

**AGRICULTURAL RESEARCH
IN THE PRIVATE SECTOR:
ISSUES ON ANALYTICAL
PERSPECTIVES**



The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, Netherlands on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force, for the purpose of assisting governments of developing countries to strengthen their agricultural research. It is a non-profit autonomous agency, international in character, and non-political in management, staffing and operations.

Of the thirteen centers in the CGIAR network, ISNAR is the only one which focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on organization, planning, manpower development, staff requirements, financial and infrastructure requirements, and related matters, thus complementing the activities of other assistance agencies. Additionally, ISNAR has an active training and communications program which cooperates with national agricultural research programs in developing countries.

ISNAR also plays an active role in assisting these national programs to establish links with both the international agricultural research centers and donors.

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PERSPECTIVES**

M. PIÑEIRO

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ISNAR

International Service for National Agricultural Research

PROAGRO SERIES

The Project on Agricultural Research Organization in Latin America (PROAGRO) is a collaborative effort between ISNAR, the International Research Development Centre (IDRC) of Canada, which provides partial financial support, and a number of Latin American research institutions responsible for research activity implementation in the region. These are the Centro de Investigaciones Sociales Sobre el Estado y la Administracion (CISEA) in Argentina, a group of researchers associated with the University of Campinas in Brazil, the Latin American Faculty of Social Sciences (FLACSO) in Ecuador, and the Instituto de Estudios Superiores Sobre la Administracion (IESA), in Venezuela.

PROAGRO's ideas and methodological approach represent a continuation of the work initiated in the cooperative Research Project on Agricultural Technology in Latin America (PROTAAL), implemented under the sponsorship of the Inter-American Institute of Cooperation for Agriculture (IICA), between 1977 and 1983. The project's current focus is on the analysis of the role and impact of private agricultural research activities within the context of the research systems of the region.

This publication series is designed to diffuse PROAGRO's methodological approach and research results and will include publications in Spanish, Portuguese, and English, the project's three working languages. The opinions and points of view expressed in the papers are those of the authors and not necessarily those of ISNAR or other participating institutions.

William K. Gamble

Director General

ISNAR

Table of Contents

I.	<u>Introduction</u>	1
II.	<u>Objectives of the project</u>	3
III.	<u>The multi-institutional system for the generation and transfer of technology: its principal components</u>	6
	A. Components of the public sector	6
	B. The private components	9
IV.	<u>Determinant factors in the development of the private sector</u>	12
	A. Nature and size of the market; perspectives for growth	14
	B. The organization of agricultural production	15
	C. The importance of technological knowledge, possibilities for private appropriation of benefits generated by technology, and possibilities to protect technological knowledge	17
	D. Socialization of research and installation costs	18
V.	<u>National research institutes in the new context</u>	19
	A. Introduction	19
	B. The creation of institutes	20
	C. The implicit assumptions	20
	D. The present situation	22
	E. General hypotheses regarding new institutional model	25
VI	<u>Some guidelines for the development of case studies</u>	28
	A. Case studies in selected countries	28
	B. A study of the seed sector from an international perspective	31
	Notes	35
	Bibliography	36

I. INTRODUCTION

In the period following the Second World War, agricultural production in Latin America remained stagnant in relation to progress made in the developed countries. A variety of analyses, and hence explanations, have been proposed concerning this phenomenon. Nevertheless, they all agree to say that the technological disconnection of Latin America with progress happening in developed nations has had considerable importance.

During the 1950s and the 1960s, agriculture in the developed countries experienced a technological revolution with important modifications in the levels of productivity. This revolution was transmitted only in a partial and fragmented way to the Latin American economies.

Most of the technological progress which took place in the developed world after the war, specially in agriculture, originated in government institutions, particularly universities. During the 1960s, a number of public institutions concerned with technological issues in agriculture were created in Latin America. The objective of these institutions was not only to generate knowledge, but also to serve as intermediaries between acquired technological knowledge and the production system.

The 1970s were also for the developed countries a very fertile period from the point of view of agricultural modernization and productivity. Additionally, during this same period, there appears to take place an improvement in the capacity to transmit technological information from the developed nations to countries technologically less advanced. As a consequence of this, a number of countries in Latin America began to experience significant changes in agricultural production.

During the same period, the institutional structure of the developed nations started to change radically, due to the involvement of the private sector in the creation and diffusion of technological change. Edquist and Edquist have defined these sectors as "social carriers of technology" whose function is performed through the production and sale of inputs and capital goods which embody technical change. The development of new social actors and institutional mechanisms is related to two basic issues. First, certain intrinsic characteristics of agricultural technology become progressively more important as a consequence of the advances made by basic research. Second, the opportunity for individuals to appropriate the economic benefits generated by new technology, and the trend in market economies for technology to lose its nature as a public good and become a merchandize.

The development and growing participation of the private sector also took place in Latin America a decade or so later, simultaneously with agricultural modernization and increased levels of production. The importance of technical change and its effect on production increases, leads the attention to the institutional organizations that made them possible. Understanding the dynamics involved in the relationship between social organizations and technological change appears as an essential prerequisite for discussing the nature and characteristics of future trends in agricultural technical change. This is the objective of PROAGRO.

These notes attempt to define the objectives, the analytical framework, and the general methodological guidelines of PROAGRO. Their purpose is to serve as a focal point in the discussions and workshops that will be

held concerning this project. They also serve as a general reference point for the research that will be carried out by the various teams involved in specific subject areas. Although each study will compile data related to a specific problem or situation, all will share common analytical elements and perspectives, in order to establish a series of comparisons between the individual results. Through this approach a greater general understanding of the problem will hopefully evolve.

In addition to this introduction, the document includes five parts. In the first part, the central objectives of the project are presented. The second part consists of a characterization of the different institutional forms adopted by the private sector in the generation and diffusion of agricultural technology. The third part presents some analytical elements, tentative hypotheses, and suggested methodology for analyzing the genesis and causes that determine the development of private institutional forms participating in the innovative process. The fourth part briefly touches upon some analytical aspects related to the impact that the development of the private sector has had upon the structure and performance of public research institutions. Finally, the fifth part discusses some operational ideas for the development of case studies in the country.

II. OBJECTIVES OF THE PROJECT

The central theme of this project is to describe and characterize the development of those new institutional mechanisms which the private sector has utilized in the process of generating and spreading technological knowledge applicable to agricultural production.

Additionally, it also seeks to analyze the impact this process has had on agricultural development.

Within this general context, the project has defined the following four interrelated objectives:

1. To analyze, using a limited number of case studies, the development of new institutional components, through which the private sector participates in the process of generating and spreading technology, and to evaluate the relative importance of these organizations in the innovative process. This analysis should be considered as a first step in the construction of an explanatory model. This model should relate the development of these organizational components and study also the influence which economic and legal factors, as well as the political and social organization of the country, have, in market economies, upon the qualitative characteristics and the performance of the organizations created.
2. To characterize the new institutional model for the generation and diffusion of technology now being developed in Latin America. This model includes public institutions usually lead by a national institute of agricultural technology, related to the Ministry of Agriculture, but with a certain degree of autonomy and a varied number of other organizations, mainly of the private sector. This multi-institutional system will be evaluated in terms of:
 - a. The allocation of resources between different types of activities;

- b. Institutional coordination;
 - c. The utilization of internationally available technology and information;
 - d. The priorities of the public research institutions required to ensure that all the necessary activities for the development of an efficient and articulated research systems are performed.
3. To characterize and evaluate the consequences which the new institutional model has over the qualitative characteristics of the technology generated, and through this, over the social organization of agricultural production and the production efficiency. This is the basic information required when considering the possible trends of the innovative process and its effects upon the nature of agricultural development in the future.
4. Finally, based upon the information and analysis developed in relation to the three objectives mentioned above, the project proposes to consider the elements necessary for the development of a scientific and technological policy for the agricultural sector, taking into consideration the new developments concerning institutional organizations and their consequences for the productive sector. This refers mainly to:
- a. Institutional mechanisms involved in the formulation of technological policies;
 - b. Mechanisms for interinstitutional coordination;
 - c. Main priorities for various organizations within the public sector;

- d. Regulation and control of private sector activities;
- e. Mechanisms for coordination with the international system for the creation of technological knowledge.

III. THE MULTI-INSTITUTIONAL SYSTEM FOR THE GENERATION AND TRANSFER OF TECHNOLOGY: ITS PRINCIPAL COMPONENTS

The institutional system for the generation and diffusion of technology is integrated by organizations of the public sector, at present the most developed and best renowned, and others of the private sector.

Among the components of the public sector, the most important ones are the national research institutes. These have been previously described and analyzed in other publications (1). For this reason, the present paper will only touch briefly upon the components of the public sector. The main objective is to analyze the components of the private sector in greater detail.

A. Components of the public sector

Towards the end of the decade of the 1950s, with the creation of INTA in Argentina, begins in Latin America an institutional revolution in the area of agricultural research. Until that period, research had been concentrated in schools of agriculture and research departments within ministries of agriculture. Because of the administrative dependency of these institutions, their scientific output was generally very low (2).

The creation of national research institutions as dependent organisms of the ministries, but with considerable autonomy, was made in response to these institutional deficiencies and to a new social conscience of the importance of agricultural technology as an instrument for development. This concept was based upon the experience and influence of events taking place at international level.

Starting with INTA in 1956, research centers were established in almost all but five of the Latin American countries. Three of them maintained research structures directly dependent from the Ministry of Agriculture. The fourth one, located in Brazil, was created at the beginning of the 1970s as a public research agency (EMBRAPA). It represented a new institutional innovation that incorporated certain differences when compared with the institutional model developed by the majority of countries in the continent.

This institutional development process in the public sector was complemented by the establishment of other public institutions, in some cases with the participation of the private sector, responsible for research and the transfer of technology for specific products. One example of this type of institution was the CEPLAC in Brazil for cocoa.

In this way, the participation of the public sector in research and transfer of agricultural technology, mainly managed through national research centers, also comprised a series of other forms of institutional organizations including, in some cases, national agencies producing technological inputs. Table 1 summarizes the most important of these.

Table 1. Institutional components of the system for generation and transfer of technology.

-
- I. PUBLIC SECTOR
1. Research departments of the ministries (Uruguay, Paraguay)
 2. National research institutes with or without extension (INTA, Argentina; ICA, Colombia; INIPA, Peru; etc.)
 3. National research enterprises (EMBRAPA)
 4. Research departments of state or provincial ministries
 5. Provincial or state institutions and/or agencies
 6. Mixed corporations by product (CEPLAC)
 7. Specialized national institutions by product
 8. Universities
 9. State enterprises
- II. PRIVATE SECTOR
- A. Processing and commercialization oligopolies (agro-industrial complexes)
 - B. Technological input procedures
 1. seeds
 2. chemicals
 3. fertilizers
 4. machines
 5. animal medicine
 - C. Agricultural producers
 1. large companies
 - i. palm oil (Costa Rica)
 - ii. banana (Costa Rica, Colombia)
 2. federations by product with and without state participation
 - i. sugar (Costa Rica, Colombia)
 - ii. coffee (Colombia, Costa Rica)
 3. associations of multi-product farmers
CREA, Argentina and CETA, Uruguay
 - D. Foundations and associations without a direct linkage to the productive system
FUSAGRI, Venezuela
-

B. The private components

Although the organizations belonging to the public sector continue to be the most important ones, specially from the point of view of the available human and financial resources, the organizational components of the private sector are progressively becoming more important.

The participation of the private sector in the innovation process is expressed through different forms of institutional and economic organizations. Simultaneously, this affects the specific objectives of the research developed, and the organization which is adopted to fulfill the given functions. Although the forms in which the private sector operates are virtually infinite, in order to analyze their role in the innovative process, it is convenient to characterize four main types.

The first of these is represented by oligopolies which control the processing or manufacturing of agro-food complexes.*

Transnational companies do not always have control of all the economic functions integrated by the complex. On the contrary, generally they control only some of the parts, through which it is possible to control

* An agro-food complex is defined as a set of economic functions which include production, processing, and circulation of one or more products with similar characteristics. For a discussion of this item see, for example, Vigorito and Suarez.

the entire set of activities performed by the complex. From the point of view of this paper, in some cases the technological components are important elements for the control of the complex. A classic example to illustrate this situation is the production of broilers. The main company controls the provision of chicks and the commercialization of the final product. In this case, technology is a central element of competition between companies, as well as in the subordination of other economic factors in the complex.

The second type of participation, and at the same time the most important in quantitative terms, is related to companies which produce technological inputs.

One of the main characteristics of the process of agricultural modernization experienced in Latin American agriculture is the growth in the use of inputs that incorporate technological innovations, and simultaneously are the principal components of technical change. A large proportion of these inputs are of industrial origin and result from research developed outside the agricultural sector.

The production and distribution of these inputs is done by private companies under the influence of large transnational corporations. The growth of the transnational sector was achieved in part through the acquisition of national companies. The subsidiaries generally specialize in the production of one or more inputs (or capital goods), for example, agricultural machinery or seeds, even though they belong to transnationals that are conglomerates with a wide array of activities.

The development of basic and applied research has had, in some cases, considerable impact upon the resources utilized. In the case of agricultural machinery and agrochemicals, the research carried out by the private sector is supported by better financial backing than the public sector. This subsector is a typical case of private appropriation of benefits and reconversion of technology into commercial goods.

The third type of private organization is directly related to the agricultural sector and is represented either by individual companies of large size or by farmers' associations, all of which -- with different objectives and legal organization -- develop research and/or transfer of technology activities. Table 1 shows the existence of farmers' associations related to the production of a single good, which usually needs some type of industrial processing, in contrast with other associations (CREA), formed by farmers who simultaneously produce several products, which is characteristic of South America.

Participation of this latter type of association is more related to the diffusion of technology than to research, although adaptive research is also part of their interest.

Finally, a fourth type of private organization is represented by associations and foundations which have no specific linkages to the productive system. This means that these organizations are not related to federations of producers or types of farmers' organizations. Their creation is generally the result of individual or institutional actions with philanthropic interests, or due to special circumstances.

IV. DETERMINANT FACTORS IN THE DEVELOPMENT OF THE PRIVATE SECTOR

The emergence and development of organizations belonging to the private sector described in the preceding section, and the participation of transnational corporations in their development, are both closely linked to the process of agricultural modernization. This process has specific characteristics, including a strong dependence on central countries, which explains the substantial participation of transnational corporations in the growth of industrial subsectors providing technological inputs or controlling the central core of agro-industrial complexes.

A discussion of conditions leading to this development exceeds the scope of the present work. Nevertheless, it is pertinent to analyze some specific conditions of sectorial nature, which influence in obvious ways the emergence and growth of these companies, and particularly the development of activities directed towards research and technology improvement. One of the empirical observations which gave rise to the project is related to the growing commercial importance of agricultural technology. This process implies the potential possibility that companies belonging to the private sector appropriate the benefits generated through the incorporation of technology into the productive system (2). This appropriation of benefits, directly through primary production, or indirectly through sale of technological inputs, is the driving force for the development of private organizations in the technological area.

In order to understand the logic of this development, as well as specific conditions which determine the emergence and qualitative nature of the development of the private sector, it is necessary to study the role which technology has played in the generation of surplus, and the socioeconomic conditions which determine the size of this surplus, and furthermore the way in which it is distributed among different social sectors. More specifically, it is important to understand the conditions which determine how certain social sectors may appropriate large enough surpluses so as to justify the creation of specific business activities. It is evident that the process through which technological innovations generate surplus, and the manner in which it is appropriated by different social sectors, depend upon certain economic conditions, the social organization, and the legal framework. Tentatively, these can be grouped into four areas (3):

- a. Size and nature of the market, and its growth perspectives;
- b. Social organization of agricultural production;
- c. Importance of technological knowledge as a competitive element, and the possibility to protect such knowledge;
- d. Measure in which the installation costs of the farms and the necessary research activities are subsidized by the public sector.

The relative importance of each of these areas varies for the different types of private organizations identified in Table 1. It also varies for different stages of development of these organizations. The following section presents some general factors affecting these relationships, and

their possible influence on the development of the private sector from the point of view of the business activity itself, as well as on specific research activities.

A. Nature and size of the market; perspectives for growth

The first point to consider is the size and degree of differentiation of the market for specific agricultural products. The size of the market is a crucial element in order to estimate the potential profit that could be developed from the investment. At the same time, the possibilities to differentiate the product, particularly with regard to certain characteristics which require or may incorporate specialized knowledge as a result of research, constitute an important element in defining the value of research activities. A traditional example of this situation are broilers, and certain fruits (strawberries) and vegetables (mushrooms).

These markets are very specialized, and the demand is strongly influenced by income levels of the urban population, by advertisement, and by the degree of sophistication of consumers.

At the same time, the nature of the supply, specially if it is organized through imports or national production (this is important in relation to the type of research activity which can be developed) will be chiefly determined by the degree to which the economic system is open (imports); by the relative perishability of the product; and by the structure of the industry at international level.

The size of the market for agricultural products requiring a certain degree of processing and identification (brands) is particularly important with respect to the development of enterprises taking part in processing and/or marketing within agrofood complexes, a position through which they can achieve a certain degree of control over the entire complex. The role of technology is generally very important, since it is one of the main elements influencing the product, the constancy of quality in some cases, and differentiation within the market.

The second element to be discussed is the size of the market for technological inputs. In this case, the main variables are the size of the agricultural sector and the importance of each particular crop; the degree to which production has been modernized; and the possibilities for export. This last point defines the relative importance of technological inputs for each unit of production and, consequently, the amount of use for each one of them.

Also, as in the previous case, the policies defining conditions for import are a crucial element in determining whether the supply of inputs is provided through import or national production.

B. The Organization of Agricultural Production

The conditions regarding the social organization of agricultural production are important from several points of view. First, consider the existence of large agricultural enterprises, with greater possibilities to take advantage of their economic power and develop

research and development activities to complement and/or replace existing ones in the public sector. This is particularly important in situations where, apart from the large scale of agricultural production, companies have achieved a high degree of vertical integration and control a significant part of the market in which they operate. In this last case, the position of these companies is very similar to that of others which control agro-food complexes, as described above.

Another important aspect is the actual industrial structure which leads to the formation of cartels which, in turn, use technology as a competitive instrument to gain an edge over those competitors that are not members of the cartel. An example of this situation is sugar production in Colombia, in which a high degree of concentration, integration, regional localization -- characteristic of this product -- and the existence of an export quota to the privileged USA market, opened the possibility and the necessity to create a cartel to distribute this quota among various sugar mills. Once this stage was achieved, technology, which had been an instrument of competition between mills, became an important component in the competition between the members of the cartel and other potential producers in different areas in the country. These two issues lead to the creation of a new research center, dedicated to cooperation in the development of the cartel members (see Piñeiro), in order to maintain their competitiveness in the market.

Even if this is a special case, it is possible to identify a number of situations with similar features, in which may be foreseen developments such as those described here.

C. The importance of technological knowledge, possibilities for private appropriation of benefits generated by technology, and possibilities to protect technological knowledge

A major element for the development of organizations dedicated to technology in the private sector, is the existence of technological innovations having a significant impact upon the productivity, or providing competitive advantages. The relationship between technology and generation of surpluses in the primary sector is strongly linked to the development of a private sector concerned mainly with the production and marketing of agricultural products. For the private sector, which produces (or imports) technological inputs, it is also necessary that the basic character of technology allow the private appropriation of benefits through production and sale of the specified inputs.

This last point requires technological innovation to be already incorporated as an input or a capital good (embodied technology) and that the market conditions (size, level of competition) guarantee a satisfactory level of profit.

These conditions determine development possibilities for entrepreneurial activities, but not necessarily the development of original research by these enterprises. The later activities are also influenced by the existence of a legal system of patents which protects those who generated knowledge (see, for example, Evenson and Evenson for a more complete discussion on this subject).

D. Socialization of research and installation costs

The previous sections have discussed some of the elements which influence the scope of surpluses generated by the size of the market and the level of prices. Nevertheless, the profit of entrepreneurial investment is also determined by costs associated with this activity.

In this way, the functions of the State can make specific activities more or less attractive, depending on whether or not it is an adequate and efficient provider of goods and services -- including technological knowledge -- and through it transfer a substantial proportion of the surpluses it directly generates. This line of thought could be used as a starting hypothesis to explain the entry of the private sector into the technological field.

In relation to entrepreneurial activities, subsidies-implied tax and credit policies, and the possible existence of direct subsidies, determine the degree to which the rest of society participates in sharing the costs derived from entrepreneurial activities. Similarly, the regulations regarding the payment of royalties, the transfer of capital, etc., directly influence the participation of transnational capital in the development of these activities.

On the other hand, research activities by private organizations are also influenced by the degree of socialization of the costs associated to research. It is important to mention here, as an example, costs associated to the development of human resources and the generation of basic knowledge necessary to develop new technology (4).

V. NATIONAL RESEARCH INSTITUTES IN THE NEW CONTEXT

A. Introduction

The national research institutes have been among the early agricultural institutions within the public sector in Latin America. The first were created more than 20 years ago, with the task of developing agricultural technology, and provide an example of institutional organization, efficient development of physical infrastructure, and adequate training of the scientific personnel required to carry out its functions.

The contribution of these organizations to the creation and diffusion of agricultural technology have not been systematically documented. Nevertheless, there is a large number of examples suggesting that their work has been effective.

However, because of the profound changes that have affected Latin American agriculture, resulting in part from the work carried out by these institutes, certain modifications in the organizational structure, as well as in the scientific conception, are necessary. These modifications should aim to adapt institutions to the profound changes in Latin American agriculture and the international scientific field, and should take advantage of the experience accumulated over the last 25 years.

B. The creation of institutes

The creation of INTA in Argentina was the first step in the cycle of institutional renewal that began in Latin America at the end of the 1950s. Following Argentina's experience, all countries on the continent, with the exception of three of the smallest, created research institutions similar to INTA during the 1960s and 1970s.

These institutes resulted from different pressures, internally within the countries and also at international level. The most important ones were the new international market conditions for specific agricultural products; the growing need to increase agricultural production in order to satisfy the demands imposed by urbanization and industrialization processes; and CEPAL's notion regarding the role that the state should play in transforming society. Within this framework, institutes would become a technological element in the complex structure of the public sector, with ample capacity to plan and pursue economic development.

C. The implicit assumptions

The creation of these institutes and the organizational form they adopted resulted from diagnosis of the conditions under which they should work, and from a series of assumptions regarding the international scientific environment. Of these, the following are particularly important:

- Latin America's agricultural sector was characterized by a dual, technologically backward agricultural structure, in which modernization was imperative and had to be adapted to the overall

needs of the countries. It was for this reason that the state had to become the instrument of modernization. This conception imposed certain limitations regarding the degree of participation of the agricultural sector in the management of the institution, and a natural tendency to create centralized agencies obedient to the policies of central government;

- The institutes should form part of the larger planning state-wide system. In this sense, they would implement policies defined at government level. On the other hand, the state was the only significant actor in the generation and diffusion of technology. The private sector had no significant role. These elements contributed to the institutes having a weak participation from the social sectors they wished to transform. At the same time, there was no apparent need to coordinate the different activities generated by other institutions or sectors involved in agricultural research;
- The developed countries had already experienced a technological revolution. This technology was available to developing countries, and in order to take advantage of it, they would have to develop an institutional structure capable of utilizing and adapting this technology to the individual context of each country;
- Finally, there was a preoccupation with the shortage of human and physical resources that could be mobilized in order to satisfy the needs of agricultural research. This shortage, at least when compared with the developed countries, suggested the need to

concentrate investments in a single institution, to ensure a certain critical mass and maximum efficiency by reducing duplication of efforts, and allowing the development of coordinated programs and projects.

D. The present situation

During the last two decades, Latin America's agricultural sector has changed significantly, as a consequence of a technological modernization process which, though unequal and fragmented, has produced noticeable increases in production. Simultaneously, the last two decades have seen a series of experiences, in regard to agricultural research organization that can be positively utilized in constructing a new perspective. The main elements of this new situation may be summarized as follows:

- The transformations undergone by the agricultural sector in some regions of the continent ensure the entrepreneurial nature of a large part of agriculture, which in turn makes rapid incorporation of available technology more possible. Moreover, the private sector has developed numerous activities related to generation and diffusion of technology, such as those introduced by seed and agrochemical companies and federations of producers (see preceding section).

This new situation has two important consequences. The first one is that it is now possible and necessary to achieve more effective integration of a wide spectrum of social sectors, related to technological development, in outlining priorities and managing

research institutions. The second is that, due to the multiplicity of institutions related to technological activities, the task of coordinating such activities becomes more important;

- The institutes should have been integrated in an institutional system, capable of formulating a technological policy to guide research activities. In fact, most countries have not developed adequate administrative instances for the formulation of such policies, and many institutes have acted implicitly without the support of an adequate organizational structure.

Moreover, the experience of the last few years has demonstrated the difficulties that exist in developing effective planning mechanisms in the context of market economies, and in the absence of adequate integration of technology users with the scientific community. This difficulty in planning from above reinforces the need for adequate mechanisms to link technology users with research institutions;

The scientific achievements of the developed countries is one of the most important issues of the last decades. Countries of small economic dimensions, as is the case for most Latin American nations, cannot ignore this fact, nor can they ignore their dependence on scientific information accumulated in developed countries. In spite of this, experience shows that each country must develop a strong research structure, which additionally will have to cover an ample range of technological needs and allow for the establishment of linkages with scientific activities in other countries.

This line of thought, together with the evidence regarding technological activities of the private sector, and the growing significance of international organizations such as the International Centers for Agricultural Research, demonstrates the need to clearly and precisely redefine the functions of national research institutes. It appears that, in the future, these should focus their attention on creating the basic knowledge required for the development of agricultural technology, largely undertaken by the private sector (e.g., genetics); pursuing general research for the generation of knowledge having little economic benefits that can be privately appropriated (e.g., soil maps); and carrying adaptive research regarding agricultural practices (agronomy) that generally cannot be developed by the private sector, especially in situations where small producers are important;

- One of the main observations resulting from an analysis of national research institutes is their manifest tendency to become progressively more bureaucratic in their management procedures and structures. A diagnosis of the problem suggests that possible reasons are their large institutional scope, the variety of problems that fall under their jurisdiction, the need to have control mechanisms to manage extended geographical coverage, and the image that some people have of these institutes as organisms that should serve a number of programs. The main point to be stressed is that research requires an institutional environment with guidelines that respect and promote scientific creativity and imagination. This requires a flexible administration, rather than just a hierarchical

one, without operational control elements of the type presently utilized and which are probably needed to manage other types of institutions.

E. General hypotheses regarding new institutional model

The diagnosis presented in the previous section suggests the need to consider some general modifications, which are deemed necessary in order to adjust this institutional model to a new context. The following present some elements that could contribute to a solution of the problems just discussed.

- Organization of a system for research and diffusion of agricultural technology. Although for many years institutes were the dominant institutions (in some cases virtually the only ones) in the area of research and technology transfer, it is important to recognize that now, in a majority of countries, there exists a set of public and private institutions participating actively in such activities. These institutions constitute an interrelated system, which must be coordinated in an organic and explicit manner. Moreover, the existence of a number of institutions provides the opportunity to create a competitive system, in which the mobility of researchers between institutions ensures a more dynamic and demanding work environment, with more specialized institutions dedicated to solving specific problems that confront the production system;

- An administrative instance for the formulation of technological policies. Each country should have the capacity to define a technological policy, that at least includes private activities, and a general framework regarding the desired type of agricultural development. The formulation of such policies is highly political in its contents, and consequently is intimately related to political power. At the same time and due to the special characteristics of scientific and technological activities, the formulation of these policies should include the participation of the scientific community and the users of new technology.

In this regard, the most adequate organizational mechanism appears to be a National Council for technological policies, with the participation of relevant social sectors and the scientific community, but without direct responsibility for the execution of research and diffusion of technology resulting from these policies. The chief instrument to implement a technological policy should be financial and, therefore, the commission could administer funds to support research activities. These activities would be implemented by the executive institutions, within the national research plans, that receive a high priority from the commission;

- Research requires a critical mass of human and financial resources. It also requires a flexible and responsive administrative system, in which authority is the consequence of scientific leadership and not of formal administrative hierarchies. To achieve such conditions, it appears that institutions must not be too large, and must have a

certain degree of specialization with a clear and precise linkage to technology users. In relation to these necessities, the system could be integrated in a number of autonomous institutions, with limited and precise mandates, replacing current institutes of large dimensions and mandates which cover an immense range of possible problems;

- Articulation with the users of technology. International experience suggests the need to develop institutional mechanisms to facilitate communication of research organisms with users of technology. This assertion mainly refers to, but not exclusively, agricultural producers. In the case of institutions dedicated to basic research, it is important that they be connected with clients of such information, i.e., in general, with other research institutions devoted to the technological development;

- The relationship with the international scientific community. The dependency and relationship of research carried out in less developed countries with the scientific knowledge generated by developed nations, is well known. However, in spite of a clear recognition of the problem, it was until now considered that transfer of information could be achieved through traditional mechanisms of scientific change, such as scientific publications, international conferences, etc. These mechanisms, although useful and important, appear insufficient as the level of complexity in technological information continues to rise, the development of technology becomes an activity of the private sector, and the centers dedicated to generating

technological knowledge multiply. In this sense, the experience of the industrial sector with respect to institutional mechanisms and actions directed towards international transference of technology, even though generally not very successful, could provide some important lessons.

The preceding five organizational principles illustrate possible changes necessary for the present research institutes. Obviously, modifications, especially with regard to coordination of research institutes with the productive sector, will have to reflect particular conditions in each country. Specifically, the characteristics of the social organization of production and the rest of the institutional system of the public sector, are elements that should be taken into account.

In relation to this, it is important to point out that the necessary reorganization of public institutions must also incorporate detailed information on the present situation and the future perspective of components of the private sector. This is an area in which information is less developed and, consequently, suggestions regarding technological policies are less elaborated. The objective of the present project is to contribute to an analysis of this subject.

VI. SOME GUIDELINES FOR THE DEVELOPMENT OF CASE STUDIES

A. Case studies in selected countries

Case studies conducted in Argentina, Brazil, and Ecuador are the main basic work to be implemented at this stage of the project. Consequently,

its principal objectives coincide with the project's general objectives, already described in Section II.

Regarding these objectives, we propose that case studies concentrate on the following activities.

- General description of the structure of public research system; evolution and present organizational structure;
- Identification of principal technological innovations experimented, in the last 20 years, in the main crops of each country studied;
- Analysis of the institutional origin of information required for the development of technology, and of technology itself. The role of the public sector in contrast with the private sector;
- Identification of the most important private companies playing a leading role in the generation of main technological innovations already identified;
- Description of the present agricultural research system, including its private and public components and their relationships with International Agricultural Research Centers and other international organisms;
- Analysis of the economic and organizational preconditions that appear to determine the development of the private sector and its characteristics. This analysis would intend to check the hypotheses

implicit in the general framework of analysis and would refer to the size and structure of the market, the development of preconditions in relation to the availability of basic knowledge, human and physical resources, and the legal system (in particular, that which is concerned with royalties, domestic capital, and the patent system);

- Evaluation of the biases of technical change implicit in the present system, and the impact of these biases on the pattern of present and future agricultural development;
- Assessment of the capacity of the institutional system to develop the necessary research and diffusion or technology activities for a coherent process of technological development. This requires a description of research functions necessary to achieve a balanced and effective supply of technology, as well as a comparison of the latter with those presently developed, in order to identify the main research gaps from a functional point of view;
- Identification of the main areas of science and technology policies and detailed recommendations concerning:
 - the nature of the research system;
 - the role of the public sector in research and diffusion of technology activities;
 - science and technology policies relating to the role of the private sector.

It is important to stress that the methodological proposal does not intend to achieve a complete and detailed description of the institutional model or the process of technical change. It neither intends to be a quantitative reconstruction of changes in the productive system from this process of technical change. On the contrary, the principal motive is to selectively characterize the main technological achievements and the organizations that mostly contributed to them.

The idea behind this proposal is to contribute to a qualitative interpretation of the general logic behind technical change, and the role played by the private sector in this process. This framework will be a central element in defining technological policies, especially with respect to the organization of an institutional system for agricultural science and technology.

B. A study of the seed sector from an international perspective

In the previous sections, we have described the growing internationalization of the technological phenomenon, in which the growth of transnationals is one of the most important elements.

This development is related to a series of issues, such as the industrial structure (concentration, oligopolization, etc.), the relationship of crops and ecological areas with those in the developed countries, and the importance of those crops in international trade.

In accordance with this, the project includes a study of one of the subsectors in which the international influence has been particularly important and interesting, and which may illustrate the general dynamics of the transnational influence upon the operation of private national organizations.

In relation with this objective, we propose to develop the following activities.

- A description of the development of the seed industry in Argentina and Brazil. Identification of main enterprises and of the crops in which these firms specialize;
- An analysis and identification of the contribution that international firms have made on the most important technological advances identified in national studies;
- The preconditions that lead to its development. Size and structure of the market; human and physical infrastructure for research. Plant breeders rights and other legal aspects;
- The relationship between national enterprises and transnational corporations. This analysis will emphasize:
 - the flow of information from the transnationals to the local companies;
 - the control of operations and executive decisions, as well as the distribution of profits;

- The relationship between private sector and IARCs. The international flow of information and technology. The analysis should concentrate on crops and identification of advances made in local studies;
- The relationship between private and public sectors in research, and the exchange of information (case studies);
- A characterization of research institutions contributing to the improvement of selected crops. Contributions of national public research and national private sector, the international private sector, and IARCs. The appropriation of profits in relation to contributions made;
- Technological biases implicit in the model and possible future consequences;
- Some policy areas of interest are:
 - the role of research by the public sector in the development of germplasm;
 - the role of the public sector in activities related to certification and control;
 - the legal system and its relation with the protection of plant varieties;
 - special problems of small countries;
 - conservation of germplasm.

The seed study comprises a series of activities which overlap with national studies, and is expected to be complementary to those studies. Nevertheless, the results should permit a more general appreciation of the influence which transnationals have on national technological development.

Notes

- (1) According to MacDermott, it is suitable to describe the innovative process as constituted by the following interrelated processes: basic research, development of technology, experimenting and adapting technology, and diffusion of technology to the productive system.
- (2) At this point, it is important to note that the appropriation of benefits as an incentive to develop certain productive activities implies a reference to the notion that an activity should not only bring a certain profit, but that this profit should be greater than that obtained through another activity. Thus, technological development has been converted into a key commodity and has a great capacity to heighten competitive levels, and therefore the profits obtainable from a large number of activities.
- (3) These elements are also influenced by what happens with social organization in the remaining sectors of the economy, and furthermore with those more closely linked to agricultural production.
- (4) Evenson has labelled this set of elements the "preconditions" necessary for research.

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