift entails that agricultural technology has been losing its identity as a public good. The role of government in the technological process has begun to change. At the same time, new financing mechanisms reflect an attempt to introduce a certain competitiveness for financial resources research organizations. Events point to growing acceptance of the principle, "whoever benefits pays." The new institutional trend poses the following questions: Can a research system be based on such a principle?; What constraints does it place on the research process?; Where should public funds come from?

Considerable experience has now been gained with financing mechanisms tied to products and, more recently, to specific projects. Both of these alternatives for financing — institutional and project funding — have advantages and disadvantages. They also have different effects on the selection of research projects, as will be discussed later.

The Volume of Investment in Agricultural Research in Latin America: A Critical Assessment

Profitability of Research Investments

Most discussions concerning the scale of financing of agricultural research focus on the amount of allocated resources and their relation to other economic variables, notably, the total value of agricultural production, the value of individual commodities, or the total investment in research and development. As a complement to this approach, important descriptive and analytical studies have been conducted on budgetary resource allocations for different activities and areas of research, for example, applied research versus basic research, commodities, regions, and types of producers.

From a slightly different perspective, resource allocation for agricultural research has also been studied in terms of investment returns. Studies of this sort also analyze specific commodity situations as well as aggregate cases either by institution or by commodity groupings (Arndt et al., 1977; Boyce and Evenson, 1975; Evenson et al., 1979; Sim and Gardner, 1978).

Table 3 presents expenditures in Latin America for agricultural research as a percentage of the value of the agricultural gross domestic product (GDP). Table 4, including information from Latin America and other regions of the world, summarizes studies of investment returns from agricultural research. The main conclusion to be drawn from Table 3 is that Latin America suffers from an underinvestment in agricultural research. The percentage of agricultural GDP used throughout the region for research is significantly lower than in more advanced countries, where expenditure on research and development easily surpasses 1.5% of the value of agricultural production (Boyce and Evenson, 1975). In the majority of countries in Latin America, the equivalent outlay does not reach 0.5%.

These signs of relative underinvestment are confirmed by the findings of studies on the profitability of investment in research, given in Table 4. In general, the rates of return range from 30% to 60% per year, with no substantial differences between developed and developing countries. Returns are also similar for research with partial funding (commodities or groups of commodities) and institutional funding. Returns are far higher than those observed for most other types of investment projects, both public and private.

Table 3. Latin America and the Caribbean: Percentage of agricultural gross domestic product allocated to agricultural research in selected countries, 1979[a]

Country	Percentage of Agricultural GDP
Costa Rica	0.24
El Salvador	0.28
Honduras	0.13
Mexico	0.52
Nicaragua	0.42[1]
Guatemala	0.27
Panama	0.36
Total (Northern Zone)	0.45
Barbados	0.90
Haiti	0.05[2]
Jamaica	0.25
Suriname	0.29[3]
Grenada	1.19[4]
Guyana	0.36[4]
Trinidad and Tobago	0.51
Dominican Republic	0.23
Total (Caribbean Zone)	0.24
Bolivia	0.87
Colombia	0.56
Ecuador	0.54
Venezuela	0.94
Peru	0.26
Total (Andean Zone)	0.61
Argentina	0.79
Brazil	0.67
Chile	0.48[1]
Paraguay	0.26
Uruguay	0.14[1]
Total (Southern Zone)	0.60
TOTAL LATIN AMERICA AND THE CARIBBEAN	0.57

Notes: [a] Preliminary estimates
[1] 1980
[2] 1978
[3] 1974
[4] 1976

Sources: Inter-American Bank 1981, International Monetary Fund 1981, Piñeiro and Trigo 1983, World Bank 1981a 1981b.

Table 4. Summary of studies of returns on agricultural research.

Country	Commodity	Period of study	Annual domestic rate of return, %	Study
U.S.A.	Hybrid Corn	1940-55	35-40	Griliches, 1958
U.S.A.	Hybrid sorghum	1940-57	20	Griliches, 1958
U.S.A.	Poultry	1915-60	21-25	Peterson, 1967
South Africa	Sugar Cane	1945-62	40	Evenson, 1969
Mexico	Wheat	1943-63	90	Ardito Barletta, 1970
Mexico	Maize	1943-63	35	Ardito Barletta, 1970
Brazil	Cotton	1924-67	77	Ayer, 1970
U.S.A.	Tomato harvester	1958-69		Schmitz & Seckler, 1970
	With no compensation to displaced workers		37-46	
	Assuming compensation of displaced workers for 50% of earnings loss		16-28	
Brazil	Cotton	1924-67	77-110	Ayer and Schuh, 1972
Peru	Maize	1954-67	35-40	Hines, 1972
			50-55	
Japan	Rice	1915-50	25-27	Hayami and Akino, 1977
Japan	Rice	1930-61	73-75	Hayami and Akino, 1977
Colombia	Rice	1957-72	60-82	Hertford, Ardila, Rocha
Colombia	Soybeans	1960-71	79-96	and Trujillo, 1977
Colombia	Wheat	1953-73	11-12	
Colombia	Cotton	1953-72	none	
Malaysia	Rubber	1932-73	24	Pee, 1977
U.S.A.	Aggregate	1937-42	50	Peterson, Fitzharris, 1977
		1947-52	51	
		1957-62	49	
		1957-72	34	
Bolivia	Sheep	1966-75	44.1	Wennergren, Whitaker, 1977
	Wheat	1966-75	-47.5	
Punjab (British India)	Agricultural research and extension	1906-56	34-44	Pray, 1978
Punjab (Pakistan)	Agricultural research and extension	1948-63	23-37	
Colombia	Rice	1957-64	79-96	Scobie and Posada, 1978
Japan	Aggregate	1880-1938	35	Tang, 1963
U.S.A.	Aggregate	1949-59	35-40	Griliches, 1964
U.S.A.	Aggregate	1949-59	not sig.	Latimer, 1964
U.S.A.	Poultry	1915-60	21	Peterson, 1967
U.S.A.	Aggregate	1949-59	47	Evenson, 1968
South Africa	Sugar cane	1945-58	40	Evenson, 1969
Mexico	Crops	1943-63	45-93	Ardito Barletta, 1970
Australia	Pasture improvement	1948-69	58-68	Duncan, 1972
India	Aggregate	1953-71	40	Evenson and Jha, 1973
India	Aggregate	1960-61	63	Kahlon, Bal, Saxena and Jha, 1977
U.S.A.	Aggregate	1938-48	30.5	Lu and Cline, 1977
		1949-59	27.5	
		1959-69	25.5	
		1969-72	23.5	

U.S.A.	Cash grains	1969	36	Bredahl, Peterson, 1976
	Poultry	1969	37	
	Dairy	1969	43	
	Livestock	1969	47	
Asia - national	Rice	1950-65	32-39	Evenson, Flores, 1978
		1966-75	73-78	
Asia - international	Rice	1966-75	74-102	
Tropics	Rice	1966-75	46-71	Flores, Evenson
Philippines	Rice	1966-75	75	and Hayami, 1978
Canada	Rapeseed	1960-75	95-110	Nagy and Furtan, 1978
U.S.A.	Aggregate	1949-59	66-100	Davis, 1979
		1964-74	37	
U.S.A.	Aggregate	1868-1926	65	Evenson, 1979
U.S.A.	Technology oriented	1927-50	95	
U.S.A. -South	Tech. oriented	1948-71	93	
U.S.A. -North	Tech. oriented	1948-71	95	
U.S.A. -West	Tech. oriented	1948-71	45	
U.S.A.	Science oriented	1927-50	110	
		1948-71	45	
U.S.A.	Farm management Research and agricultural extension	1948-71	110	

Regardless of possible reservations about the methods used for estimating rates of return in Table 4, it is clear from the social standpoint that, instead of allocating resources to alternatives with less profit potential, it would be beneficial to increase investment in research.

Research Infrastructure: Minimum and Optimum Size

We have seen that agricultural research in Latin America, considering its potential contribution to development, consistently receives an inadequate level of support. The absolute level of resources invested in research and technology development is less important, however, than the relationship between total resources available for research and the scale of operations of different research systems. More specifically, the crucial issue is whether available resources are sufficient for research activities to operate at the minimum level requisite for producing results.

Past discussion on the scale of antecedent research systems has been almost totally dominated by those who refer to an optimum scale of operations; and this is a dual optimum, relating both to internal aspects of the research process, and to external factors (Binswanger, 1978; Evenson, 1977, 1978; Hossfall et al., 1975; Pound and Waggonar, 1972; Ruttan, 1978; Schmookler, 1966; Sehgal, 1977).

As far as internal considerations are concerned, a large organization, it can be argued, has a positive effect by increasing possibilities of exchange among scientists and researchers in different disciplines and with different viewpoints. Such intellectual exchange may mean major savings (better use of experiments, etc.) on specific research projects. Those who hold this position regard an increase in the size and diversification of research systems as a step towards the optimum. An opposing viewpoint, however, maintains that research organizations become increasingly difficult to administer and manage as they grow larger, thereby forfeiting some degree of efficiency and productivity.

Empirical evidence on this subject is conflicting. Schultz (1971) and Evenson (1971) both lean toward economies of scale, especially the association of experimental stations with research-oriented universities. By contrast, Kamien and Schwartz (1975) and Schmookler (1966), as quoted by Ruttan (1978), indicate that productivity — measured by number of patents per researcher — is lower in large laboratories than in small ones. Support for this viewpoint, specific to the agricultural sector, can be found in Pound and Waggonar (1972).

As far as external considerations with a bearing on optimum research system size, Binswanger (1978) has argued that the situation should be analyzed from the perspective of the profitability of research investments; a profitability which is clearly related to the area of impact covered by the research in question.

For the purposes of this discussion, we believe that the minimum, rather than optimum size of a research system provides the best basis on which to judge whether or not the system is receiving adequate resources. This focuses discussion of resources on the question of how much can be achieved with what is currently available.

The minimum operating requirements of a research system cannot be assessed in the abstract. They depend not only on technical questions, but also, importantly, on institutional considerations. The latter include the mandate which the research organization has to fulfill, both in terms of products and regions. The minimum scale of operations will also be affected by the type of problem to be researched, as well as by the possibility of using information generated for other purposes or available internationally. It is vital to stress, however, that the capacity to apply research findings from abroad cannot be divorced from the capability for performing original research.

Evenson and Kislev (1975) estimated that a low-income country with average research capabilities could obtain US$55,000 of benefits from US$1,000 of research performed in other countries located in a similar geographic and climatic zone. For a country with no indigenous research capability, however, the benefit only would be US$1,700. This clearly demonstrates the importance and need for achieving and sustaining minimum levels of investment and expertise in national agricultural research organizations.

The objective of this paper is not to expound at length for the minimum scale needed for a research system to work properly. This is a topic which we lack the background and information to pursue in depth. Consequently, we would be overreaching ourselves to discuss seriously whether or not budgetary resources are adequate from this standpoint. Given the importance of the issue for proposing reinforcements to national research systems, however, we believe it is appropriate to touch on the subject briefly in an attempt to assess current and potential capabilities for maintaining a minimum research module.

Table 5 gives an estimate of maintenance costs for a minimum research module for a single product. If this estimate is compared with current research budgets in U.S. dollars (see Appendix 1), we find that only the larger countries in Latin America appear to be in a position to finance a broad coverage (multi-product) research infrastructure. This opinion is wholly confirmed if we analyze the situation for specific commodities, taking the figure of 1% of their production value as a basis for investment in research. Appendix 2 presents production values for six basic commodities from Latin America and the Caribbean: wheat, rice, corn, potatoes, cassava, and beans. Of the 114 value data presented, only 40 were sufficient to cover (at 1%) the costs of the minimum research module in Table 5. Oram (1977), analyzing national capabilities for funding research programs of different sizes, on the basis of land surface area under different crops, reached a similar conclusion.

Topics for Discussion

Our observations on the magnitude of investment in agricultural research in Latin America suggest two broad areas for discussion.

The first is exploratory: to look into why there is underinvestment in agricultural research despite the high rate of return. An important point to consider is the possible influences exerted by sources of funding by the nature of the mechanisms through which financial resources are channeled into research organizations. Several authors have suggested that one of the difficulties faced by agricultural research organizations in their efforts to obtain higher budgets is the long-term nature of their research activities. It is this which places them at a disadvantage in the eyes of political decision-makers when investment in agricultural research is weighed against alternatives that produce results more rapidly. Discovery of ways to help agricultural research compete for investment funds is an important prerequisite for reinforcing the operating capabilities of national research systems.

The second topic for discussion involves the apparent absence in many countries of the region of the economic capacity to make research investments. In this connection, we should consider the validity of the concept of minimum research infrastructure and we should also examine how international reciprocal cooperation might contribute to overcoming national constraints.

Table 5. Estimated cost of a minimum research module for one product[1] (in thousands of current U.S. dollars).

I. Direct research costs (60% of total budget)			US$ 306
A. Personnel		245	
1. 4 chief researchers, M.S. or Ph.,D. 3 person/years in plant breeding, agronomy and pest and disease control and 1 person/year equivalent in socioeconomics and other specializations, according to requirements (soils, physiology, etc.). Total cost per person/year[2] US$30,000	120		
2. 8 specialists, university graduates. Total cost per person/year US$12,500	100		
3. Training Calculated on the basis of 2x1 rate of retention; total rotation every 15 years; cost of US$100,000 per Ph.D. (M.S. 60%) Total annual cost for a permanent team of 3 Ph.D. and 1 M.S. (approximately).	25		
B. Services and materials Calculated as 12.5% of direct costs.		38	
C. Equipment Calculated as 7.5% of direct costs.		23	
II. General Costs and Administration (40% of total budget) Includes direction, support and services (administration, laboratories, library, communications, field, etc.).			204
A. Personnel Calculated as 60% of general and administrative costs.		122	
B. Services and materials 25% of general and administrative costs.		51	
C. Investments and equipment 15% of general and administrative costs.		31	
Total Budget			510

Percent summary by broad budgetary items (approximate)

A. Personnel	72.5%
B. Services and materials	17.5%
C. Equipment	10.0%

[1] The estimates were made using the budgetary structure of the international agricultural research centers as a guideline for determining the percent of each item of expenditure.

[2] US$30,000 was used as an average of the case for the different countries of the region. The sum includes salaries plus benefits. A variation of US$1,000 above or below this average figure implies an increase or decrease of US$4,250 in the total budget.

Public vs. Private Financing of Agricultural Research: Implied Economic Forces

Budgetary resources for research have evolved over time. Increasingly nowadays, funding schemes are being tied directly either to the users or the beneficiaries of new technological findings.

The central issue relating to private sector financing of research is the extent to which a proportion of the economic benefits derived from the use of new technologies can be appropriated for financing discovery costs. This proportion, which ideally must be large enough to cover all research costs incurred, will depend essentially on the nature of the findings or products emerging from the research process, and specifically on their economic characteristics. Here it may be helpful to examine two closely related questions: (a) whether or not projected research findings are likely to have an economic value; and (b) whether or not this economic value can be appropriated by specific economic sectors.

The Economic Value of Agricultural Research

In conceptual terms, all findings or products of the research process have a potential economic value. Certain intrinsic characteristics, however, will determine whether or not given results have a real economic value in the marketplace that can be translated into a price. In general this value is associated with whether or not research findings can eventually be incorporated into physical inputs and capital goods.

It is the nature of physical inputs and capital goods that they can be bought and sold and may be protected by patent and copyright laws which entitle the holders of official rights to exclusive use. Thus a proportion of the economic value generated by new technology can be transformed into private benefit through concessions in the form of patents and the receipt of royalties, or through the pricing system itself.

The findings of basic scientific research and of research and development activities oriented toward improving productive processes, agronomic practices, and management do not offer the same possibilities for private appropriation of the economic value generated through their use.

On the whole, new scientific research findings are useful for highly diverse situations and problems and have no direct application to productive processes. This makes it difficult to determine their economic value. These findings and information are difficult to patent; their use is practically cost-free. In this context scientific research findings are public goods, and no economic agent can exclusively appropriate the economic value generated by them. Added to high investment costs and the uncertain nature of research processes, this means that such activity can only be of interest to the private sector under special conditions. "Public goods" are those that, once they become available, can be enjoyed by anyone whether he contributed to their provision or not; their essential characteristics are that they are enjoyed but not consumed and their benefits are derived without any act of appropriation. (Steiner, 1977).

By contrast, research findings related to organizational, methodological, agronomic, and management practices are generally tied to specific productive processes. Consequently, it is possible to determine precisely what economic benefits will be derived from their use, and thus to attach an economic value to them. Nevertheless, because of the difficulty of framing policies of exclusion for the use of these findings, the possibility of these benefits accruing only to those who generated them is reduced substantially. Thus, this type of information also has the characteristics of a public good just as the findings and scientific principles discussed above.

As a result, the private sector is interested primarily in research activities that have to do with commodities and/or inputs. Part of the economic value generated by this type of research can easily be appropriated and investments can, therefore, be recovered. Other research activities are less attractive to profit-seeking investors; they are likely to receive private sector attention only in specific institutional settings as discussed below.

Risk, Level of Investment, and Private Interest

The general assertions about the economic value of research presented above may be altered by certain specific characteristics of the research processes associated with different types of output. This is particularly true for the risks involved in obtaining results and in recovering investments.

The probability is uncertain that certain types of research will ultimately produce results of economic value. This would be true, for example, of preliminary research for exploring ideas and approaches that have intuitively practical implications for solving production problems. In other situations, such as research for generating know-how and methods for preventing the occurrence of some given event, uncertainty stems from the impossibility of determining when the output might be used in such a way that the investment can be recovered. This uncertainty has a negative effect on private-sector willingness to assume the risk of funding the research.

Other basic factors related to the interest and likelihood of private-sector participation in funding research activities are the magnitude and complexity of the required investments and the scale of potential application of the findings. Certain types of research require a critical mass of physical and human resources that can be provided only by the public sector. The scale of application of research findings has a substantial impact on the rate of recovery of research costs and, consequently, on the extent to which the private sector may be interested in advancing funds. If new technologies have a broad field of application, benefits will be greater and/or recovery of initial research and development costs will be faster. As a result, investments will be more profitable. Regardless of the economic nature of specific research outputs, the private sector is likely to have limited interest if the application of findings is too narrow to ensure profitability.

In the final analysis, however, the choice between public and private financing depends not only on the characteristics and nature of participated research findings, but also on the economic and political contexts in which the research unfolds. The possibility of private participation will be greater in larger countries with more homogeneous production situations. This further underscores the problems discussed above. It is also clear that certain models for organizing economic activities, such as multinational initiatives, offer much broader alternatives than those which are limited to the national context. These considerations form plausible hypotheses for explaining differences in the degree of private sector participation in agricultural research in different countries and they explain the dynamic activity of multinational enterprises in this area.

Topics for Discussion

Private participation opens an array of possibilities for achieving budgetary increases to support agricultural research. Nevertheless, such participation, far from universal is closely tied to certain types of research and production situations that have the potential for adequate returns on investment. Furthermore, the interest and capability of the private sector to participate are closely related both to the state of progress of scientific development and to the nature and degree of economic development (presence and extent of technological input markets) in any specific research setting. In this connection, there are two key questions: To what extent can private financing replace public funding? Can a research system exist that obtains its financing exclusively through the market, — that is to say, is a system feasible where those who benefit from the research bear the brunt of its funding?

The major point for consideration in discussing these questions is the closeness of the ties that bind together the different types of research involved in the process of developing new technologies. Adequate financing mechanisms must be able to ensure that all these types of research can be undertaken, otherwise, the potential of the total system for generating concrete technological answers to production problems will be drastically reduced.

Is It Possible to Develop Mechanisms Through Which the Beneficiaries Fund the Research?

In the previous section we identified the economic characteristics of different types of research and their implications for research financing. The possibility of private-sector participation in funding certain types of research was indicated, particularly those types related to technological advances where private appropriation of benefits would eventually be possible.

In this section, we will evaluate such private-sector funding, analyzing the institutional mechanisms needed to make it work. Discussion will first deal with those processes through which research produces benefits and the principles that guide the distribution of those benefits among different economic sectors. It will then move on to the limitations and real possibilities of having potential beneficiaries pay for research costs.

Economic Sectors Participating in the Distribution of Agricultural Research Benefits

Broadly speaking the benefits of research consist of increased economic surplus as the result of production cost reductions through technical change. This process takes place through a shift to the right in the supply curve for the commodity under consideration, thereby permitting reduced production costs and increased consumption levels. Both the reduction and increase imply rising levels of economic activity and, consequently, the greater well-being of society.

The distribution of research benefits is shown in Figure 1(a). Line AD is the demand curve, and line CO is the supply curve before technological change. In this situation, Q1 is the quantity being produced for price P1, and the total economic surplus consists of area ABC. (It is assumed that the demand curve reflects the commodity's marginal utility for consumers; and the supply curve reflects the marginal opportunity cost of resources used in production). Technological change displaces the supply curve to CO', generating a new equilibrium situation with a higher quantity Q2 and a lower price P2. In the new situation, the economic surplus is AFC, and area CBF is the net increase in the surplus produced by technical change.

The economic surplus generated by research through technical change is distributed among five different economic sectors.

1. Consumers
2. Agricultural producers
3. Landowners
4. Producers of technological inputs (hybrid seed, machinery, fertilizer, agrochemicals, etc.)
5. Rural workers.

The proportion of total benefits from technical change that accrue to each sector depends on the shape (basically, the elasticity) of the supply and demand curves, the type of technology involved, and the structure of the market for inputs and products.

From the point of view of appraising alternative methods of research funding there are three distributive conflicts that should be considered:

* between producers and consumers
* between producers and manufacturers of technological inputs
* between producers (as entrepreneurs) and landowners

Between producers and consumers. This conflict concerns what proportion of the economic surplus flows toward the consumers in the form of lower prices and higher consumption, and how much is obtained by the producer sector. Given a supply situation (changes), the distribution of any surplus will depend on the elasticity of the demand curve for the commodity in question. When the demand for the goods is more elastic (inelastic), price changes produced by supply increases are smaller (greater) and the benefits to consumers are greater (smaller) than those to producers.

Between producers and manufacturers of technological inputs. The crux of this equation is the ability of those who produce the inputs to protect the know-how embodied in their product through patents, brands, or other mechanisms of exclusion for the use of the inputs. If this protection is possible, input suppliers obtain a certain degree of oligopolistic power which becomes monopolistic in the extreme case of total protection. Under such a market structure, suppliers have the leverage to set input prices above production costs, thus securing for themselves part of the surplus generated by the use of their input in the productive process. Through this process, part of the surplus obtained by farm producers will be transferred, via higher input prices, to producers of inputs. Input prices, which are higher than those that would prevail in a perfect competition situation, limit the adoption of the new technology and the total surplus generated by technical change thus falls short of meeting its full potential.

Briefly, when input producers are able to protect the know-how incorporated into their goods, the total surplus generated by technical change is less than when the new know-how can be used free of charge. Input producers are also capable of appropriating part of the production surplus. In a temporal context, however, the ability to appropriate surpluses depends on the effective capacity to protect new knowledge through patents and brands; in general, this capacity diminishes as the period of analysis is extended.

Between producers (as entrepreneurs) and landowners. Competition here is only relevant where producers do not own their land. Then the distribution of benefits between these two groups depends essentially on the impact of new techniques on the productivity of other production factors.

This, in turn, depends on the type of innovative technology in question and the relative availability of leading production factors: land, capital, and business skills. Because in most countries there are absolute limitations to land availability, benefits generated by technical change are appropriated by landowners through increases in the price of land.

How the Economic Surplus Generated by Technical Change Can Be Channeled Toward Research Funding

Three economic sectors must be considered when trying to determine how to divert economic surplus to research funding: consumers, input producers; and agricultural producers, including landowners.

Consumers are usually the major beneficiaries of technical change processes. From an institutional standpoint, however, they are the most difficult sector to involve directly in research funding. The sheer number, dispersion, and poor organization of consumers are major drawbacks. So is the minimal size of the benefit that accrues to each individual consumer. Another difficulty is that consumers seldom relate benefits (lower prices, better product quality) to technical change and research. The sum of these arguments means that as far as consumers are concerned the surplus needed for research funding must be obtained through indirect mechanisms.

As for agricultural producers, it is more feasible to channel towards research funding the surplus generated by technical change which they enjoy. Here too, however, we encounter considerations similar to those that impede direct consumer contributions. The major problem is the relative difficulty of demonstrating the exact relationship between research, technical change, and economic surplus. Consequently, producer enthusiasm for research activities has remained rather low, with interest flaring up largely in crisis situations, for example, pests or drought. Producers' lack of commitment to agricultural research has on occasion been used to justify indirect mechanisms traditionally adopted to raise funds. Over time, economic surplus generated by technical change generally accrues to higher land prices. Thus, land taxes appear to be a legitimate mechanism for redirecting surplus toward research.

Other alternatives for obtaining part of the economic surplus generated by technical change are also available. These, however, depend both on the nature of the markets in which production is sold and on certain characteristics of the economic and institutional structure of the agricultural sector.

The fund-raising strategy of INTA in Argentina demonstrates an awareness of such dependency. Because a considerable percentage of national agricultural production goes to the foreign market, the agricultural sector contends with highly elastic demand. Any shift in supply primarily benefits the producing sector. In this economic setting, an export tax serves to capture part of those benefits. INTA's budget draws largely on export taxes. This same type of economic alternative is feasible in economies with a broad potential for import substitution. In such a situation, expansion in production has no substantial impact on domestic prices and the producing sector captures the benefits of technical change.

Another example of direct financing occurs when institutional formats bring together different groups or subsectors of agricultural producers, thus facilitating an awareness among them of the importance of research and its instrumental contribution to the generation of economic surplus. Awareness paves the way toward institutionalization of direct financing mechanisms, as FEDERACAFE and CENICAKAPÑA in Colombia, and CEPLAC in Brazil illustrate. These organizations appear related to certain characteristics of the products which they produce, to the degree of regional concentration of production, and to the homogeneity of the producing sector (Piñeiro and Trigo, 1983).

Direct financing may take the form of specific taxes for research or allocations from promotional funds, fed by taxes or direct producer contributions. It provides better opportunities than national agricultural research institutes do for establishing ties between producers and research.

In this context, we would like to mention the experience of the Regional Consortia for Agricultural

Experimentation (CREA Groups) in Argentina and other Southern Cone countries. Their producers participate directly in the dissemination of new technologies by setting up producer groups which fund technical assistance and horizontal exchange of technology. On occasion, they also participate in testing and adapting technologies to the specific conditions of each producer group (especially for agronomic and management practices).

Any discussion of the economic consequences of research for the producers of technological inputs must distinguish between two situations essentially related to the nature of the input markets involved. In the first situation, if markets operate under standards of perfect competition, research costs are reflected in the input supply curve and are passed on through prices. The magnitude of the increase depends on the shape (elasticity) of the demand curve. Increases in input prices reduce the level of adoption and the technical change will produce a smaller surplus than if the research had been conducted by the public sector. Under such circumstances an alternative financial mechanism is that of research subsidies to prevent research costs from being added to input prices. The advisability of such a system must be assessed by comparing the magnitude of needed subsidies to surpluses that would otherwise be lost through higher input prices.

A further point to be considered, although not one directly related to the appropriation of surplus, is that this research subsidy mechanism might facilitate the decentralization of certain phases of the process of developing new technologies. Decentralization would mean greater competitive potential and perhaps keep researchers more closely in touch with the problems and needs of the production process. An important topic for discussion here concerns policies on brand names and patents for technologies developed under subsidy, for the possibility of taking out a patent would incorporate imperfections into the market by allowing input manufacturers to raise their prices in order to recover part of the economic surplus generated by technical change.

The second situation that we need to consider involves input markets which operate under oligopolistic or monopolistic conditions. Here, input prices do not respond to production costs or to research and development costs, but instead are determined by the degree of exculsive central exercise by the producing firm. Subsidy mechanisms are of limited use. The alternative is to establish taxes based on the economic benefits (earnings) of enterprises. This would make it possible to recover part of the surplus appropriated by the producing enterprise, without total loss of the surplus resulting from higher input prices.

A final consideration relevant to how the economic surplus generated by technical change can be channeled toward financing research relates to the long-term nature of research. While research costs must be met in the present, research benefits materialize in the future. The temporal dissociation between financial requirements and research impact is generally associated with the usual limits of political support for research. Traditional research financial schemes, based on public funds (annual allocations from the national budget) mean, in effect, that income from today's taxpayers is being forcibly extracted to subsidize future generations. An alternative would be the use of medium- and long-term credits to finance research. Those who actually benefit from new technology would then assume the costs of generating it. Such a credit system, however, would intensify one of the problems already plaguing research in Latin America: there is too little contact between those who use new technological discoveries and those who select research priorities. Indeed, financing through credit weakens the ties between research organizations and research users; it also complicates follow-up studies on the effectiveness and relevance of the innovation process.

Topics for Discussion

Lack of budgetary support for agricultural research is frequently attributed to its long-term nature and to the difficulty beneficiaries have in linking research investmens directly to research benefits, whether in the form of higher production, better products, or lower prices. As a consequence, agricultural research has had to rely on traditional funding mechanisms, most commonly on direct allocations from the national budget. This approach, however, has not proven sound for obtaining stable budgetary support. The persistent economic crises beleaguering many countries in recent decades, and poor ties between research organizations and research users erode the dependability of traditional modes of financing.

In recent times, discussion of these issues has gravitated increasingly towards the forging of stronger relationships between researchers and research users as a solution to funding problems. The positive experiences of specific agricultural research organizations such as those for coffee and sugar cane in Colombia, and cocoa in Brazil, have contributed to growing interest in alternatives for financing research.

This paper has analyzed such alternatives by examining the processes through which different types of research generate benefits, and the economic and institutional mechanisms available for converting part of these benefits into substantial financing for research activities. The analysis has shown, however, that for purposes of implementation, the concrete possibilities we can identify for appropriating benefits as research financing are not generic. In most instances, possible funding mechanisms are related to characteristics of a specific type of research, commodity or institutional organization in the agricultural sector, or to a specific production situation. What we need to consider, therefore, are the validity of indirect fund-raising mechanisms (for example, specific taxes or credits), the feasibility of implementing them under different circumstances, and the reliability of various institutional formats for exploiting this financial potential without altering either the long-term objectives or the productive capacity of the technological system. We cannot dissociate this last point from the issues discussed in the previous section regarding different types of research and the necessary interrelationships among them.

Operational Alternatives: Institutional and Project Funding

In Latin America the basic funding mechanism for agricultural research has been functional at the institutional level: resources are apportioned to support a research organization, in accordance with the budgetary needs of its operations and overall research program. Several countries have been introducing modifications in recent years that incorporate project funding schemes. In such schemes, funds are allocated to researchers or research teams on the basis of specific research proposals. Both the basic funding mechanism and this increasingly popular alternative have advantages and disadvantages in administrative and in managerial terms, as well as profound long-term implications for research priorities and institutional organization.

Advantages and Disadvantages of Funding Options From the Point of View of Resources Available for Research

Institutional funding involves fewer administrative costs per unit of resources used for research (Ruttan, 1982). Similarly, this format minimizes the time researchers must spend obtaining funds to support their projects (Bredhal, Bryant, and Ruttan, 1980).

The major advantage of project financing, on the other hand, is the way in which it increases an institution's ability to mould research programs to the needs of specific users. Consequently, project funding enhances the possibility of maintaining better, more direct ties with users. This format can, therefore, help eliminate barriers between research institutes and the production sector, barriers which help account for the lukewarm political support that has affected research in recent times. At the same time, the greater flexibility of the project-funding system is important for attracting specific resources that would otherwise not be channeled into research, also for harnessing the research capabilities of organizations not oriented towards research as a high priority activity, but which, nevertheless, have human and institutional resources useful for developing this type of activity. In Latin America, this is a particularly important possibility for universities, given their large contingents of human resources and lack of budgetary support needed for incorporating research effectively into their educational activities. In certain respects then, project financing permits a freer flow and better use of certain resources than institutional funding does. It does not appear to be as effective, however, for assuring the development of certain types of basic research, or the persistence of long-term programs in specific areas. Concrete examples bear out this contention and suggest that institutional financing schemes have special advantages in assuring systematic research coverage. Consider, for example, the funding of coffee research in Colombia and Costa Rica, cocoa research in Brazil, rubber research in Malaysia, and the experiences of the international centers financed by the Consultative Group on International Agricultural Research (CGIAR).

Finally, research programs in systems that depend primarily on institutional support tend to be hermetic and self-pertuating to a high degree, a phenomenon that has been identified as a main cause for the loss of contact with user groups. The greater flexibility of project

financing facilitates the introduction and incorporation of new areas of scientific and technological interests, counteracting any "geriatric" tendencies in the institute concerned and orienting research more intensively towards solving production problems.

Long-term Effects of Funding Alternatives on Research Priorities

Choice of funding systems is likely to bear important implications for the composition of an institution's research package and the organization of its research system. These implications derive from how different funding systems involve different points of decision-making about research priorities. In the case of institutional funding, such decisions are made by the research organization itself which submits a comprehensive program of proposed activities to the central government. The government then usually allocates funds without analyzing research priorities or needs, but purely on a basis of overall fiscal considerations. In the case of project funding, however, decisions about what research will be carried out are largely a perogative of the funding source.

This difference has a decisive impact on the continuity of research programs and on the possibility of ensuring a proper balance between different types of research and/or the needs of different clientele groups. With institutional funding, such continuity balance is ostensibly achieved through the processes of planning and allocating priorities for the agricultural sector. Formally, these processes are the responsibility of external planning agencies but, in practice, research institutes have considerable independence in decision-making (Piñeiro and Trigo, 1982). This has made it possible for them to maintain a certain continuity in their research programs, even though in too many cases their course may have diverged from national priorities in general, from agrarian policies in particular, and from the priorities of users.

The use of project funding decentralizes decision-making about research priorities. It, therefore, introduces a need to develop alternative mechanisms for maintaining consistency among research programs and for keeping them relevant to overall policy objectives. The current trend toward the establishment of National Research Councils recognizes this need. Such Councils provide an appropriate framework for coordinating the full array of research activities in the national system and for striking a balance among various types of research and the needs of users.

Topics for Discussion

The inadequacy of budgetary support that haunts agricultural research in Latin America and the Caribbean has been attributed to different causes. These include the economic restrictions and fiscal crises seemingly endemic to the countries of the region and the common notion of politicians and consumers alike that agricultural research activities are sluggish, ineffective, and unrelated to production problems.

These difficulties, especially those involving the public's perception of research, may derive from certain characteristics of existing institutional models for the generation and transfer of technology. These models have tended to minimize contact between researchers and clientele for specific technology. Instead they have favored centralized institutional schemes designed to make more efficient use of comparatively scarce available resources.

Developments in recent times indicate that if new flexible schemes for financing research can be more widely introduced, such as project funding, for example, then research programs might be streamlined and the resources available for agricultural research might even increase. At the same time, the use of these mechanisms, it must be conceded, introduces the risk of disintegration of the research system in the agricultural sector and loss of the capability to embark on long-term programs in pursuit of comprehensive objectives for scientific and technological development.

The central issue, therefore, is how to incorporate the advantages of a competitive mechanism such as project funding, while maintaining the capability of the overall system to embark on long-term programs. In the light of recent experiences in the region, the main topic we wish to suggest for discussion is how we can achieve institutional alternatives that would both allow this balance to be maintained and permit current organizational structures to be adjusted while the chosen alternatives are put into effect.

Summary and Closing Remarks

The problems of funding agricultural research in Latin America are embodied in two closely interrelated issues. The first involves the amount of budgetary support forthcoming during the past 20 years. The second involves the nature of the mechanisms through which allocated funds flow into research activities.

The agricultural research budget for the region as a whole has expanded dramatically in the last two decades. Yet, the picture varies strikingly in different countries. In some, budgetary growth in the 1960s gave way to stagnation, even collapse in the 1970s. Extreme year-to-year variations also have characterized recent agricultural research budgets in a number of countries.

When the budget situation in Latin America is compared with that elsewhere in the world and the profitability of investment in agricultural research is considered, the conclusion is inescapable that the region is underinvesting. Moreover, once budgets are compared with the requirements of a minimum research module, it becomes clear that in all too many Latin American countries, the financing made available is inadequate to maintain an agricultural research infrastructure with any realistic chance of success.

The challenge that emerges from this analysis is how to obtain larger, more stable budgets for the better development of research activities.

Traditionally most agricultural research has been a public-sector activity funded through a national research institute by an annual allocation from the national budget. This has placed agricultural research in direct financial competition with other public-sector activities. In view of growing fiscal deficits in many Latin American countries, and given the predominantly long-term nature of agricultural research activities, the competitive situation has meant a loss of budgetary support for research. The rise of alternative methods of funding agricultural research, such as financing from specific private sources and project funding may, perhaps, be interpreted as responses to this unsatisfactory situation, responses which, at least in theory, promise to be able to provide some remedies.

Participation of the private sector in financing agricultural research augurs well for increasing and stabilizing budgetary support. Yet, certain matters must not be lost sight of in designing financing mechanisms for the technological system as a whole.

In the first place, participation of the private sector is usually confined to certain types of products and specific institutional situations, for example, export goods and commodity organizations. For this reason, public participation remains indispensable for maintaining a proper balance in efforts to supply new technological know-how.

In the second place, private participation is partial to certain types of agricultural research, applied and adaptive, and to activities closely related to the development or improvement of inputs, capital goods, and in general, technologies for more economically developed sectors. As a result, public participation assumes great importance, both for providing services to the small farming sector and for maintaining the overall productive capacity of the technological system.

Project financing mechanisms offer greater flexibility for adapting research to the conditions and needs of users. Consequently, they are a better vehicle for connecting users to research organizations; a relationship inadequately developed by most systems that receive institutional financing. Indeed, a short circuit between researchers and prospective clients is regarded as one cause behind the decline in political and budgetary support for agricultural research.

It is important to realize that financing schemes based on project funding may well fragment the capacity of a research system. There schemes hinder long-term research programs, especially for basic research. They also tend to interfere with the setting of research and development priorities which confirm to national objectives for overall development.

There is no doubt that private participation in project financing may help improve the level and stability of financing for research activities. It is clear, however, that private participation cannot replace public funds. Project funding does not eliminate the need for effective institutional financing. The central thesis of this paper is that the funding of agricultural research institutions should be designed to make use of the advantages of both public and private schemes. The end result should be a research package that maintains a proper balance among different types of research, sensitive to the diverse technological needs of the many research users in the agricultural sector.

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APPENDIX I: Latin America and the Caribbean: Budgetary resources for agricultural research in 1980.

Zone and country	Budgetary resources (US$1,000)
Northern Zone	
Costa Rica	2,083
El Salvador	2,875
Honduras	979
México	66,155
Nicaragua	1,815
Guatemala	5,785
Panama	2,255
Caribbean Zone	
Barbados	901
Haiti	290[1]
Jamaica	770
Surinam	248[2]
Grenada	206
Guyana	419[3]
Trinidad and Tobago	771
Dominican Republic	2,336
Andean Zone	
Bolivia	3,292
Colombia	2,610
Ecuador	6,857
Venezuela	39,171
Perú	4,355
Southern Zone	
Argentina	152,410
Brazil	142,317
Chile	12,866
Paraguay	6,547
Uruguay	847

[1] 1978
[2] 1973
[3] 1977

Sources: Oram and Bindlish (1981); Piñeiro and Trigo (1983).

APPENDIX 2: Production value of wheat, rice, corn, potatoes, cassava and beans for countries of Latin America and the Caribbean — average for 1950-1980 (data in thousand U.S. dollars).

Zones and Countries	Wheat	Rice	Corn	Potatoes	Cassava	Beans
Northern Zone						
Costa Rica	—	59,332	9,639	2,775	3,586	7,873
El Salvador	—	16,526	54,740	1,332	2,527	23,352
Honduras	147	9,128	42,126	555	1,712	23,908
Mexico	397,929	156,480	1,097,180	83,916	5,151	479,828
Nicaragua	—	21,842	23,443	222	3,847	29,079
Guatemala	7,644	10,758	97,818	5,550	1,891	42,256
Panama		59,658	8,330	1,221	6,520	2,129
Caribbean Zone						
Barbados	—	—	179	—	163	—
Haiti	—	37,164	22,372	888	32,682	26,132
Jamaica	—	1,304	1,309	1,221	3,423	—
Suriname	—	—	—	—	—	—
Grenada	—	—	119	—	—	—
Guyana	—	—	—	—	—	—
Trinidad & Tobago	—	—	—	—	815	—
Dominican Republic	—	106,602	5,355	2,664	28,574	21,217
Andean Zone						
Bolivia	8,350	33,904	38,437	84,582	44,499	1,112
Colombia	6,659	545,398	98,770	197,469	343,115	41,700
Ecuador	5,954	109,536	28,203	44,955	49,389	15,568
Venezuela	147	167,564	82,467	21,423	58,517	25,576
Peru	16,905	166,912	73,780	184,371	68,297	30,580
Southern Zone						
Argentina	1,198,050	101,386	925,582	175,824	35,860	101,748
Brazil	374,556	2,749,810	2,055,963	212,343	4,111,512	1,177,608
Chile	120,687	36,838	41,293	89,910	—	32,820
Paraguay	4,998	20,212	51,884	666	280,360	31,136
Uruguay	49,333	75,958	16,898	15,207	—	1,573

Source: Compiled on the basis of data from FAO production yearbooks using average national and international prices during the years 1975-1980.

Note: A hyphen (-) means that data were not available or did not exist.

CHAPTER SIX: International Cooperation in Agricultural Research

Eduardo Venezian L.
Director of the Postgraduate Program in Agricultural Economics
Catholic University of Chile

It is widely acknowledged at the present time that the solution to world food and rural development problems depends largely on agricultural research. Farmland is becoming scarce throughout the world. Growth of agricultural production and income must come increasingly, therefore, from the higher productivity of resources employed in agriculture. It is not surprising then to observe a mounting interest on the part of international organizations and development agencies based in industrial countries to encourage and support agricultural research on a worldwide basis.

This interest has been reinforced by abundant evidence from economic analyses which show high social returns from investment in agricultural research, both in developed and in developing countries (Evenson et al., 1980).

International cooperation for agricultural research involves multiple objectives, disparate participants, and widely varied methods of action. The composite picture is a complex one. There are far-reaching, specialized international and regional organizations, such as the Food and Agriculture Organization (FAO) and other United Nations agencies, the Inter-American, African, Asian, and World Banks, and the Inter-American Institute for Cooperation on Agriculture (IICA). Additionally, there are the foreign aid agencies of more advanced countries: the United States Agency for International Development (USAID); the Canadian International Development Agency (CIDA); the International Development Research Centre (IDRC); the Swedish International Development Agency (SIDA); the United Kingdom Overseas Development Agency (ODA); and others. Finally, there are philanthropic foundations like Ford, Rockefeller, and Kellogg, multinational companies, and other private institutions that give international aid.

These three types of institutions assist agricultural research programs financially and/or technically. They act bilaterally or multilaterally, or else work in an indirect way as, for example, when financing international centers for agricultural research (the International Center for Improvement of Maize and Wheat (CIMMYT), the International Center for Tropical Agriculture (CIAT), the International Rice Research Institute (IRRI), etc.) We have had considerable experience with this kind of assistance which is well documented, even if rigorous evaluations of its effectiveness remain to be made.

Another form of international cooperation known as "horizontal cooperation," has been acquiring growing importance in recent years. Horizontal cooperation involves groups of developing countries working together in programs or organizations that entail a significant amount of mutual aid, without this collaboration curtailing in any way the contributions from outside bodies that such programs or organizations may receive. The institutional forms of horizontal cooperation for agricultural research have been labelled "international associations," to distinguish them from traditional international organizations (Venezian, 1982). Examples include IFARD, SEARCA, PRECODEPA, CONOSUR,[1] regional scientific agricultural and animal associations, and others. In general, these associations have a limited scope, are regional, far from rich, and their activities are not well known or documented. Nevertheless, it appears that sometimes they help strengthen national agricultural research, especially aspects not amenable to intervention by larger agencies.

Whatever form international cooperation or assistance may take, it implies decisions and the use of complementary national resources. Furthermore, international assistance necessitates administrative tasks which represent significant inputs for the research institutes of developing countries. The economic and administrative implications for national institutes are particularly important; while such cooperation demands active participation, it contributes little by way of foreign financial resources.

This paper is concerned with international cooperation from the perspective of the national agricultural research systems, or institutes, of developing countries. Special emphasis is given to horizontal cooperation because of its increasing prominence, particularly in Latin America, and because it influences the administration of research in developing countries more than assistance does from traditional international organizations.

[1] See the annex at the end of this paper for an explanation of the acronyms of international associations appearing in the text.

The following analysis and criteria of evaluation, however, are applicable to all forms of international cooperation. In this paper, the subject will be approached strictly from the point of view of recipient countries, omitting considerations specifically relevant to donor agencies or countries.

For purposes of evaluation let us consider international cooperation for agricultural research as an economic activity; an activity, that is, using resources and generating a product. In this context, international cooperation can be analyzed in terms of the inputs that it contributes to the research process itself, by how it thus influences research productivity.

In principle, it is widely accepted that the goal of cooperation is to increase the social returns from investment in agricultural research in developing countries.[1] The economic approach has the advantage of providing a frame of analysis that makes it possible to identify variables relevant to the problem and to apply explicit criteria that may help in decision-making. It is this approach which we will use to evaluate the implications of international cooperation for national agricultural research systems (NARS).

Because the mechanisms of international cooperation are diverse and complex, especially those of the comparatively little known horizontal cooperation, in the next section of this paper we examine different forms of assistance to the NARS of developing countries. We also present a model for classification and functional analysis that expedites the selection of institutional alternatives in keeping with the specific needs and conditions of developing countries.

This is followed by a discussion of the problem of evaluating international cooperation which introduces a conceptual model for guiding decisions on resource allocation in developing countries to cooperative programs for agricultural research.

[1] It is possible that in some instances aid provided by advanced countries has other objectives (e.g., political, social, or economic gain for the donors). These will not be considered here, for they fall outside the interests of national agricultural research systems.

Finally, we draw conclusions from the preceding analysis, and suggest areas and forms of cooperation promising for future actions to strengthen the NARS of developing countries.

Modes of International Cooperation

National Agricultural Research and External Cooperation

International cooperation for agricultural research means collaborative work between developing countries, and international organizations or agencies from advanced countries, or shared efforts among all three. The aim of cooperation is to transfer resources, scientific and technical knowledge, and organizational know-how to the NARS of developing countries effectively with the ultimate purpose of strengthening them and raising their productivity.

Implicit in this definition of cooperation is that agricultural research on the national level is necessary and cannot simply be substituted for by importing knowledge and information from other centers. This fact is being emphasized increasingly by experts, who recognize that many agricultural problems and technologies are highly specific to a country or region (Schultz, 1979; Johnson, 1979).

Even if a large part of available scientific and technical knowledge can be transferred among countries, its effective use by farmers requires adaptation to local conditions of soil, climate, and other variables. Furthermore, dissemination of new techniques frequently results in difficulties at the local level which can only be overcome by further research.

On the other hand, modern agricultural technology, based on science and engineering, is complex. Its practice in a new setting can only be achieved successfully by well-trained professionals. All this requires the development of a national capacity for research. The extent and excellence of research systems may vary with conditions in each country, nevertheless, some type of indigenous research organization is essential in order to make effective use of modern technology and scientific knowledge in agriculture.

The creation of international agricultural research centers (IARCs), beginning in the 1960s, was a most significant innovation in the field of international cooperation; it

represents an important contribution by developed to developing countries. The existence of the IARCs, however, brings greater demands to bear upon the NARS. In fact, the present-day urgency of strengthening national institutes derives in large part from their centrality to the productivity of the international centers (Ruttan, 1982).

This situation has induced a certain reorientation of external aid, with a priority for supporting the outreach activities (extension or links with NARS) of the international centers. In an analogous manner, recognition of the need to reinforce the NARS has prompted creation of specialized organizations, such as the International Agricultural Development Service (IADS), sponsored by the Rockefeller Foundation, and the International Service for National Agricultural Research (ISNAR), funded by the Consultative Group for International Agricultural Research (CGIAR). It has also motivated heavy loans from international banks for the NARS of many countries.

Notwithstanding the results achieved in international cooperation during the last four decades, many problems persist. The world situation and political conditions, moreover, are not what they once were, making many strategies and policies of the past no longer relevant. In effect, newly independent countries have emerged, increasing global heterogeneity with respect to resources, levels of development, and human capital. The rapid technological and economic progress of industrialized countries has, at the same time, both opened up new agricultural possibilities and reduced the competitiveness of products from developing countries. Political attitudes in both groups of countries have changed, compounding the difficulty of trying to continue to carry out certain types of traditional collaboration. Furthermore, the amount of resources allocated for economic aid has been reduced significantly, and large international organizations have, for various reasons, lost some of their past effectiveness.

All of these developments suggest that maintaining active NARS will demand new ideas and approaches, with recipient countries called upon to play a more active and direct role. Horizontal cooperation through international associations thus acquires particular, timely interest in relation to agricultural research.

As a consequence of the diversity of developing countries, their problems, and concerned international agencies, there are many ways in which cooperation for agricultural research can be structured. In order to examine the relative effectiveness of alternate formats, it is convenient first to define both (a) the NARS, and (b) their main problems. It is, after all, the limitations and/or deficiencies of the NARS that justify current international action.

The national agricultural research systems

Agricultural research, as a formal scientific activity, is relatively new in developing countries, generally only having started after World War II. From its beginnings until a few years ago, the most important or sole agent of agricultural research has been a central national institute of public character. Such institutes have also usually been the principal national recipient of foreign aid for agricultural research. In recent years, however, other institutions have gained significance in the field of agricultural research. These now need to be considered components of the NARS as well. They have also been seen to play increasingly important roles in schemes of international cooperation for agricultural research.

Although it is not possible to generalize about a typical system — the heterogeneity of developing countries is too great — the following categories of institutions can at least be distinguished as common components of a national system.

Central national institute. With a network of centers and experiment stations, this type is usually the largest, best-staffed and funded agricultural research institution. Programs cover a broad spectrum of subjects and tasks, and research undertaken is as a rule of a long-term nature and has an applied, problem-solving orientation.

Decentralized or specialized public research institutes. These are similar to the central national institute in organization, but with narrower work areas, restricted geographical programs (e.g., state centers in Brazil), or specific crops (e.g., sugar cane, coffee, livestock) or problems (e.g., dryland agriculture).

Universities, colleges, and schools of agriculture. The degree to which these institutions actually engage in research varies greatly. In some countries their research function is significant. Usually, however, universities operate on a project basis, which means commitment to shorter-term, sharply focused studies of a theoretical rather than applied nature.

Farmers' organizations. In many countries, certain experiment stations or research institutions are supported by farmers' organizations. Links with the national research establishment are often informal and weak.

Industry-supported institutes. Large business or industrial concerns may occasionally run agricultural research institutes devoted to special crops (e.g., cocoa, malt, barley) or problems (e.g., seed improvement) of commercial interest to them. The results of their research do not necessarily become public. The effect on domestic agriculture and overall national research is fairly limited.

Private research institutes. Several developing countries have research institutes supported by private groups and foundations or run by individuals for profit. These may be of importance in restricted geographical areas.

As noted earlier, international assistance for agricultural research has been concentrated on supporting the first type of institution, the national agricultural research institute. Nevertheless, at the present time international cooperation must take into account the whole national research system. In particular ways, such as the training and exchange of scientists, universities now play a crucial part. On the other hand, the increasing interest of the private sector in overall research and development (R&D) activities is penetrating to the agrarian sector. To make the most of the potential contribution of these various institutions to collaborative international programs, their input must be recognized.

Problems and Needs of National Agricultural Research Systems

The programing and management of foreign assistance, from the standpoint of donor agencies as well as recipient countries, is largely a function of the deficiencies and needs of the NARS. Depending on the nature of local problems, different forms of international cooperation will be more or less efficient in helping to solve them. A scanning of evaluation reports on the research systems of developing countries shows certain common major bottlenecks to performance and growth — not all of which are present everywhere:

* Undervaluation of research. Agricultural research is not sufficiently well understood and valued by its direct beneficiaries, farmers; it is even less appreciated by the general public. Policy-makers and governments reflect this undervaluation through the expenditures which they approve for national agricultural research. These are generally low, in relation to the agricultural GNP, but the lowest of anywhere, in fact, is in Latin America (Boyce and Evenson, 1975).

* Neglect of research results. For various reasons, research results often are not utilized, or they take a long time to reach producers. It may be that the recommended technology is ill-adapted to local conditions, or uneconomical. Whatever the reason, to the extent that findings are not implemented, the social payoff of investment in research is obviously lower than it might be.

* Weak communication within research systems. National research systems do not have a cohesive structure. Communication among institutions is weak. National programs may duplicate domestic or foreign research efforts, leave significant gaps, subside into routine, or fail to respond to changing situations.

* Inadequate program planning and design. Poor planning adversely affects the setting of priorities, drains staff motivation, and reduces a research system's sensitivity to farmers' needs.

* Scarcity of skilled management professionals. Research management, especially complex in institutes with outlying stations and dependencies, requires skilled specialized administrators. These are usually trained on-the-job. Frequent turnover, however, for reasons often alien to research, make it difficult to keep proven managers in responsible positions.

* Difficulty in training and retaining staff. Frequent complaints refer to the scarcity of highly trained staff available for agricultural research and the "brain drain" of qualified personnel away from the research system to other better paid activities. Opportunities for training researchers are limited, and reduction in international aid for fellowships has aggravated the skilled manpower problem recently in many countries.

* Shortage of funds. Although shortage of funds is practically always a problem in almost any research activity, in agricultural research there is acute underinvestment. Budgetary inflexibility and administrative procedures, moreover, far too often obstruct execution of projects.

* Weakness of the professional research environment. Given the relative newness of agricultural research systems in developing countries, it is not surprising that much remains to improve about the work environment; there is still too little professional stimulus, exchange of ideas, constructive criticism, academic incentive, and recognition — all essential elements for the efficient performance of researchers. The small size of many Latin American countries, or of their present agricultural research system, is a serious obstacle for developing a professional environment conducive to greater creativity and productivity.

* Problems of access to germplasm and other inputs. Restrictions imposed by various countries on the importation of genetic material and other elements required for experimentation often hamper their agricultural research system.

This range of basic problems, despite differences among regions and countries, constitutes a generally reliable map of areas where international cooperation can prove most valuable. It provides specific targets for improvement, useful for evaluating how different forms of international cooperation perform in terms of meeting the needs of NARS in developing countries.

The persistence of the problems noted above, even after years of assistance and efforts, testifies to the great need which remains for innovative ideas and approaches to international cooperation. In answer to this need, current programs of horizontal cooperation appear promising.

Format of International Cooperation

International cooperation for agricultural research can be divided in two categories, depending on the origin of the resources involved and the degree of multilateral participation by developing countries. The first category contains "traditional" international organizations, foreign aid agencies or foundations of industrialized countries, and various bodies which they have established, such as CGIAR. The second category consists of "international associations" (IA) characterized by a high level of horizontal cooperation among countries who are recipients of aid.

There is a large variety of IAs, many of them little known (cf. Appendix). Further discussion here of forms of international cooperation refers especially to this group of institutions and programs, drawing on the abundance of examples and experience which they have to offer.

Cooperation with traditional organizations, predominantly in the general context of agricultural development, has involved three distinctive alternatives: (a) counterpart professionals, that is, foreign scientists and technicians, have been sent to developing countries to collaborate with nationals in performing research; (b) institutional agreements have been signed, generally with universities of developed countries, in which donors undertake to provide a whole set of services for a collaborative program; (c) IARCs have been established (Ruttan, 1982).

The first two of these models predominated until the beginning of the 1970s. In addition to long-term visiting staff, they might include any of the following in their programs: consultants, libraries, equipment, new buildings, scholarships, administrative services, and operational funds.

With the advent of IARCs, cooperation has become indirect and multinational: assistance for agricultural research comes from various sources, is concentrated in the centers, and is not intended for the benefit of any one country in particular. Fundamentally, these centers are sources of new scientific and technological knowledge, as well as repositories of genetic materials. Unlike earlier models of international cooperation, however, they lack resources to donate to national institutions.

The decline of bilateral aid programs and ascendancy of multilateral ones in the past 15 years further emphasizes the importance of horizontal cooperation through IAs. IAs provide a valuable mechanism to channel part of the aid given by traditional organizations. In fact, to carry out their activities almost all IAs attract resources from traditional organizations.

IAs listed in the Appendix include the most important ones, those that have had or might soon have a significant role in agricultural research. Many have a wider scope of activities. In order to appreciate the nature of these associations and of their influence on agricultural research adequately, despite their heterogeneity, some generalizations about them are necessary. Suggested here is a classification of IAs based on convenient criteria, that might help decision-makers in developing countries make choices related to desirable forms of international cooperation.

Disparate criteria can be used to classify IAs: geographical area, government participation, degree of organization, financial sources (Venezian, 1982). Given the purposes of the present analysis, however, the most pertinent approach is clearly one that focuses on the objectives of various IAs and their modes of operation, with particular reference to agricultural research.

Objectives

In general, IAs are set up to achieve one or more of the following objectives. The acronyms of IAs listed in the Appendix appear in parentheses below to indicate associations which would include the objective in question among their primary goals:

Training. Trained manpower for agricultural research can be acquired either through academic degree programs (UWI, SEARCA), in which case education itself assumes the highest priority, or through special, less formal courses, usually associated with research or with other primary functions of an institution (CATIE, CIDIAT).

Research. When research as the pursuit of new knowledge is a primary goal, an IA may execute research itself in its own facilities (INCAP, CATIE), or execute research in cooperation with other institutions in their facilities (REDINAA, PCCMCA); or sponsor or fund research to be performed by external persons or institutions (SIECA, PRECODEPA).

Technical assistance. Provision of advisory and consulting services on agricultural matters can be done directly by an IA, or the association may serve as a clearing house to bring together those who offer and those who require such technical assistance (INCAP, CATIE).

Diffusion of information. An IA may facilitate access to or disseminate information. This information may be scientific, technical, economic, or in some other way related to broad areas of agriculture. It is not merely a question of publishing in-house research results.

Exchange of knowledge, professional discussion. The IA's task here is essentially to provide a forum for agricultural scientists, technicians, and policy-makers in recognition of the inherent value of the exchange of ideas (ALCA, AAASA, AAACU, PCCMCA). Any additional effects of these exchanges would fall under other objectives.

Coordination, planning, central administrative services. Some IAs are set up explicitly to facilitate coordination and joint planning to avoid duplication, to achieve a critical mass of manpower, to ensure proper control, and/or to administer collaborative agreements previously established (APCC, PROMECAFE, OIRSA, REDINAA).

Promotion or protection. Certain IAs, especially those organized around a specific commodity, theme, or problem, are primarily concerned with promoting, protecting, or otherwise fostering the interests of their subject. Fund-raising, lobbying, advertising, and public image campaigns are all directed to this single end (RGA, APCC).

In general, IAs pursue several objectives simultaneously. Many, it should be noted, do not have agricultural research as explicit objective. Even the actions of these IAs, however, influence agricultural research with varying degree of intensity.

For the sake of simplifying the complex picture presented by the multiple functions of IAs, let us now distinguish them according to the relative importance of agricultural research among their objectives:

* Agricultural research is a primary objective.

* Agricultural research is a secondary objective, or though not explicitly addressed, it is closely affected by the IA's actions.

* Agricultural research is only incidental to the IA's objectives and activities.

With this division in mind, we can more readily evaluate the performance or the potential of different IAs relative to their strengthening national agricultural research systems.

Modes of Operation

The set of organizational characteristics, methods, and actions which an IA develops to reach its objectives constitutes its mode of operation. Many combinations

are possible. Our purpose here is to identify a few that might help in assessing the role that can be played by IAs in advancing the cause of agricultural research.

An empirical examination of IAs suggests the following operational aspects might be of particular significance to our analysis: degree of institutional structure (legal statutes, official recognition, history, sources and stability of funding, physical infrastructure and personnel); definition and regularity of programs (ranging from formal plans subject to evaluation to ad hoc actions); and the mode of programs, procedures, and implementation (directly, through the IA's own set-up; through others by special agreements and with a minimum of own facilities; or working exclusively through meetings and mailings, without personnel or facilities).

Each of these groups of factors allows us to rank IAs in terms of the complexity of their organization and operation. In the interests of simplification, this ranking can be split into three main institutional categories:

1. "Executive" IAs: Fully-established agencies with regular programs carried out principally by themselves.
2. "Supportive" IAs: Fully-established agencies with regular programs carried out largely through, or by, other institutions.
3. "Coordinating/promoting" IAs: Medium- to loosely established agencies with less rigorous programs, carried out almost exclusively through their members or by other institutions.

In general, the power of IAs to implement their programs decreases from category 1 to 3, even if the same is not necessarily true about their degree of possible impact upon agricultural research at the national level.

Functional Classification of International Associations

Combining criteria related to objectives and to modes of operation in a double-entry matrix yields the classification scheme below. IAs from the Appendix have been entered in their respective categories.

Table 1: A Classification of International Associations by Objectives and Mode of Operation

	Mode of Operation		
Objectives	1 Executive	2 Supportive	3 Coordinating promoting
A: Research is primary	AVRDC CARDI CATIE ICIPE ILMA CIDIAT	SEARCA SAFGRAD PROMECAFE CONOSUR CODESRIA	IFARD PCCMCA PRECODEPA REDINAA
B. Research is secondary	OIRSA DLCOE	AGRINTER AIBA AIBDA	AACU,AAASA ALCA,ALPA ALEAS,AFAA CADI, COFAF UNICA,IAAE
C. Research is incidental	ALALC CARIFTA EAEC SIECA	AOAD SID	AAU,APCC IACO,CINDA (Commodity and producers associations)

Note: Appendix gives full names and descriptions of organizations designated here by acronym.

The IAs in row B should raise fewer expectations about their impact on research, for research is not their primary concern. Nevertheless, their effect may be significant where these IAs are concerned with limited aspects of research that happen to have broad applications. For instance, the IAs in cell B-1 provide incentives for research on pest-control, livestock, and plant diseases; those in B-2 deal with the question of accessibility and/or diffusion of agricultural, scientific, and technical materials, a service instrumental in both facilitating research by national scientists and making results widely available to others.

Similarly, the IAs in cell B-3, principally professional associations of agricultural scientists, provide the incentives and peer review that are basic ingredients of the positive environment for research often lacking in national systems. Indeed, the associations in this group might vastly increase their impact on national research systems; many untapped means are open to them, including more frequent research meetings and specialized workshops, prizes, honors, and publications. The effect of these IAs should be especially significant for the research systems of smaller developing countries, where the problem of scientific isolation is most severe.

Finally, the IAs in row C are only of interest to us because of the chance that at particular times or under certain circumstances they may support national agricultural research systems. SIECA in cell C-1, for example, a powerful and effective regional agency in Central America which had its heyday in the 1960s, has conducted or supported many studies, institutional development projects, research, and training activities which, admittedly indirectly, have benefited agricultural research. The EAEC in Africa, now defunct, once played a similar role.

In cell C-2, institutions like AOAD might influence research as part of their general activities of assistance to agricultural development. In cell C-3, IAs are typically promoting or lobbying agencies devoted to particular commodities and problems, for example, sugar, cacao, and rubber. These may seldom be concerned with supporting research as such, but such support may be a by-product of their campaigning efforts.

Large international organizations have been omitted from Table 1. They could probably best be classified in column 1. Yet given the multiplicity of their development

The analytical and programatic advantage of this approach is that it readily enables us to assess the potential and actual roles of IAs in strengthening national agricultural research. It also helps in devising strategies for tapping the resources of different types of IAs or for encouraging their efforts in proportion to their relative impact on, and effectiveness in fostering research.

Two hypotheses are implicit in the classification framework: the expected impact of IAs on national agricultural research should diminish as one moves from rows A to C; and from columns 1 to 3. In practice, significant departures from these assumptions may be found, however.

IAs in cell A-1 are formally well structured. With an important level of dedication to agricultural research, they should, theoretically, have the strongest positive influence on national research systems. Yet, this is not always so, for these very associations sometimes become substitutes for national institutions (particularly in the country where they are based), or compete with them for funding, scientists, and prestige. Such competition, as discussed later in this paper, usually takes place at the cost of the national system.

The IAs in cell A-2 should be next in effectiveness for strengthening national research systems. Actually, since they do not have the competitive element just noted, they may be even superior in this respect to IAs in cell A-1. Indeed, this kind of association will cooperate smoothly with national research systems, while its high degree of institutional establishment allows it to channel international aid efficiently.

Cell A-3 includes IAs that, though primarily occupied with research, are less structured than those in A-1 or A-2 and do not command sufficient resources or other means to have a strong or broad impact on NARS. In fact, an historical analysis would show the great volatility of institutions in this group: they may be easily created in response to a temporary problem, or by an energetic leader, but they vanish with similar ease. It is important to note, however, that this kind of IA may, in specific circumstances, be of great value in helping NARS to solve particular problems. The Central American Cooperative Program for Food Crop Improvement (PCCMCA), for example, the oldest IA listed in group A-3, has exerted a positive influence in Central American crop research for many years.

objectives and the complexity of their internal subdivisions, they would not be suitable for inclusion in the matrix unless their activities were broken down and distributed among the various cells where they belong. For a few such organizations, however, classification in the matrix would be simple and straightforward, as with the international agricultural research centers (cell A-1).

Outline for the Evaluation of International Cooperation

The Problem

International aid and cooperation for agricultural research, an activity that requires human and material resources, obviously entails a cost. International organizations and advanced countries do not entirely bear this cost; developing countries themselves must also pay for cooperation. The problem, concisely, is how to decide where, and for what purpose available funds will be used; how in other words, to allocate each dollar of international cooperation among the variety of possible alternatives discussed in the previous section, so as to maximize returns in terms of increased productivity from agricultural research in developing countries.

Donors, both countries and organizations, we must realize, like to behave according to their own will, so that recipient countries usually have only limited negotiating capacity to influence resource allocation. Particularly knotty problems arise in the case of international cooperative programs, or international associations in which participation implies a substantial financial contribution. How should a national research institute, for example, decide whether to take part in an international program? How should it determine what part of its resources to allocate to it? Although at times the estimated benefit/cost ratio may be substantial, thus making decisions rather obvious, on other occasions the matter may require careful, detailed analysis.

A Schematic Model of International Cooperation in Agricultural Research

Agricultural research can be thought of as a chain production process starting from certain human and material resources and a stock of knowledge. It generates new farming techniques and practices which, eventually, agricultural producers will adopt. Research is as a rule rather slow and protracted. The knowledge-generation process is likely to involve successive setbacks and loops, along which various partial results may be incorporated at different levels or stages. By its very nature, research is subject to a high degree of uncertainty. Its ultimate success depends on numerous factors, not all of which are easy to foresee or control.

In Figure 1, the basic elements of the research process occupy the center column. Here we should keep in mind that research is a response to a series of demands and supplies (Evenson, 1971). The needs of agricultural production generate a demand for new technologies and inputs, the creation of which requires new knowledge or biological materials; the need to achieve these in turn generates an upward demand until eventually basic research is undertaken. The opposite process is also to be observed: that is, the availability of new knowledge or materials induces their use to generate further knowledge or materials which ultimately result in new inputs or techniques of practical use to agriculture.

The main factors affecting agricultural research productivity are indicated in the right hand column of Figure 1. Qualitative aspects of primary resources for research are important: the talent and motivation of investigators, their work methodologies, the physical facilities, and equipment available to them. The organization of the national system of research, its size and diversity, the degree of access which it enjoys to information and scientific materials, the level of dialogue which takes place among professionals, peer incentives, the existence of esteem and public support for research — all these bear upon the results a system will achieve, within the constraints, of course, imposed by the initial resource endowment. In a more advanced phase of the process, feedback mechanisms are essential to ensure the relevance of research to farmers' needs and interests and, consequently, to increase the likelihood that they will adopt innovations.

Adoption of new technology will depend on the ability of the institutional organization to perform extension work, as well as on the responsiveness and skills of potential users. It should be noted that in the end the productivity of agricultural research (return on investment) is a function of how effectively farmers employ technology.

The schematic portrayal of agricultural research in Figure 1 incorporates in its left hand column the contributions that international cooperation has to offer; these appear printed alongside the phases of the research process to which they are relevant.

It should be reiterated that there is a demand for international resources throughout the various phases of establishing NARS as described earlier. For instance, in the early stages of the development of a national system, the kind of international support for agricultural research which developing countries require — especially the poorer ones — include such scarce basic resources as

	Principal Research Process	
		Conditioning elements of productivity
International Cooperation and Assistance		
	Resources: Scientist, support staff Stock of knoweledge, skills, Physical infrastructure, funds	Quality, talent, motivation Methodology of research Quantity and quality of material Resource
Physical Resources Scientists, Funds		
	Uncertainty	
Help in Institutional Organization and Administration		
	Basic research Applied research	
		Institutional organization Scientific exchange Access to information and genetic materials Scale of research activity Public support of research
Basic Research Methodology Reduction of Uncertainty of Research		
	Intermediate products New knowledge, techniques, Information	
Genetic Material and Intermediate Results		Administrative capacity for agricultural research
	Idem. Successive stages	
Scale Economies in Agricultural Research Multinational Programs	Final product: New inputs for production New production techniques Improved crops and improved	Feedback mechanisms
Evaluation of Agricultural Research Systems	Decisions of resource Allocation	Influence of users in decisions of research programs
		Level of human and material resources
	Transfer of technology	
Extension and Transfer of Technology		Management capacity of farmers Extension organizations
	Farm production	

Figure 1. Diagram of Agricultural Research.

visiting scientists, consultants in institutional organizations, and experimental station management. Later on, the contribution of genetic materials, intermediate research results, and facilities for exchange and dialogue among scientists acquire greater importance, corresponding to the more formidable research capacity that already exists nowadays in some developing countries.

In addition, programs of "horizontal cooperation" offer the possibility of scale economies not feasible at the purely national level. Logic, as well as empirical evidence, indicate that the productivity of a research system increases with its size, at least up to a certain point. This can be attributed among other factors, to the inspirational effect of working as part of a "critical mass" of scientists, to possible interrelations between concurrent research projects, and our conceptual model of the research process provides us with a frame of reference in which to assess the costs and benefits of different alternatives to international cooperation. A rigorous economic evaluation would require a complex series of theoretical definitions related to periods of time, rates of social discount, and redistributive effects. Such rigor is, however, beyond the scope of this paper. Nevertheless, the model presented here facilitates a systematic analysis of the relevant factors which national research institutes should consider when making decisions about preferable forms of international cooperation.

The Costs of International Cooperation

Developing countries are well aware that international assistance involves two principal kinds of costs: (a) those incurred by donating agencies, and (b) those incurred by the recipients. The first need only be taken into account in our economic evaluation to the extent that they affect national decisions on research programs, and hence, the allocation of national resources. They may also become of interest if only a limited supply of international resources for agricultural research is available so that each country must be concerned with the size of its share and with the way it uses it. Strictly speaking, however, the cost of donated resources is not borne by the developing country that receives assistance and, therefore, should not be entered in any cost benefit analysis performed from its standpoint.

The costs of international cooperation incurred by developing countries are again of two kinds: (a) direct, or actual costs, and (b) hidden, or indirect costs. The latter are perhaps more important for our analysis because, not being explicit, they are easy to overlook or disregard and their omission can lead to wrong decisions.

Actual costs. Actual costs are equal to the value of national resources, including financial contributions, spent on cooperative agricultural research programs. Almost all international cooperation, for example, requires developing countries to supply counterpart resources: researchers, equipment and operating expenses. The cost of such resources in connection with well-defined, specific collaborative projects is easy to identify and to calculate.

Next, a developing country's share of the budget of international programs or organizations, which will be devoted partially to agricultural research, is also to be taken into account. This cost, however, is not so easily measurable from the standpoint of the national agricultural research system — except for programs such as PRECODEPA or CONOSUR, for instance, where national contributions come from the research budget of participating countries.

Finally, developing countries must realize that the cost of certain resources may suddenly increase by virtue of their being devoted to an international program. This is rather typical of the salaries and fringe benefits of national personnel who collaborate in international programs, the result of a sort of demonstration effect.

Indirect costs. Hidden costs arise for diverse reasons. They constitute a problem about which national research directors in developing countries frequently complain. The principal items contributing to these costs are the following:

* Much administrative time and resources may be devoted to supporting international cooperative programs, in ways not directly linked to actual projects, and which never yield a tangible benefit (for example, hospitality, supplying information).

* The opportunity cost of resources, above all scientific personnel, diverted from other uses towards cooperative programs. This is a real cost when an international program imposes an adverse shift in national research priorities; or when, as a consequence of their

participation in an international program, national scientists, whose numbers are limited, must devote much of their time to administrative or other duties at which they have no comparative advantage.

* Cuts in national research funding, that may be induced by successful international programs which gain prestige at the expense of domestic institutions and scientists. Some forms of international cooperation, such as the support of international agricultural centers, have been blamed at times for a reduction in external resources available to the national research systems. Such diversion of funds, stemming from international cooperative efforts, can indeed be considered a cost of cooperation for the NARS of developing countries.

* Last, kinds of assistance tied to international cooperation which for all intents and purposes cannot be refused, but which are at best marginally productive for the recipient country, also represent a cost. One case in point: "foreign experts," whose suitability and qualifications for the job at hand are debatable.

Although in practice it may be nearly impossible for a national research director facing decisions on international programs to establish quantitative estimates for all potential costs, it will nevertheless be useful for him to consider and weigh each one of them specifically. For any item that appears important, a value can be assigned to ensure that it is not neglected in the ex-ante evaluation of projects. The conscious search for all possible costs attached to international cooperative activities obliges donors and recipients to reach an agreement about the detailed and precise definitions of programs. This in itself promotes better decision-making, including the timely reformulation of programs in ways more advantageous to the developing country.

The Benefits of International Cooperation

In agricultural research, the general truth obtains that benefits are harder to define and estimate than costs. Two principal approaches for measuring the benefits of international cooperative programs can be adapted: (a) the descriptive method, which enumerates and quantifies the various activities, resources, or output that are contributed by or stem from such cooperation and which strengthen the NARS; and (b) the economic analysis method which defines the benefits of cooperation in terms of the savings of costs it represents for a country. With reference to Figure 1, both methods involve specification of the forms in which international cooperation responds to demands at various stages of the research process by providing resources and services not available in the country itself.

The descriptive method. Ex-post evaluations of assistance programs of any kind are usually based on a listing and quantification of activities which represent program benefits. Although this procedure falls short of a rigorous economic evaluation, it is still useful. It entails the description and assessment of the principal elements that any research institution entering into a collaborative venture should consider when trying to determine possible benefits in store.

In the case of international cooperation, benefits may include the following:

* Research projects conducted or supported by national research institutes and weighed by their quality and scope. (For reasons already alluded to, projects carried out by external agencies without national personnel can actually be detrimental rather than beneficial to the national institute.) Naturally, many such projects include in their results: The production of improved inputs, new techniques, and information; research publications, whether articles in scientific journals, bulletins, or books.

* Seminars, meetings, congresses, and other professional gatherings, of direct relevance to agricultural problems, organized by the participant countries.

* Funds supplied to national research institutes through grants, budgetary contributions, or contracts.

* Staff and/or advisory services provided to national research institutes.

* "Linkage" services with external institutions. This benefit is difficult to pin down, but it refers to situations in which an international agency acts on behalf of a national research institute to acquire information, place research students, locate and hire personnel, etc. This type of assistance is of particular value to smaller developing countries.

* Promotion of public support for national research. International associations can enhance public understanding and government support of national research efforts. Towards this end, many means are at their disposal: speeches, campaigns, and personal influence.

It is not difficult to think of ways to measure and assess the factors above so as to construct indices that permit comparisons among alternative projects, through time, or with programs in other economic sectors. These indices could then facilitate an objective evaluation of different situations of international cooperation. Even though values obtained would not be monetary, they would still provide standards to compare with the estimated cost of various cooperative programs, and thereby yield some notion of relative productivity from the perspective of the research system or institute benefiting from the aid.

The economic-analysis approach. Under the economic analysis method for evaluating the social returns of international cooperative programs, the starting point is the assumption that the agricultural research system of a developing country has an effective demand for the services supplied by cooperative programs (resources, output, knowledge). That is, in the absence of cooperative assistance, the developing country would itself have to incur expenditures to obtain the same services.

Thus, the benefits of international cooperation are represented by the savings it allows to a developing country that choses to participate. These savings may arise, for instance, from the following situations:

* Training of research personnel. Any national research system must incur costs for training high level researchers. Fellowships abroad and in-service training are expensive. There are also costs for administering training programs. If an international cooperative program supplies and administers fellowships, training seminars, and special courses, resulting savings would represent a benefit the program provides.

* Hiring high-level experts and consultants. Personnel with special skills necessary for certain aspects of agricultural research. In general, less developed countries can only obtain such manpower from foreign sources and at a high cost. The savings represented by acquiring necessary experts through international cooperative programs free of charge, or under favorable terms, constitute a benefit.

* Access to intermediate research results. The opportunity, to make use of intermediate research results is offered by some international programs, such as those linking CIMMYT, CIAT and other institutes of this class with national institutes. Not having to generate the same research results already available elsewhere means obvious savings. The value of the time saved, including that of confirming and adapting results before disseminating them, can have an enormous impact on the productivity of the NARS.

* Obtaining scientific, technical, and administrative information. The costs of acquiring information from abroad can be considerably reduced through participation in international programs which perform this service for member countries.

* Obtaining genetic materials. The time and cost of obtaining and preserving genetic materials required for agricultural research are prohibitively expensive for many NARS. International cooperation, especially involving IARCs such as CIMMYT and IRRI, permits access to these materials at a negligible cost to developing countries. Their savings represent a major benefit.

In a similar manner, it is possible to consider other services secured at a lower cost through international cooperation programs as benefits to the national research institutes of developing countries. When a monetary value is placed on these benefits, it is possible to compute the extent to which various international cooperation programs have solid contributions to make.

In general terms, the minimum benefit from these programs is represented by how much a country itself would be prepared to pay for the services or products obtained; and the maximum benefit by the influence that the cooperative program has had on strengthening the recipient NARS. The maximum benefit can be estimated approximately through the descriptive method explained earlier, the method used customarily by external assistance agencies and foundations to make their own program evaluations. It is not surprising, given the commitment of international institutions to demonstrate the success of their activities, that the upper limit of possible benefits from cooperation is apt to be cited.

Application of the descriptive method [illegible] h a similar bias is not as opportune for national research institutes in developing countries, however; after all, they must invest part of their own resources in international cooperation activities. From their standpoint, conservative estimates of benefits are preferable. These, indeed, do occur in practice. This helps explain why it frequently happens that international cooperative programs, set up with a significant contribution from some external organization

(for example, ILMA and CIDIAT, founded by FAO and OAS, respectively), can no longer survive once their funding has to come exclusively from what were once the recipient countries. Doubtless, the same fate will overtake agricultural research programs.

Potential Prospects for International Cooperation

Continuity of the Need for Cooperation

We can foresee a continuing demand for some time from developing countries for international assistance in the field of agricultural research. Pressures for economic and agricultural development are unlikely to abate, nor is the predominant role of technological innovation in increasing agricultural production likely to diminish. International assistance agencies and developing countries both appear to appreciate the situation now more than ever before. This has created a favorable climate for cooperation in agricultural research.

Nevertheless, the difficulty of establishing horizontal cooperation remains considerable. Difficulties persist in the NARS, even in countries that have benefited from foreign aid over two or three decades. Limitation in research and management capability are even greater in poorer, smaller, younger nations, whether in Africa, the Caribbean, or the Pacific. It is no wonder that traditional assistance agencies give preference to these recipients.

On the other hand, the enlarged research capacity that has been achieved by many developing nations creates new and different needs that must be attended to in order to augment the effectiveness of their research systems. Also, for recently created IARCs to make themselves useful they must be able, as previously discussed, to refer results to solid national systems that can profit from and sustain technological advances.

Problems of funding cooperative ventures have been compounded, moreover, by a global reduction of the financial resources available for national agricultural research of the traditional variety. The steady expansion of the years 1950-70 glimmers in memory. The shrinkage of current NARS budgets can partially be traced to the expense of maintaining the still comparatively new network of international research centers, an expense which can be expected to be with us for a long time to come. Given this financial picture, international programs of horizontal cooperation would appear a promising approach to agricultural research, not only because they contribute directly to the efforts of developing countries, but also because they offer varied and flexible mechanisms for selectively distributing aid from traditional international sources.

Prospects for International Associations

Let us return now to discuss the international associations which constitute the principal forms of horizontal cooperation currently practiced in connection with agricultural research. Keeping appropriate cost/benefit criteria in mind, we can formulate several hypotheses about which forms of cooperation have better prospects under prevailing conditions in specific countries or regions.

For several reasons, prospects for new executive-type IAs with research as their priority (for example, CATIE, AVRDC) do not appear promising. Such IAs that now exist arose during a period when external organizations took the lead in creating and financing them. Their formation took place in a vacuum of national institutions and personnel who might fulfill their roles. This situation has changed dramatically. National research systems have been strengthened (even in Africa where universities, in particular, play a significant role), while at the same time traditional donors have been shifting their support to international research centers. At present, it is evident that such centers enjoy a pre-emptive priority over IAs that might conceivably perform a similar function.

Likewise, the negative aspect of competition between these executive-type IAs and NARS has been noted. It seems unlikely that developing countries will be willing to create and maintain such expensive associations with high fixed or overhead costs. They perceive too low a benefit/cost ratio to make the investment attractive. In fact, past examples suggest such IAs either evolve into national institutions (for example, CIDIAT, ILMA) or eventually attempt to join CGIAR centers (for example, WARDA, AVRDC). Both metamorphoses mean increased financial security and a greater likelihood of survival.

Forms of cooperation might presently undergo a different development, however, in smaller or poorer countries in culturally homogenous regions where a similarity of problems prevails for example, the Sahel or Pacific Islands. Yet, also in these areas, new IAs are not

likely to get off the ground unless they can demonstrate clear scale economies for agricultural research and generate significant international funding to complement horizontal cooperation. Meeting these conditions is no longer feasible in Latin America or Asia.

In contrast, horizontal cooperation in the form of supportive or coordinating/promoting IAs has brighter prospects, even for associations without agricultural research as a primary objective. At least this is true where reasonably professional national research systems are in operation — which undoubtedly includes the majority of developing countries at present, especially in Latin America.

Supportive IAs with research among their principal objectives are particularly interesting because of how they coordinate tasks by permitting groups of institutions to benefit from each others' comparative advantages. SEARCA in Asia is a noteworthy example. SEARCA combines research with graduate education in agricultural sciences.

The advanced training of agricultural scientists, a basic problem which all national research systems must resolve, deserves special attention.

Academic institutions of a fair quality at the graduate level sometimes as part of a national agricultural research institute as, for example, in Argentina and Colombia, represent an important resource in many developing countries. It is now possible, therefore, to conduct a major part of the training of researchers at home, rather than in the United States or Europe as was necessary in the past. Although some international cooperation is taking place on training matters (SEARCA again deserves mention), there remains vast potential for expanding horizontal programs, particularly in regions like Latin America where language and culture are sufficiently uniform not to create problems. It is indeed surprising that no association of graduate programs in agricultural sciences yet exists in Latin America. Such an association could promote suitable curricula, as well as the exchange of students and professors; it could make it possible for candidate researchers to profit from a mix of the best specialized training available in member countries. This seems a natural field for initiatives by IICA or some similar organization.

Certainly, programs of this nature would have high cost/benefit ratios for participating countries. Graduate training entails high fixed costs. Many developing countries at present are bearing such costs, when in fact, the number of graduate students per speciality in each country is small. It is a classic situation where the division of labor and scale economies would benefit all participants.

Another form of the supportive IA with good prospects is that which links national and international research institutes on specific subjects of joint interest in such a way that the national institutes retain executive responsibility. As CONOSUR in Latin America and SAFGRAD in Africa have been demonstrating, this form of collaboration reinforces research directly in each member country, incorporates elements of external technical assistance, facilitates the exchange of staff and knowledge among countries, and utilizes the resources, both financial and administrative, of traditional international aid organizations. It appears, at first sight, in any event, to be a type of cooperation with high cost benefit ratios for all participants.

In addition, horizontal cooperation appears to be promising in the realm of the coordinating/promoting associations, even if these do not include agricultural research among their primary objectives. The potential value of such IAs derives from the fact that under the present state of development of most national research systems, there is a great need for more fluent exchange of information, experiences, and knowledge, particularly through personal contacts among scientists and researchers, and through reciprocal visits to their respective institutions. To thrive, research requires a vigorous intellectual environment which includes professional stimulus and peer recognition — under the best circumstances, researchers feel themselves part of a relatively large community, motivated by the same objectives and professional standards. Given the diversity of research specializations and the comparatively small size of most national research systems, at least in terms of numbers of researchers with advanced training, a pooling or exchange of experts from many countries is essential to establish the kind of work setting which yields the best research results.

The large number of associations already at work to bring about the exchange of professional people (such as AAACU, ALCA, ALEAS, UNICA) is noteworthy. There is also a growing number of associations whose primary objective is the coordination of specific topics of agricultural research (PCCMCA, PRECODEPA, IFARD).

Similarities of concern among national research systems also make coordination of activities among several countries attractive. Many of the problems investigated recur throughout large regions. Efforts to avoid duplication of research, to use both human and material resources complementarily, and to plan research activities jointly will result in appreciable savings and greater productivity for the national systems participating. Coordinating IAs, moreover, are typically low cost operations. They can be expected to show high cost/benefit ratios for their member countries.

On the whole, cooperation through supportive and coordinating/promoting IAs is fairly active at present. Yet most of it has been on a relatively limited scale. We can anticipate activities expanding significantly in the future, however, as the major benefits that result from exchange and integration sponsored by these associations become more evident to participants and potential participants.

These IAs might also prove invaluable for promoting agricultural research and making it better understood by governments and the public at large. It is common knowledge that opinions and recommendations put forth by groups with broad representation and international backing have a much greater impact than similar views propounded by individuals or institutions on their own. And to be sure, the enlightenment of policy-makers about the profitability of agricultural research is devoutly to be wished, for as we have already had occasion in this paper to regret, the lack of government understanding and support in developing countries frequently prevents, to their own loss, the expansion and strengthening of national research systems.

Finally, the potential of these categories of international associations as vehicles for international cooperation gives them another role to play: to serve as mechanisms for attracting traditional types of aid from industrialized countries and international organizations and distributing it effectively. Although with supportive IAs this role is now a common enough one, there is scope for expanding it among coordinating/promoting associations. There are good arguments, for example, in favor of IFARD's accommodating assistance agencies that want to reach a broad spectrum of domestic research institutions in several developing countries. In a similar way, an assistance agency interested in the problems of Amazonian agriculture might find it advantageous to channel its assistance through an association like REDINAA.

Final Remarks

Certain aspects of horizontal international cooperation, based on the experiences of international associations, have so far been mentioned only tangentially in this paper. They need to be brought forward, however, because of their implications for the future development of this approach to cooperation in agricultural research.

These aspects are summarized in the following comments.

* The initial, or even long-term, support by traditional external aid organizations seems to be indispensable to IAs for their development and sustained performance. Almost all IAs examined had such financial support, however modest in extent. The point is that an external catalyst seems necessary to achieve institutional expansion in this field.

* The majority of horizontal cooperation activities have a regional or subregional character; that is, they imply geographical proximity of participant countries. In addition, they concentrate on specific themes, crops or problems. It appears that the objectives of horizontal cooperation must be explicit and limited to achieve a working consensus among participating countries, institutes, or professionals.

* In contrast to those in Africa and Asia, IAs in Latin America are relatively abundant, particularly in Central America and the Caribbean. This may suggest how significantly homogeneity of culture, history, and language — as well as similarity of problems — increases the viability of association in cooperative programs. The catalytic importance of external agencies (such as OAS, IICA, Rockefeller Foundation) tends to be confirmed by IA experiences in this hemisphere.

* Paired together, the two preceding statements would suggest that efforts at horizontal cooperation should be confined to situations where objectives are concrete, where countries show a certain basic resemblance to each other, and where distance is not a problem. Global organizations would seem well advised to establish subdivisions that comply with these suggested conditions.

* The reasons that appear to induce countries, or their national research institutes and agricultural scientists, to associate are diverse and vary according to circumstances. In any event, catalytic external agents have an important role to play in accurately identifying latent motives and in helping to give them expression and fulfillment through cooperative institutions. It appears logical for external assistance organizations to have an interest in creating associations as mechanisms to reinforce and maintain, on a collective, long-term basis, activities which these organizations themselves once supported country by country (for example, formation of cadres of agricultural scientists).

* There seem to be few instances — at least in recent times — in which an IA has been called into being to realize possibilities of specialization and division of labor among member countries, or to achieve economies of scale and thereby increase the overall productivity of regional agricultural research. The planning and coordination requirements, and the political and domestic administrative implications of such an association appear too complex at present for its successful operation. The disappointing experiences of regional economic integration agreements testify to the difficulties. Nevertheless, the motives we have discussed should, theoretically, continue to exercise a powerful influence on developing countries to seek workable horizontal cooperation schemes.

* The predominant impulse that seems to have given rise to many international associations is recognition of the need for communication among scientists and institutions. Exchange of knowledge, information on work plans, research results, and general intensification of personal interaction among agricultural administrators and researchers constitute the leit-motivs of a majority of existing IAs. More complex forms of cooperation — for example, those suggested in the previous paragraph — appear likely to materialize in the future as extensions of IAs now principally devoted to communication.

* Another stimulus to the formation of international associations is their potential to attract resources for the national research system, both from developing and developed countries. New efforts at horizontal cooperation with this objective in mind can safely be foreseen.

* It is important to recognize that the cost/benefit ratio of cooperative programs may differ among participating countries. Not every country can, therefore, be expected to be equally enthusiastic about a given program. For this reason, it is essential to refine criteria and methods for evaluating international cooperation.

* In relation to the foregoing, and given that it is difficult to take advantage of situations in which all are net gainers when cooperation exclusively involves developing countries, it appears essential for some transfer of resources to take place towards the countries that participate in associations. This implies that either external funds support this cooperation, or relatively more developed countries among those participating must be willing to subsidize the others. In other words, cost/benefit ratios for weaker partners must be raised in order to provide them with an incentive to join.

In closing, we should recognize that, notwithstanding the presentation in this paper, information about horizontal cooperation through international associations is scarce; what exists is often incomplete and difficult to get. Little is yet known about successful and unsuccessful experiences. It is hoped that this paper will stimulate sufficiently systematic and rigorous study of the topic to permit better comparison among different institutional forms, and to help guide decision-makers in the choices they make about participating in horizontal cooperation programs for agricultural research.

Appendix

Description of Selected International Associations

Principal international associations that in some way are involved with the agricultural research systems of developing countries are presented in the following pages. A variety of organizational forms and institutional denominations are included under the generic label of "international associations," including institutes, centers, universities, associations, councils, organizations, programs, etc. All the IAs listed, however, share certain characteristics as discussed in the main text of this paper.

IAs appear below by major world regions and in alphabetical order of their (original language) acronyms. Capsule descriptions appear when background information has made that possible.

Worldwide

AVRDC: Asian Vegetable Research and Development Center

An international center devoted to research and training on vegetable crops in the tropics. Founded in 1971, and based in Taiwan, AVRDC is supported among others by its host country, USAID, the Philippines, and Japan. Although it does not receive funds from the CGIAR, AVRDC has associate membership in that group.

IAAE: International Association of Agricultural Economists

A professional association similar to regional and national associations of agricultural economists. It meets triennially and does limited publishing of research reports. Supported by members' fees and special contributions, IAAE plays a limited, indirect role in support of economic research on agriculture.

IAPB: International Association of Plant Breeders

IFARD: International Federation of Agricultural Research Systems for Development

ISHS: International Society of Horticultural Sciences

RGA: Rubber Growers Association

SID: Society for International Development

A broad-gauged professional association of development-oriented social scientists, which serves as a forum for exchanges of ideas through meetings and regular publications. Supported by members' fees, institutional contributions, and special grants, SID plays an indirect role in agriculture through its concern with socioeconomic development studies on agriculture.

Latin America

ACW: Andean Corn Workers

AGRINTER: Inter-American Agricultural Information Service

The regional agency for systematizing collection and computerization of published materials on agriculture, corresponding to FAO's Agricultural Research Information Service, AGRIS. It operates under the umbrella of IICA.

AIBDA: Inter American Association of Agricultural Librarians and Documentationists

The regional organization of professionals in this field; its secretariat operates from IICA's headquarters in Costa Rica.

ALALC: Latin American Free Trade Association

See CARIFTA.

ALCA: Latin American Association of Agricultural Sciences

A professional society of plant breeders, geneticists, and agronomists from or interested in Latin American countries. Founded in the early 1960s, supported by membership fees and occasional grants, ALCA holds annual meetings within the region. ALCA has a rotating secretariat.

ALEAS: Latin American Association of Higher Schools of Agriculture

A regional group of university-level advocational institutes and faculties of agriculture. ALEAS, formed about 1960, holds annual meetings of deans and directors

to exchange views on agricultural education and research. Supported by member institutions and occasional grants.

ALPA: Latin American Association of Animal Sciences

Similar to ALCA, for animal production scientists.

CARDI: Caribbean Agricultural Research and Development Institute

CARIFTA: Caribbean Free Trade Association

CARIFTA, ALALC, PA, and SIECA are regional governmental agencies for economic integration, set up after the fashion of their European counterparts. Their research orientation has been largely economic and social including studies done in the agricultural sector. Through support of and coordination with specialized institutions in the region, SIECA has had a larger impact than the others, especially on agricultural technology.

CATIE: Tropical Agronomic Center for Research and Training

An autonomous regional center for Central America, Panama, and the Caribbean, established in 1973. It evolved out of IICA, from which it inherited its excellent physical facilities at Turrialba, Costa Rica. CATIE is a full-fledged, operational organization, similar to the international agricultural research centers supported by CGIAR.

CINDA: Inter-University Center for Andean Development

An association of the private and Catholic universities of five Andean countries, CINDA seeks cooperation in research, staff exchanges, and the educational planning of its member institutions. Agricultural research is touched upon to the extent that universities undertake active research in their agricultural schools.

CLACSO: Latin American Council for the Social Sciences

An independent regional association of social science training and research centers, including rural social science centers, CLACSO coordinates, supports, funds, and executes research in its field. (It has had some importance in fostering socioeconomic research on agriculture.) Funds are obtained mainly from foundations and other donors. (CLACSO and DESAL, below, are only marginally related to agronomic research; they are listed here because of their interest as organizations at the international (regional) level.)

DESAL: Institute for the Economic and Social Development of Latin America

A regional, autonomous research center, linked to and largely supported by the Catholic Church, DESAL conducts research on socioeconomic aspects of development, including agriculture, and it provides technical assistance. (See note under CLACSO.)

CIDIAT: Inter-American Center for the Integrated Development of Soil and Water

An autonomous research and training institution established by the OAS in Venezuela in the 1960s. Although after several years of operation its funding was absorbed, mostly by the host country, it continues to serve the entire region.

ILMA: Latin American Institute of Agricultural Marketing

A training, research, and advisory center, originally set up by the FAO in the 1960s with member nations' support. After several years of operation it was terminated and subsequently taken over by Colombia as a national institution.

INCAP: Nutrition Institute for Central America and Panama

A regional research, training, and technical cooperation center created in 1946 by the governments of its member countries under the sponsorship of the Pan American Health Organization. Among its activities, INCAP carries out research on agricultural subjects such as animal nutrition and cereal grains. It is a highly structured organization.

OIRSA: Regional International Organization of Plant and Animal Health

A regional organization for control of plant and animal diseases, created in 1955 by the five Central American countries, Mexico, and Panama. OIRSA devises and

implements measures for disease control in the region, trains personnel, and promotes technical assistance. It is a full-fledged, operational institution.

PA: Andean Pact

See CARIFTA.

PCCMCA: Central American Cooperative Program for Food Crop Improvement

A working arrangement that since 1946 has brought together agricultural researchers from the five Central American nations. PCCMCA operates principally through its annual meeting at which research results and plans are presented and discussed. A voluntary participation program with no formal structure, it grew out of Rockefeller Foundation activities in the region.

PRECODEPA: Regional Cooperaave Potato Program

A regional association of national potato programs of Central America, the Caribbean, and Mexico, formed in 1978. It brings together in a loose format the national research institutes that control such programs.

PROMECAFE: Cooperative Program for the Protection and Modernization of Coffee Culture in Mexico, Central America, and Panama

A regional governmental program established in 1978 with the participation of CATIE and OIRSA. Execution and coordination tasks are performed by IICA. PROMECAFE's functions include research, training, technical assistance, and other cooperative efforts aimed at improving coffee production in the region. Funding from member country quotas, IICA, and other sources.

REDINAA: Network of Agricultural Research for the Amazon

This recently established (1980) collaborative agreement among the national agricultural research institutes of Amazonic countries (Colombia, Ecuador, Peru, Bolivia, Brazil, and Venezuela), coordinates their work on the Amazonia, including the development of a master research strategy, and the promotion of information exchanges. It has no executive organ of its own.

SIECA: Secretariat for Central American Economic Integration

See CARIFTA.

UNICA: Association of Caribbean Universities and Research Institutes

A voluntary association of Caribbean universities and research institutes dedicated to directed efforts for Caribbean development. Founded in 1968 by 16 universities in the islands and surrounding coastal countries, UNICA now has 45 members representing a constituency of more than 300,000 students and 30,000 faculty.

UWI: University of the West Indies, Agricultural Faculty

A regional training and research institution of the former British colonial Caribbean nations, UNI evolved out of the Imperial College of Agriculture. It is one of the most significant agricultural research institutions in its geographical area.

Africa and the Middle East

AAASA: The Association for the Advancement of Agricultural Sciences in Africa

The agricultural scientists' continent-wide organization, created in 1968. AAASA is organized in a similar fashion to other international and North American professional associations. Membership consists of individuals, national research institutes, and agricultural faculties. AAASA's essential aims are to foster the development and application of agricultural sciences in Africa, and to provide opportunities for exchange of knowledge and experiences among agricultural scientists. It works through conferences, meetings, and publications. Funded through members fees and donations.

AAU: Association of Arab Universities

This independent association of all Arab universities is based in Saudi Arabia. AAU promotes cooperative programs, exchange programs, and seminars among member universities. Its main activity is the biannual meeting of deans, by faculty, including agriculture.

AFAA: Associations of Faculties of Agriculture in Africa

This association, formed in 1973, has headquarters at the home institution of its executive secretary (at present in Morocco). AFAA aims generally at strengthening the development of agricultural education and research, and particularly at improving course offerings in its member institutions. Support comes from members fees, donations, and grants.

AOAD: Arab Organization for Agricultural Development

An official organization of the Arab League, based in Sudan. Its mandate covers activities such as feasibility studies, publications, regional meetings, seminars, and training courses, all in relation to agriculture. As yet, negligible activity in relation to agricultural research.

APGRC: African Plant Genetic Resources Committee

EAEC: East Africa Economic Community

This was an important subregional government organization formed by Kenya, Tanzania, and Uganda, until its collapse in 1977. While it operated, EAEC ran the major universities and agricultural research institutes of its three members as joint regional institutions.

IACO: Inter-African Coffee Organization

ICIPE: International Centre for Insect Physiology and Ecology

This center was established in 1970 in Kenya, to increase the capability of African countries in pest management and control. ICIPE undertakes and promotes research in insect science and provides advanced training in this field. It also organizes seminars and workshops, and generally fosters communication among professionals. Supported by the Kenyan government and international donors.

SAFGRAD: Semi-Arid Food Grain Research and Development

A project of the Scientific and Technical Research Commission of the Organization of African Unity, established in 1977. SAFGRAD involves 26 participating countries. Its mandate is to undertake research on five basic crops on behalf of the semi-arid region of Africa. The project, administered by an international corporation based in Upper Volta, operates mainly by contracting out research to international centers acting independently or in partnership with national institutions.

UASRC: Union of Arab Scientific Research Councils

An autonomous body based in Iraq concerned with promoting scientific research, cooperation projects, meetings, and seminars. It has an agricultural committee.

Asia and the Pacific

AAACU: Asian Association of Agricultural Colleges and Universities

Akin to its counterparts in Latin America and Africa (ALEAS, AFAA).

AIBA Agricultural Information Bureau for Africa

The Asian component of AGRIS, the international service for information on agricultural research.

APCC: Asian and Pacific Coconut Community

An intergovernmental organization with headquarters in Indonesia whose purpose is to foster economic cooperation in the coconut industry among member countries. APCC research is limited to economic aspects. It is primarily a promoting agency, providing information and limited advisory services.

COFAF: Committee on Food, Agriculture, and Forestry

A specialized body of the regional Association of South East Asian Nations (ASEAN).

SABRO: South Asia Breeders Organization

SEARCA: South East Asia Regional Center for Graduate Study and Research in Agriculture

A regional agricultural educational center, created in 1969, forming part of the South East Asian Ministers of Education Organization (SEAMEO); located in the Philippines. SEARCA is funded by its host country and the SEAMEO secretariat. It is essentially an administering agency whose programs are conducted principally through the University of the Philippines at Los Baños and through the use of the facilities of its many other participant institutions. SEARCA's aims are basically the improvement of graduate training in agriculture, sponsorship and coordination of research programs, and dissemination of the findings of agricultural research.

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EPILOGUE: Perspectives for the Future of Agricultural Research in Latin America and the Caribbean

Eduardo Alvarez-Luna
Vice President of IFARD for
Latin America and the Caribbean

We have been fortunate at this second meeting of the Latin American and the Caribbean chapter of the International Federation for Agricultural Research and Development (IFARD) to have had the opportunity of listening to many researchers, experts, and distinguished guests from regional and international organizations who are working in the field of agricultural development. We have listened to many suggestions and proposals made by experienced scientists who are very seriously concerned with food production. They have related this subject to the field of agricultural research in a very positive manner.

We here are all anxious to find realistic ways of increasing the food producing capacity of our countries. This is a goal, one with a high priority. How else can we hope to feed the more than five billion people currently living on this earth, a number which according to UNESCO, will have grown to 11 billion by the year 2,000.

We have looked together at areas of urgent need for agricultural research and we have reached agreement that we must ensure that only people who are both well trained and conscious of socioeconomic constraints will be the ones who formulate decisions crucial to agricultural progress. It has been said before, but I think it worth repeating, that agricultural problems have to be resolved by agriculturalists. The best way for us to accomplish this is by providing dynamic leadership for our agricultural researchers.

Obviously, human resources are the most important resources at our disposal. We need to concentrate on developing these human resources through professional programs in which researchers can be identified, trained, and learn dedication to their fields. These programs need to motivate people to participate fully in the solution of agricultural problems in such a way that we create a symbiosis between researchers with their programs, and farmers with their problems.

This means that we need to exercise a sense of responsibility in the recruitment of agricultural personnel. Each and every researcher should have the opportunity to participate in the decision-making processes that affect him directly and to participate in periodic evaluations of institutional life and results that should examine both the work of researchers and the researchers themselves.

On the other hand, the framework in which scientific innovation, transformation, and development occurs needs to be changed. Both man and institutions must evolve. It is desirable that scientists be in the vanguard of developing both the prospects and the horizons of their own organizations. Innovation, transformation, and development of institutions, as well as of researchers, will enable us to make the best possible use of financial resources. These need to be adequate for carrying out the programs proposed by scientific and technical personnel and they must also accord with the real potential of the research institution.

Some years ago, the Food and Agriculture Organization (FAO) made a proposal that the governments of the 25 most developed countries in the world should divert to agricultural research 5% of the total money which they spent on arms. In just one of these countries, the sum for weapons escalated to a total of US$385 billion in 1982. FAO also suggested that other countries, especially those of the Third World, should dedicate 3% of all public spending for use in research. These suggestions have not been implemented. Why? Perhaps because many countries do not understand the urgency of the situation. They consider fluctuations in their agricultural production as temporary problems which can be resolved in the foreseeable future. The truth of the matter is that this view is not necessarily correct. Our confidence falters when we take into account the alarming nature of the difficulties food production sometimes encounters and when we note that currently there are nearly one billion people in the world who suffer from malnutrition, almost half of them stricken with chronic hunger. In fact, 50 million people starve to death every year. Against this background, it is a matter of considerable concern that so many countries pay such little attention as they have to agriculture, as opposed to other development activities.

We have three fundamental challenges to meet:

1. To make the earth more productive by increasing agricultural output.

2. To raise the quality of crops and livestock being produced.

3. To lower the cost of their production.

The world's population cannot be better fed if staple foods cost more than people can afford to pay.

Until a few years ago the main sources of funds for agricultural research were public. It has become obvious, however, that the public sector often focuses on too close a horizon, while agricultural growth calls for short-, medium-, and long-term goals. This means changing the attitude of decision-makers. Research workers must influence policy-makers to utilize research funding for studying the rational use of soil, water, climate, fertilizer, and herbicides, in order to combat pests and diseases, to speed up growing cycles, and to develop new strains that are more resistant to disease. To achieve any or all of these goals is to offer producers the means to realize greater productivity. Researchers' concerns about funding sources have led them to explore new possibilities for financing agricultural research. Their explorations have been opening up opportunities that are flexible and timely.

Non-government funding of research has already started. It is even growing in Argentina, Venezuela, Colombia, Mexico, Chile, and other countries in the region. In these countries, agricultural producers and industrialists in general, who together depend on agricultural production, have accepted the fact that production is likely to stagnate without the aid of scientific research and the availability of new technology and know-how generated in laboratories, experiments, fields, greenhouses, even on farmers' lands. Without new technology, farming is likely to remain primitive. Farmers will continue to be distant from the frontiers of agricultural progress. Non-public funds for research need to be administered through channels which can be controlled and safeguarded in a ways that ensure their optimum use.

All human activities should, without doubt, be the subject of continuous study; study that generates new information. Indeed, we are living today in the Information Age. Yet sometimes one piece of information will contradict another, requiring judgment about the quality of information. We must be careful not to allow professional jealousies and interests to prevent us from realizing information belongs to us all and it is in all of our interests that it be used in the most effective way. Accurate information is absolutely necessary to ensure that those responsible for agricultural policies may be able to judge programs and support those carrying them out. Information should enable research directors to make the most efficient decisions possible about the use of the human and material resources at their disposal. Information can help them, too, to evaluate the benefits and costs of research and application of the new technology which research generates.

Bibliographic information is important for research workers in today's world, affording them the chance to become aware of what other scientists have discovered working in the same area of specialization. Such awareness prevents wasting both time and resources. We have enough long roads to wander to make the most of whatever shortcuts the work of others may provide for us. It is therefore important that national information systems be well stocked with genetic and other information vital to the agricultural research effort. They should be urged to increase their scope and interest to a regional, continental, even global level. To be sure, we must learn to look on human knowledge as the common property of all mankind. The world will only progress once it recognizes and accepts the need for joint activities and interdependence.

An ethical attitude towards the interchange of information on the part of researchers would help us all to optimize the use of resources which, although at times abundant, always have been and always will be too limited in their totality to allow us to surmount the agricultural problems facing Latin America and the Caribbean.

Information systems based on cooperation, professionalism, and equity should be the basis for developing standards and mechanisms which will help to broaden scientific exchanges and international cooperation. There should be a true interchange of information at the highest level possible, which gives

paramount priority to identifying the programs that specific national systems need in order to accomplish their objectives — although common courses of action are clearly a source of extra strength. Exchanges of information and collateral activities have begun to take place. Where countries have comparative advantages, they have been able to help less-privileged neighbors.

I must also ask you to consider whether we should continue to give prime emphasis in our research goals to the competitive establishment of consumer market monopolies, or whether perhaps we have reached a stage of responsibility where our foremost objective must become to fight together against world hunger. Need I say the two approaches are not necessarily compatible?

Bearing this in mind, IFARD should promote principles of ethics and morality in intra-institutional changes and recommend cooperation in order to ensure that research activities are handled and managed on a basis of equity and reciprocity. Otherwise there can be no social benefits from such interchanges.

I am reminded of a tragedy that occurred in my country in the Yucatán, the home of the Mayas, an area where henequen is a traditional crop. At the beginning of this century, some botanical researchers from Europe arrived, apparently to study the cultivation of henequen, so that they could offer the benefits of their specialist knowledge to the indigenous people of this region. Their actions, however, did not fit this supposed goal. By subterfuge, they took the germplasm of this Mexican plant to the African colonies of their homeland. Twenty years later, the sales of Mexican hemp collapsed when supplies from African colonies flooded the world market. This is a perfect example of social injustice arising from scientific interchange, one from which the people of the Yucatán have not yet been able to recover.

Given the food shortage that burdens the whole world today, it is necessary as a first step towards survival for every country to become self-sufficient. That is not enough, however. We must also at least be able to help meet the demands of our regional communities. Researchers should not be the victims of isolationism. The governments of our countries have accepted the need to devote more attention to life under rural conditions, and to give greater support to research in agriculture, livestock, fishing, and forestry — not only in the interests of achieving self-sufficiency but, and this is most important, in order to treat men with equity and justice, especially those who work the land and who have suffered from urban and industrial development without necessarily reaping any benefits from it.

In Mexico, the state has established an agricultural system which by 1981 enabled us to satisfy domestic demand for maize, beans, and rice. This year we will also be self-sufficient in wheat. Yet, in Mexico, we aspire to more: We also look forward to full economic self-sufficiency and social development of producers, especially small farmers.

Without doubt, we are currently witnessing what we can call an agricultural revolution, based on innovations in agricultural technology. Researchers, technicians, and extension workers are acting as agents of change. All striving towards the same goal: greater productivity of crops and livestock.

In a world in which human values are apparently in a state of crisis, we must ask ourselves how to enhance our credibility; how to win the confidence of producers, researchers, and extension workers. I think it should be possible, for those people who live in the various countries of our region to be noble and generous people. We will first need to break the elitism of the past, however, moving ahead while demonstrating our respect for time-honored production techniques. We have to convince the rural population that our research workers have good intentions and the interests of the whole community, including producers at heart. This has to be done with acts rather than words. Social harmony in a participatory society will not develop by chance alone, but only in response to perceived necessity. We must be ready to persevere, for at times we will surely encounter serious problems of regional sentiment that hamper communication and solidarity.

Each era of government has its own style, especially in a presidential system. Where executive power enjoys popular support, it can provide true leadership, even at times eliminating bureaucratic impediments to progress. Frequently in our political system, there is too little sense of dynamic leadership. Instead, a kind of power vacuum prevails in which government officials remain the prisoners of an indifferent bureaucratic system. In fact, there may be more opposition to change and reform than support, especially when corrupt elements become embattled in self-defense. The bureaucracy may even

consider itself to be the supreme judge of knowledge, the guiding force in society. For too long, its delaying tactics may counteract the potentially beneficial impact of science and technology.

Because they may be deceived or distracted, those who make high-level decisions sometimes underestimate the importance of the contribution scientific research has to make in the area of efficient agricultural production. On the other hand, leaders often condone familiar agricultural activities, such as land clearance to increase the area under cultivation, expanding mechanization, and perhaps surface irrigation through grandiose schemes. Perpetuation of outdated methods, as opposed to the use of new technology, may create a system where consumer subsidies and low farm prices are the rule, where producers grow frustrated, and where low productivity helps generate inflation.

There is no need for Latin America and the Caribbean to continue to suffer from this situation. We must desist from basing our agriculture on a subsistence system which leads to extensive migration and settlements of human poverty and misery encircling our cities. Our land is capable of feeding our present as well as our future populations, even populations several times the size of the present ones. First, however, we need to develop a commonsense, logical response to the production problems raised by our growing population. We need to ensure that it will be scientists who determine future policies relating to land, water, fertilizer, and pesticides under our range of agroclimatic conditions.

Scientists in different countries demonstrate contrasting attitudes towards adopting this responsibility. There are those determined to bring about change and to modernize production systems; but there are others, and they perhaps are in the majority, who are severely discouraged, who have practically given up hope because new technology is currently not being used appropriately or is not reaching the smaller producers who need it most.

IFARD could become a driving force to dispel this attitude of frustration. We should use all the means at our disposal to humanize academic programs, to improve the training of new researchers, to revitalize interest in creative research. We should recognize that researchers and producers have common goals and we should direct research activities to their concrete realization. IFARD should spare no effort to convince governments to provide a minimum investment for agricultural research, equivalent to at least 1% of the agricultural gross development product. Above all, we should try to establish the principle that the making of decisions and recommendations on matters related to increasing agricultural productivity should be the prerogative of scientists and scientific institutions. It is in the scientific community, to be sure, that true competence lies to formulate and organize programs to bring about necessary change.

Friends and colleagues from the great countries of our continent, I think this second meeting has proven to be an excellent forum. It has enabled us to meditate together on the nature of our agricultural research problems and on the role IFARD might play in fulfilling the desires of our countries to advance through agricultural development.

It is unfortunate that the world continues at such high cost to face up to many problems only when they constitute an immediate risk. With foresight and determination, we might save ourselves considerable suffering and expense. If we are not listened to today, however, you can be sure we will be tomorrow, for there is no alternative to cooperation for feeding the world.