AGRICULTURAL R&D IN PARAGUAY

Policy, Investments, and Institutional Profile

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The International Food Policy Research Institute was established in 1975 to identify and analyze alternative national and international strategies and policies for meeting food needs of the developing world on a sustainable basis, with particular emphasis on low-income countries and on the poorer groups in those countries. While the research effort is geared to the precise objective of contributing to the reduction of hunger and malnutrition, the factors involved are many and wide-ranging, requiring analysis of underlying processes and extending beyond a narrowly defined food sector. The Institute's research program reflects worldwide collaboration with governments and private and public institutions interested in increasing food production and improving the equity of its distribution. Research results are disseminated to policymakers, opinion formers, administrators, policy analysts, researchers, and others concerned with national and international food and agricultural policy. IFPRI is member of the Consultative Group on International Agricultural Research (CGIAR).

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DIA is a technical agency under the Ministry of Agriculture and Livestock (MAG) responsible for crop research in Paraguay. DIA's objectives are to generate, validate, and transfer technologies suitable for sustainable development of crop and agroindustry sectors of Paraguay. This implies the development and diffusion of technologies adapted to the country's ecological, economical, and social conditions of the majority of Paraguay's producers. DIA is almost entirely dependent upon government and donor funding.

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Established in 1998, the Regional Fund for Agricultural Technology (FONTAGRO) is a consortium to promote strategic agricultural research of relevance for the Latin American and Caribbean Region, with direct participation of the countries of the region in priority setting and funding of research projects. FONTAGRO's purpose is to promote the agricultural sector's increase in competitiveness while protecting natural resources and reducing poverty in the region, through the generation of agricultural technologies with international public goods characteristics, and by facilitating the exchange of scientific knowledge among research organizations within the region, as well as with other regions. FONTAGRO's financial resources are basically the contributions of the member countries to an endowment fund, whose income finances regional and strategic research projects on a non-reimbursable basis. Research projects are developed and implemented by national research organizations (research institutes, universities, NGOs, and private organizations) and international and regional research centers working in association with national research entities. Projects are selected on a competitive basis, in accordance with the objectives of the Fund and its priority research areas defined in the Medium Term Plan, and evaluated by economic, technical, institutional, and environmental criteria established in the Fund's Manual of Operations.

ABSTRACT

By world, and even regional standards, Paraguay's agricultural R&D investments and institutions are comparatively small and almost entirely dependent upon government and donor funding. The institutional structure has remained virtually unchanged over the past three decades, with the majority of research conducted by the crop and livestock directorates of the Ministry of Agriculture and Livestock.

Government-performed agricultural R&D is, and has been, highly dependent on donor support in the form of two IDB loans in the 1970s and early-1980s and in more recent years in-kind donor contributions and technical cooperation from countries including Japan, Korea, and Germany. Government funding appears to have decreased during the early-1990s prompting a legislative proposal for the establishment of an independent semipublic agency funded by government and private sources. The proposal was prepared in the mid-1990s, and a decision has been pending since then; more recently the proposal has been put on hold until at least 2002; following a public reform process that is currently underway in Paraguay.

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ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
CETAPAR	Centro Tecnológico Agropecuario en Paraguay (Agricultural Technical Center of Paraguay)
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CIP	Centro Internacional de la Papa (International Potato Center)
CONACYT	Consejo Nacional de Ciencia y Tecnología (National Council for Science and Technology)
CRIA	Centro Regional de Investigación Agrícola (Regional Center for Crops Research)
DIA	Dirección de Investigación Agrícola (Crops Research Directorate)
DIAER	Dirección de Investigación Agropecuaria y Extensión Rural (Agricultural Research and Rural Extension Directorate)
DIEAF	Dirección de Investigación y Extensión Agropecuaria y Forestal (Agricultural and Forestry Research and Extension Directorate)
DIPA	Dirección de Investigación y Producción Animal (Animal Research and Production Directorate)
ENA	Escuela Nacional de Agricultura (National School of Agriculture)
FCA	Facultad de Ciencias Agrarias (Faculty of Agricultural Sciences)
FCV	Facultad de Ciencias Veterinarias (Faculty of Veterinary Sciences)
FIPAE	Fondo de Investigación para Proyectos Agrarios Especiales (Research Fund for Special Agrarian Projects)
FONACYT	Fondo Nacional de Ciencia y Tecnología (National Fund for Science and Technology)
FTE	Full-time equivalent
GDP	Gross domestic product
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Cooperation)
IAN	Instituto Agronómico Nacional (National Institute of Agronomy)
IDB	Inter-American Development Bank
IICA	Instituto Interamericano de Cooperación para la Agricultura (Interamerican Institute for Agricultural Cooperation)
INAPE	Instituto Nacional de Pesca (National Institute for Fisheries)
IPTA	Instituto Paraguayo de Tecnología Agraria (Paraguayan Institute for Agrarian Technology)
JICA	Japanese International Cooperation Agency
MAG	Ministerio de Agricultura y Ganadería (Ministry of Agriculture and Livestock)
NGO	Nongovernmental organization
PIDAP	Proyecto Integrado de Desarrollo Agropecuario del Paraguay (Multipurpose Agricultural Development Program of Paraguay)
PRODEGA	Projecto de Desarrollo Ganadero (Livestock Development Program)
PRONIEGA	Programa Nacional de Investigación y Extensión Ganadera (National Livestock Research and Extension Program)

ACRONYMS (continued)

PPP	Purchasing power parity
R&D	Research and development
SFN	Servicio Forestal Nacional (National Forestry Service)
STICA	Servicio Técnico Interamericano de Cooperación Agrícola (Inter-American Technical Service for Agricultural Research)
UNA	Universidad Nacional de Asunción (National University of Asunción)
USAID	United States Agency for International Development

CONTENTS

AGRICULTURAL R&D IN PARAGUAY: POLICY, INVESTMENTS, AND INSTITUTIONAL PROFILE

Nienke M. Beintema, Patricia Zambrano, Mario Nuñez, and Philip G. Pardey*

1. INTRODUCTION

In contrast to many other countries throughout Latin America efforts to revamp public-sector agricultural research and development (R&D) agencies in Paraguay have yet to come to fruition. Major change was proposed in the mid-1990s in the form of a proposal to establish a national agricultural research institute, the Paraguayan Institute for Agrarian Technology (IPTA), as a joint public-private venture with multiple funding sources. This institute would take over the activities of the Crop Research Directorate (DIA) and the Animal Research and Production Directorate (DIPA) of the Ministry of Agriculture and Livestock (MAG). IPTA's mandate would also include forestry research, currently under the mandate of the National Forestry Service (SFN), despite the fact that this agency discontinued research in recent years. The proposal for the creation of IPTA is still pending, however, and it now appears that no legislative decision will be made until at least 2002, following a public reform process that is currently underway in Paraguay.

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Paraguay is a landlocked country situated in the central zone of South America. Agriculture has been, and continues to be, the foundation of the country's economy, employing 35 percent of the economically active population in 1998 and generating 25 percent of GDP (World Bank 2000 and FAO 2000). The agricultural sector contributed over 80 percent of total export revenue in 1997. Soybean is the dominant commodity, contributing over 40 percent of total export revenue, excluding re-exports. Cotton was at one time the main export commodity, but its share of total export revenue has decreased substantially from around 30 percent in 1975 to only 6 percent in 1997, while total cotton-growing area dropped from 381,000 hectares in 1993/94 to 230,000 hectares in 1997/98. This decline was the result of a combination of factors including poor seed quality, the spread of the pest boll weevil from Brazil, and low prices. Despite the substantial decrease in total production, cotton remains an important part of Paraguay's economy because it is still the major income source for around 200,000 farmers (EIU 1998).[1]

This paper provides an overview of both recent changes and historical developments regarding agricultural research in Paraguay, reporting results of an institutional survey of agricultural R&D agencies—of which there are few.

[1] Cotton production involves labor-intensive, smallholder farming, while soybean production tends to involve large-scale, capital-intensive commercial operations.

2. POLICY AND INSTITUTIONAL DEVELOPMENTS

2.1 HISTORICAL PERSPECTIVES[2]

Agricultural research in Paraguay began in 1887 with the establishment of a private research station in Yaraguarazapá by Dr. Moisés Santiago Bertoni. Dr. Bertoni also established the Agronomic Station in Puerto Bertoni in 1894, and later became the first director of the National School of Agriculture (ENA) established in Trinidad in 1896. In 1914, ENA was renamed the Botanical and Zoological Museum and Garden, and from the early-1920s until 1930, German-born scientist Karl Fiebrig conducted agricultural research there, primarily related to cotton seed. Dr. Bertoni and his colleagues published more than 300 articles on agricultural issues during 1887–1929, and this extensive body of work led to the establishment of the Division of Agriculture and Agricultural Defense in 1923 with the aim of promoting cotton, tobacco, and other strategic crops. The division operated for a year under the umbrella of the Agricultural Bank of Paraguay, but in 1924 was removed from the bank's responsibility to become the Agriculture and Agricultural Defense Directorate, an autonomous body.

The directorate was closed in 1930, seemingly a consequence of a territorial dispute between Paraguay and Bolivia over access to the river Paraguay, and hence the Atlantic Ocean.[3] It was not until the early-1940s that public research resumed. In 1943, the Inter-American Technical Service for Agricultural Cooperation (STICA)—a U.S. government agency locally staffed by both Americans and Paraguayans—established the

[2] This section draws mainly from Alvarez (1986). Other references used in specific parts of this section are cited in the text.

[3] The dispute led to what is now known as "the Chaco War" (1932–35).

National Institute of Agronomy (IAN) in Caacupé (50 km east of Asunción) and the Experiment Station *Barrerito* in Caapucú (150 km south of Asunción). IAN focused its research predominantly on wheat, soybeans, beans, corn, sorghum, citrus fruits, cotton, tobacco, and pasture. *Barrerito* began as a demonstration farm for livestock and also sold bulls and female calves at subsidized rates. In 1953 a second agricultural experiment farm, *Chacra Experimental*, was established in Capitán Miranda. The latter was renamed the Regional Center for Crops Research (CRIA) in 1970, and focused its research on fruits, soybeans, corn, cotton, and wheat.

MAG was created in 1950, but seemingly didn't instigate research activities until 1966 when the ministry was restructured and STICA's responsibilities were transferred to its newly created Agricultural Research and Rural Extension Directorate (DIAER). Among other activities, DIAER had two separate research programs, one for crops and forestry, and the other for livestock. The former took over IAN and CRIA's operations, while the latter took over *Barrerito's* operations.

DIAER's Crops and Forestry Program focused on ten commodities (oil seeds, fruits, vegetables, wood, cotton, wheat, tobacco, meat, milk, and industrial oil seeds) and in 1969 was restructured and renamed the Agricultural and Forestry Research and Extension Directorate (DIEAF). At the same time, DIAER's Livestock Program was renamed the National Livestock Research and Extension Program (PRONIEGA), which was initiated by an international cooperation agreement between the U.S. Agency for International Development (USAID), MAG, and the Faculty of Agronomy and Veterinary Sciences at the National University of Asunción (UNA) (IDB 1971). PRONIEGA's establishment included two additional livestock experiment stations—*Chaco*, chosen to represent the western region where 40 percent of livestock area is

located, and *San Lorenzo*, the National Research and Extension Center. Concurrent with this 1969 restructuring, the original livestock activities at *Barrerito* became known as the Livestock Development Program (PRODEGA).

During the 1970s early-1980s Paraguay received funding to improve existing research facilities and to fund graduate-level training via two consecutive loans from the Inter-American Development Bank (IDB) for the Multipurpose Agricultural Development Program of Paraguay (PIDAP I and PIDAP II). The first loan was approved in 1971 and ran until 1975 at a cost of US$25 million. Along with upgrades to the existing facilities (IAN, CRIA, *Barrerito*, *San Lorenzo*, and *Chaco*) eight new experiment stations were built and equipped, and a substantial number of crop and livestock projects were undertaken during the early-1970s (IDB 1989). A second IDB loan of US$8 million was approved in 1979 to finance PIDAP II, which ran until 1987 at a total cost of US$13 million. With this second loan, US$4.7 million was earmarked for crop research and US$2 million for livestock research (Soler 1999). US$7 million was used for the construction of three new experiment stations along with further expansion and development of CRIA, *Barrerito*, and 21 extension stations—despite many difficulties such as major delays and design problems. Within the crop-research component, seven crops were targeted: cotton, tobacco, soybeans, wheat, rice, corn, and sugarcane. DIEAF released 41 crop varieties during 1967-86 (IDB 1989). Both programs included funding for postgraduate training abroad and short-term training courses for a large number of staff (Soler 1999).

Although these two loans contributed considerably to the improvement of the research facilities and training of staff, in actuality, research activities did not proceed at

many of the newly established or improved facilities. Two of the newly established experiment stations, for example, were never properly staffed or made fully operational.

In 1990, MAG's organizational structure was simplified with the establishment of three subsecretariats. DIEAF was renamed DIA and placed under the Subsecretariat for Crops. The Subsecretariat for Livestock took over the responsibility for PRODEGA and PRONIEGA, and these two were merged in 1994 to become DIPA.

SFN was created in 1995, and one of its six departments absorbed the forestry-related research formerly undertaken by DIEAF, but as mentioned earlier, SFN does not currently conduct research.

In order to address the agricultural needs of Japanese settlers in Paraguay's south, two training centers were established—the first in 1957 in Colonia Fram (currently called La Paz) and the second in 1962 in Colonia Alto Paraná (currently called Yguazú).[4] In 1972 the two centers were merged, to be renamed the Agricultural Experiment Center of Paraguay two years later. In 1988 the center was renamed the Agricultural Technical Center of Paraguay (CETAPAR). CETAPAR has engaged in research and extension activities since its early days, targeting commodities of primary interest to the Japanese settlers (soybeans, wheat, tomatoes, livestock, and pastures). Since 1985 the Japanese International Cooperation Agency (JICA) has held administrative responsibility for CETAPAR.

In 1956, the Faculty of Agronomy and Veterinary Sciences was established at the National University of Asunción (UNA), located in San Lorenzo.[5] This faculty was

[4] Paraguay is divided into geopolitical boundaries called departments. *Colonias* are colonization areas.

[5] The National University of Asunción was established in 1890, and was the only university in Paraguay until 1960 when the private Catholic University of Asunción was established. Several other

divided in 1974 to become the Faculty of Agronomic Engineering and the Faculty of Veterinary Sciences (FCV). The Faculty of Agronomic Engineering was renamed the Faculty of Agricultural Sciences (FCA) in 1994. It has three additional campuses in Pedro Juan Caballero, Caazapá, and San Pedro del Ycuamandyyú, which were established in 1980, 1994, and 1996, respectively. More than 2,300 students have graduated from FCA since its establishment in 1974 (FCA 1998).

2.1 CONTEMPORARY DEVELOPMENTS

Agricultural research in Paraguay is conducted by only a small number of agencies.[6] They mainly undertake applied research; basic research activities account only for a small share of the total (Ovelar 1999). DIA—one of two directorates under MAG currently conducting research—is the most significant agency. DIA's headquarters is located in San Lorenzo and accommodates the national director and three departments: the Department for Planning, Monitoring, and Evaluation; the Department for Technology Transfer; and the Department for Technical Coordination. In addition, DIA consists of IAN, CRIA, the Experiment Station *Chaco Central*, and six experiment farms located in various regions of the country (see appendix table C.1 for DIA's organizational structure). *Chaco Central* is the only unit in DIA that is located in the western region of Paraguay; all other units, including DIA's headquarters, are located in the country's eastern region. IAN and CRIA have adequate technical staff and infrastructure to conduct long-term research. The research station and six farms are considerably smaller in size

private universities have been established since then, but UNA remains the only one with an agricultural research program.

[6] These agricultural R&D agencies are listed in appendix B.

(e.g., less than 10 researchers) and are mainly used for varietal testing and for site replication of research projects (Santander 1992). Research activities are organized into twelve national programs, eight of which focus on crops (see appendix table C.3 for details).

DIA has on-going cooperation agreements with various international technical corporation agencies such as the German Agency for Technical Cooperation (GTZ) and JICA, which have manifested as joint research projects accompanied by considerable financial grants. These grants have even stretched to provide for experiment stations, such as *Loma Plata* in Chaco Central. In addition, cooperation agreements exist between DIA and the Inter-American Institute for Agricultural Cooperation (IICA), and with the three Latin American based centers of the Consultative Group on International Agricultural Research (CGIAR): the International Center for Tropical Agriculture (CIAT), the International Maize and Wheat Improvement Center (CIMMYT), and the International Potato Center (CIP). These international agreements have helped DIA to train its research staff and to introduce new crop varieties (Macagno 1993).

Livestock, veterinary, and fisheries research at MAG fall under the responsibility of DIPA but, in contrast to DIA, research is not its sole activity.[7] DIPA's research focuses on meat, milk pasture, bee keeping, fisheries, sheep and goats, animal nutrition, meat bi-products, and veterinary diagnosis. Research is carried out at the experiment stations *Barrerito* (in Caapucú), *Chaco* (in Río Verde), and *Eusebio Ayala*, named for the town in which the station is located (see appendix tables C.2 and C.4 for DIPA's organizational structure and research programs).

[7] DIPA is also responsible for extension.

A key factor in Paraguay's agricultural R&D restructuring was the creation of the National Council for Science and Technology (CONACYT) in 1997. The council represents public and private interests in the formulation of national science and technology policies, including the necessary funding mechanisms—the latter being implemented by the National Fund for Science and Technology (FONACYT). As previously mentioned, a proposal was developed in the mid-1990s to merge DIA and DIPA, along with the suspended forestry research activities of SFN, into one national agency responsible for crops, livestock and forestry research, IPTA. The IDB was instrumental in forming these plans and committed to a new loan that would encompass, among other things, the establishment of the institute. Under this current proposal, IPTA would be a semipublic organization with control over funds received from the government as well as other funding raised through international or national agreements or treaties, revenues from sales and services, and other resources. The proposal also included the creation of a Research Fund for Special Agrarian Projects (FIPAE), which would support representation of IPTA researchers, private consultants, universities, and regional government in the formulation and implementation of private-sector-driven R&D projects. To date, progress on enacting the legislation for the creation of IPTA has been slow. The proposal was developed in 1993, submitted to congress in 1995, and since then has remained on hold. More recently it was announced that no decision will be made until at least 2002 given plans for public-sector reform, which will impact MAG and likely necessitate a major overhaul of what by that time will be a nine-year-old proposal.

As previously discussed, CETAPAR engages in research, extension, and training activities predominantly for Japanese settlers. Research focuses on cereal, vegetables, livestock, soil, and crop protection. Although CETAPAR is a relative small agency, its

research activities are significant because of the prominent role the center played in the agricultural development of southern Paraguay. CETAPAR has claimed that the introduction and rapid expansion of soybean production in recent years can be traced to their research and extension efforts. CETAPAR introduced stable, high-yielding soybean varieties that are planted by 45 percent of all Japanese producers. They also introduced new wheat varieties, greenhouse tomatoes, livestock breeds, and improved pasture species (JICA 1996). CETAPAR is located in Yguazú in the department Alto Paraná, where all its R&D activities are carried out, and has an extension center in Pirapó. Cooperation between CETAPAR and DIA is on-going, with two DIA personnel currently at CETAPAR working on wheat and soybeans, and sustainable production practices of cereals. CETAPAR is also collaborating with GTZ.[8]

Staff at UNA's FCA and FCV also engage in research, although most of their time is spent teaching. FCA undertakes research in the areas of agronomic engineering, forestry, human ecology, and fruit trees. FCV conducts research in the areas of animal production, veterinary medicine, and fisheries.

A small number of other agencies in Paraguay have some (often ad-hoc) research activities, but their contributions to total agricultural research are minimal. Some nongovernmental organizations (NGOs) carry out agricultural research, predominantly on a regional basis specializing in crops like cassava and other staple foods for smallholder farmers, the aim being safeguarding traditional agricultural practices for sustainable agriculture (Santander 1992). No research is conducted by multinational private companies in Paraguay, but some national private-sector R&D exists. Examples are private sugarcane plantations in the department of Guaira; crop and livestock research

[8] In 1999 one German researcher was situated at CETAPAR as part of this GTZ project.

undertaken by the Mennonites[9] in the department of Boquerón; and grain and sustainable production research conducted by descendents of Japanese and European settlers in the departments of Alto Paraná and Itapúa. Such private-sector and NGO research is excluded from the data analysis in the remainder of this paper because it accounts for a minimal share of total agricultural R&D in Paraguay, and is difficult to measure accurately.

3. FUNDING SOURCES AND MECHANISMS

Only partial data on funding sources were available for DIA, and no information was forthcoming for the other four agencies in our sample. In 1998, DIA received $5.5 million (1993 international dollars)[10] or 3,362 million 1993 guaranies from the government via MAG (table 1). Fiscal crisis in Paraguay during the 1990s caused total government funding to decrease at an average rate of 3.3 percent per year. Revenues from the sale of products such as seed, cotton fiber, and laboratory services accounted for only a small share of total funds and remained fairly constant over the years. In 1998 sales revenue totaled $0.3 million (1993 international dollars) or 181 million 1993 guaranies.

[9] The Mennonites are descendants of the Anabaptists, one of several reformist groups in Switzerland and Holland during the early 16th century.

[10] The financial data in this paper were converted to 1993 international dollars by first deflating funds compiled in local currency units using a Paraguayan GDP deflator with the base year 1993, and converting to U.S. dollars using a 1993 purchasing power parity (PPP) index from World Bank (2000) (see also appendix A). PPPs are synthetic exchange rates used to reflect the purchasing power of currencies, typically comparing prices among a broader basket of goods and services than do conventional exchange rates.

Table 1—*Trends in DIA's Funding Sources, 1991-98*

	1991	1992	1993	1994	1995	1996	1997	1998
Funds in constant local currencies				(*million 1993 guaranies*)				
Government	3,944.4	4,918.8	3,762.2	3,646.7	3,470.3	3,548.0	3,673.7	3,362.0
Sales	150.2	143.1	178.9	218.5	321.8	261.0	292.0	181.0
Total	*4,094.6*	*5,062.0*	*3,941.1*	*3,865.2*	*3,792.1*	*3,809.0*	*3,965.7*	*3,543.0*
Funds in constant international dollars				(*million 1993 international dollars*)				
Government	6.4	8.0	6.1	6.0	5.7	5.8	6.0	5.5
Sales	0.2	0.2	0.3	0.4	0.5	0.4	0.5	0.3
Total	*6.7*	*8.3*	*6.4*	*6.3*	*6.2*	*6.2*	*6.5*	*5.8*
Shares				(*percentage*)				
Government	96.3	97.2	95.5	94.3	91.5	93.1	92.6	94.9
Sales	3.7	2.8	4.5	5.7	8.5	6.9	7.4	5.1

Source: Compiled by authors from survey data; GDP deflators and 1993 PPP from World Bank (2000).

Note: Data exclude donor contributions, which were mainly received in kind.

Table 1, however, does not provide a complete picture of DIA's total funding as donor contributions to DIA are excluded. These are mostly *in kind* contributions (e.g., infrastructure and equipment) and therefore are difficult, if not impossible, to estimate. Such contributions have been on going since DIA's predecessor, DIEAF, was established. In addition, DIA has received considerable international technical cooperation over the years in the form of long- and short-term visiting researchers.

Japan is DIA's primary donor, over the years providing substantial in kind contributions. In addition, a number of JICA researchers have visited DIA to provide technical assistance. In November 1998, for example, 10 Japanese researchers from JICA visited DIA to work on soybean research and fruit and vegetable production (such as strawberries and tomatoes). Currently there are three long-term visiting researchers from Japan along with several others who come and go as projects dictate. The German government built a new research center in Chaco as part of a GTZ project that began in

the early 1990s, and the Korean government purchased equipment for DIA's biotechnology laboratory in addition to providing technical assistance through visiting scientists. DIA also received technical assistance and contributions in kind from the governments of China—for research on biotechnology, vegetables, orchids and other flowers, and pineapples—and of France for cotton research.

Despite lack of information on funding sources for the other agencies, it is known that CETAPAR is almost completely funded by the Japanese government.[11]

4. HUMAN AND FINANCIAL RESOURCES

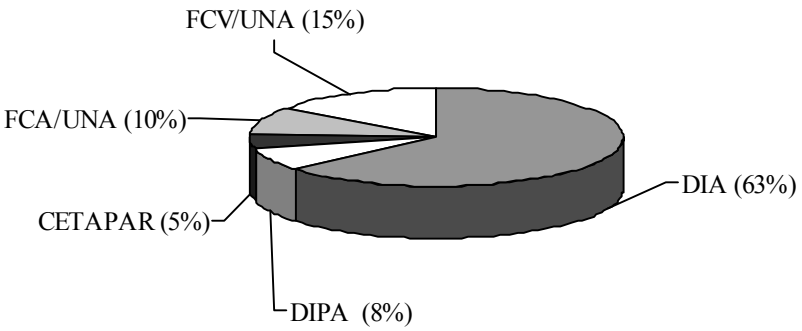
4.1 AGRICULTURAL R&D STAFFING TRENDS

Most of the agricultural R&D activities in Paraguay are carried out by the public sector. In 1996 the five agricultural R&D agencies in our sample employed a total of 158 full-time equivalent (fte) researchers (figure 1).[12] Close to two thirds of these were employed at DIA (100 fte researchers), UNA's FCA and FCV accounted for 24 percent combined, leaving DIPA and CETAPAR with only 5 and 8 percent respectively.

[11] Following the definitions in appendix A and the Frascati Manual (OECD 1994), CETAPAR is categorized as a "government agency, abroad" and so would normally be excluded; however, given CETAPAR's importance in the development of the Paraguayan agricultural sector, we chose to include it here.

[12] See appendix A for definitions of fte and other concepts used throughout this paper.

Figure 1—*Composition of Paraguayan Agricultural R&D Personnel, 1996*



Source: Compiled by authors from survey data.

Historical data on total research staff were only available for DIA, DIPA, their predecessors, and partly for CETAPAR. Total fte research staff of the government agencies increased steadily from the late-1970s through to the early-1990s (from 36 in 1977 to 128 by 1992) with annual growth rates of 13.5 and 6.9 percent for the late-1970s and 1980s respectively (table 3). From 1992, however, total government research staff decreased to 112 fte researchers in 1996. This decline coincides with cuts to government funding already discussed, and was more severe for DIPA, which experienced an average decline of 9.6 percent per year during the early-1990s. The decline in DIA's research staff during the same period appears to be the result of structural changes rather than the fiscal crisis. When the directorate moved from Asunción to Caacupé, not all staff agreed to move, some remaining at MAG; a further five researchers went to FCA when the Experiment Station *Caazapá* moved there from DIA in 1996.

Researcher data for CETAPAR were only available from 1989. In contrast to the government agencies, CETAPAR's research staff numbers increased in the early-1990s with an average of 11.0 percent per year, but from a very small base.

Table 2—*Trends in Nonacademic Research Staff, 1976–98*

	Government agencies				
	DIA[a]	DIPA[b]	Subtotal	CETAPAR	Total
Researchers			(*fte's per year*)		
1976–80	30.2	11.2	41.4	na	na
1981–85	64.5	17.5	82.0	na	na
1986–90	96.0	20.0	116.0	4.3[c]	na
1991–95	107.6	15.7	123.3	6.3	129.6
1996	100.0	12.0	112.0	7.5	119.5
1998	100.0	na	na	na	na
Annual growth rates[d]			(*percentage*)		
1976–81	15.78	8.05	13.52	na	na
1981–91	8.12	1.92	6.92	na	na
1991–96	–1.88	–9.55	–2.86	11.01	–2.25
1971–96	8.18	1.50	6.88	na	na

Source: Compiled by authors from survey data, Oram and Gieben (1984), and Alvarez (1986).

Note: Data are presented as five-year averages. No timeseries data were available for FCA and FCV.

a. DIA was established in 1990; prior data are for its predecessor DIEAF.
b. DIPA was established in 1995; prior data are for its predecessor PRONIEGA.
c. Average for 1989–90.
d. Least squares growth rates.

Degree Status

In 1996 over one third of the 158 fte researchers in our five-agency sample held postgraduate degrees while the overall number of researchers trained to PhD level was small (4 percent or 6.4 fte researchers). By way of comparison, Uruguay—also a small country in terms of total agricultural research agencies and staff—had a comparable share of 35 percent of total fte research staff trained to the postgraduate level in 1996 (Beintema et al. 2000b). The corresponding share in a mid-size country such as Colombia was considerable higher at 49 percent in the same year (Beintema et al. 2000a).

The share of fte researchers with postgraduate degrees varied substantially among the different agencies. DIA and DIPA had lower postgraduate researcher shares than the

five-agency average (27 and 15 percent respectively) in 1996, and only one researcher held a doctorate degree. Shares of fte research staff with postgraduate degrees at FCA and FCV were 76 and 64 percent respectively. CETAPAR employed 2.7 fte researchers with doctorate degrees—mainly Japanese researchers trained in the early-1960s—but none with MSc degrees.

Table 3—*Degree Status of Paraguayan Researchers, 1996*

	Researchers				Shares		
Type of Agency	BSc	MSc	PhD	Total	BSc	MSc	PhD
		(*fte's*)				(*percentage*)	
Government Agencies							
DIA	73.0	26.0	1.0	100.0	73.0	26.0	1.0
DIPA	10.2	1.8	–	12.0	85.0	15.0	–
Higher education agencies							
FCA/UNA	3.6	9.6	1.7	15.0	24.3	64.3	11.4
FCV/UNA	8.4	13.6	1.0	23.0	36.4	59.3	4.3
Other							
CETAPAR	4.8	–	2.7	7.5	64.0	–	36.0
Total	*100.0*	*51.1*	*6.4*	*157.5*	*63.5*	*32.4*	*4.1*

Source: Compiled by authors from survey data.

Given UNA does not offer relevant postgraduate training in the agricultural sciences, all postgraduate degrees were obtained abroad, mostly in Brazil and Argentina. Most of the degrees obtained in the 1970s and early-1980s were financed through the IDB-supported PIDAP I and II projects.[13] Others received grants offered by universities abroad.

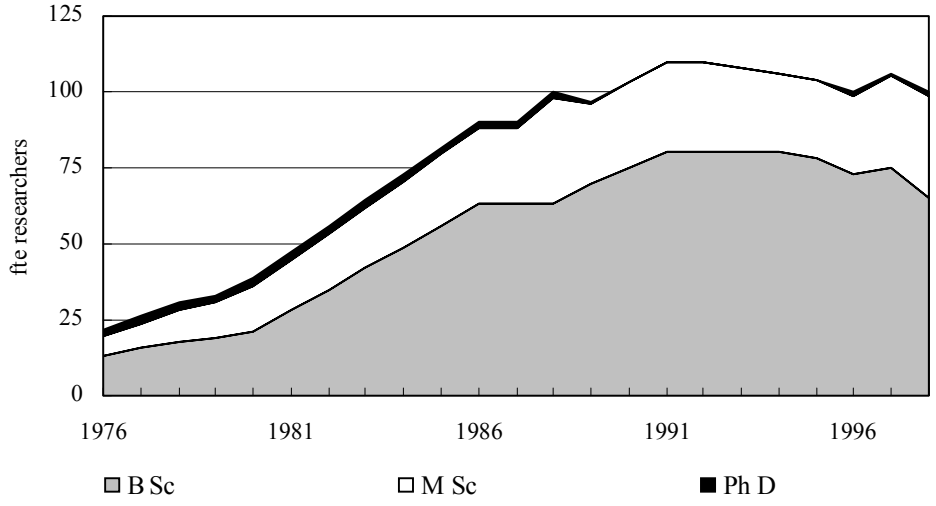
Reliable historical data on degree status were only available for DIA and its predecessor DIEAF (figure 2). In contrast to many other Latin American countries the

[13] Six MAG staff undertook doctorate training and 35 MSc training abroad. In addition 38 staff undertook 6 to 12 months of professional training (Soler 1999).

share of researchers with postgraduate degrees has decreased over the years from an average of 42 percent during the late 1970s to an average of 26 percent during the early-1990s. In 1998, however, 10 researchers holding BSc degrees left DIA resulting in an increase in the postgraduate researcher share to 35 percent.

More particularly, the number of researchers with doctorate degrees remained very low over the entire period. During the late-1970s and 1980s only two to three DIEAF researchers held doctorate degrees, during DIA's first six years there were none, and during 1996-98 there was only one. Seemingly, this was the result of low salaries, a disincentive for researchers to work in the government sector.

Figure 2—*Degree Status of DIA's Research Staff, 1976–98*



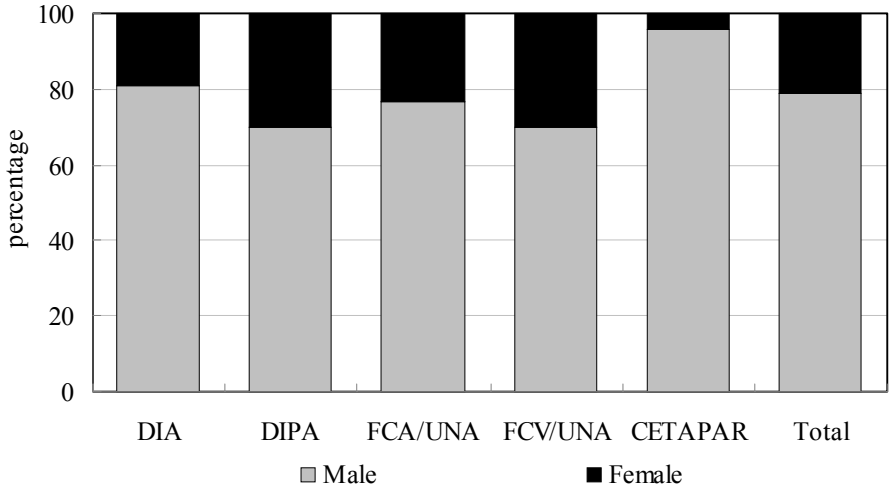
Source: Compiled by authors from survey data.

Gender

In 1996, 21 percent of the 158 fte agricultural researchers in our sample were female, ranging from 4 percent at CETAPAR to 30 percent at DIPA and FCV (figure 3). This average share of female staff for Paraguay agricultural R&D agencies is comparable to the average share of female staff employed at the Colombia agricultural R&D agencies

(Beintema et al. 2000a), but lower than the 30 percent found for their Uruguayan counterparts (Beintema et al. 2000b).

Figure 3—*Gender of Research Staff, 1996*



Source: Compiled by authors from survey data.

DIA—the only agency for which we had historical data—experienced a substantial increase in the share of females in total research staff from 14 percent in 1986 to 21 percent in the early 1990s to 29 percent in 1998. A common trend in many Latin American countries is a somewhat higher average share of female agricultural students to female researchers in total agricultural research staff. This is most often the result of a drop in the share of women pursuing professional careers after graduation. Paraguay followed this trend with shares of female students of 30 and 38 for FCA and FCV respectively in 1996, which was considerable higher than the 21 percent share of female agricultural scientists.

4.2 AGRICULTURAL R&D EXPENDITURE TRENDS

Historical data on expenditure were available for DIA and DIPA for the period 1976–96, and for CETAPAR for 1991-96 (table 4). Total expenditures for the two government agencies increased in constant prices at an average rate of 5.5 percent per year and in 1996 totaled $7.3 million (1993 international dollars) or 4.5 billion 1993 guaranies. The intertemporal pattern of growth was uneven with two periods of considerable growth. The first period was a result of the aforementioned IDB projects—PIDAP I and II—during the 1970s and early-1980s (figure 4). The second period of growth occurred during the late-1980s and appears to be the result of increased government contributions to DIA and DIPA—a result of the newly established democracy. These two periods of growth were separated by severe deterioration in the expenditures of the two government agencies during the mid-1980s. In the early-1990s total expenditures again declined for the two government agencies as a result of the fiscal crisis, but this was less severe than the decline during the mid-1980s. However, as previously mentioned, DIA's expenditure figures—and probably DIPA's as well—do not include in kind contributions from donors. It appears that these omitted contributions are sizable and have been increasing in recent years, therefore the effect that these contributions would have on the negative trend of the 1990s, were it possible to quantify and include them, is unclear.

Contrary to the government agricultural R&D expenditures, CETAPAR's expenditures increased during the early-1990s with a growth rate of 16.8 percent per year, but, again, from a comparatively small base.

Table 4—*Trends in Paraguayan Nonacademic Agricultural Research Expenditures, 1976–98*

	Government agencies				
	DIA[a]	DIPA[b]	Subtotal	CETAPAR	Total
Expenditures in constant local currencies		(*thousand 1993 guaranies per year*)			
1976–80	1,236.5	516.9	1,753.4	na	na
1981–85	4,116.5	636.4	4,752.8	na	na
1986–90	2,089.5	304.8	2,394.3	na	na
1991–95	4,151.0	687.5	4,838.5	283.8	5,122.3
1996	3,809.0	659.2	4,468.3	436.2	4,904.5
1998	3,543.0	na	na	na	na
Expenditures in constant international dollars		(*thousand 1993 international dollars per year*)			
1976–80	2.0	0.8	2.9	na	na
1981–85	6.7	1.0	7.8	na	na
1986–90	3.4	0.5	3.9	na	na
1991–95	6.8	1.1	7.9	0.5	8.4
1996	6.2	1.1	7.3	0.7	8.0
1998	5.8	na	na	na	na
Annual growth rates[c]			(*percentage*)		
1976–81	39.33	37.23	39.23	na	na
1981–91	–5.79	–7.88	–6.27	na	na
1991–96	–3.50	–0.64	–3.13	16.88	–2.03
1971–96	6.42	2.22	5.49	na	na

Source: Compiled by authors from survey data and Oram and Gieben (1984); GDP deflator and 1993 PPP from World Bank (2000).

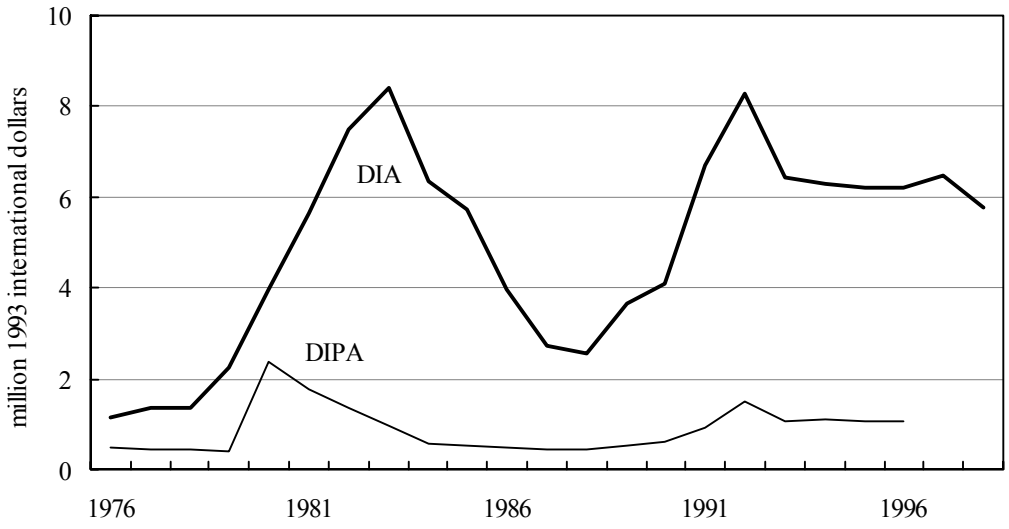
Note: Data are presented as five-year averages. No time-series data were available for FCA and FCV.

a. DIA was established in 1990; prior data are for its predecessor DIEAF. Data exclude donor contributions, which were received predominantly in kind.

b. DIPA was established in 1995; prior data are for its predecessor PRONIEGA.

c. Least squares growth rates.

Figure 4—*DIA and DIPA's Research Expenditure Trends, 1976-98*



Source: Compiled by authors from survey data and Oram and Gieben (1984).

Expenditure data for FCA and FCV included only direct research funding from the university and research funds obtained from other sources. Ideally, total expenditure should also include an estimate of basic operating costs associated with the research including salaries, rent, and utilities based on time spent on research, but this information is not usually available. As an alternative, an estimate of total research expenditure for the two faculties was calculated using combined average expenditure per researcher data for DIA and DIPA in 1996, scaled up using the total fte researchers employed by the FCA and FCV. This calculation yielded an estimated $10 million (in 1993 international dollars) in total spending on agricultural R&D for 1996, equivalent to 6,421 million 1993 guaranies (table 5).

Table 5—*Total Agricultural R&D Expenditures and Intensity Ratios, 1996*

Total agricultural R&D expenditures in—	
millions 1993 international dollars	10.5
millions 1993 guaranies	6,420.5
Agricultural R&D expenditures as a share—	
of Agricultural GDP	0.2
Expenditures per researcher in—	
thousands 1993 international dollars	66.6
thousands 1993 guaranies	40,765.1
Expenditures per capita in—	
1993 international dollars	2.1
1993 guaranties	1,295.2
Expenditures per economically active agricultural population in—	
1993 international dollars	15.8
1993 guaranties	9,654.9

Source: Compiled by authors from survey data; Agricultural GDP, GDP deflators, and PPP from World Bank (2000); Total and economically active agricultural population from FAO (2000).

Note: Expenditures for FCA and FCV are estimated using average expenditures per researcher for DIA and DIPA combined.

Intensity Ratios

Intensity ratios—total public R&D spending as a percentage of agricultural output (AgGDP)—are commonly used to compare a country's agricultural R&D spending in an international context.[14] In 1996, the share of agricultural R&D spending relative to agricultural GDP was 0.2 percent, which is low compared with other developing countries. For example, the intensity ratio for Colombia was 0.53 percent in the same year (Beintema et al. 2000a). As discussed earlier, however, total expenditures for DIA, and probably for DIPA as well, exclude considerable in kind donor support not included

[14] Some exclude for-profit private research expenditures when forming this ratio, presuming that such spending is directed toward input and postharvest activities that are not reflected in agricultural GDP. Given the lack of private R&D in Paraguay, this was not an issue in this case.

in our figures. The inclusion of these figures would raise the intensity ratio for Paraguay, but we suspect it would still be low compared with many other developing countries.

Two other internationally comparable expenditure indicators are agricultural R&D spending per capita and agricultural R&D spending per economically active agricultural population. In 1996, for Paraguay these measured $2.1 and $15.8 respectively (in 1993 international prices). By way of comparison, for Colombia agricultural R&D spending per capita was $3.3 the same year (Beintema et al. 2000a).

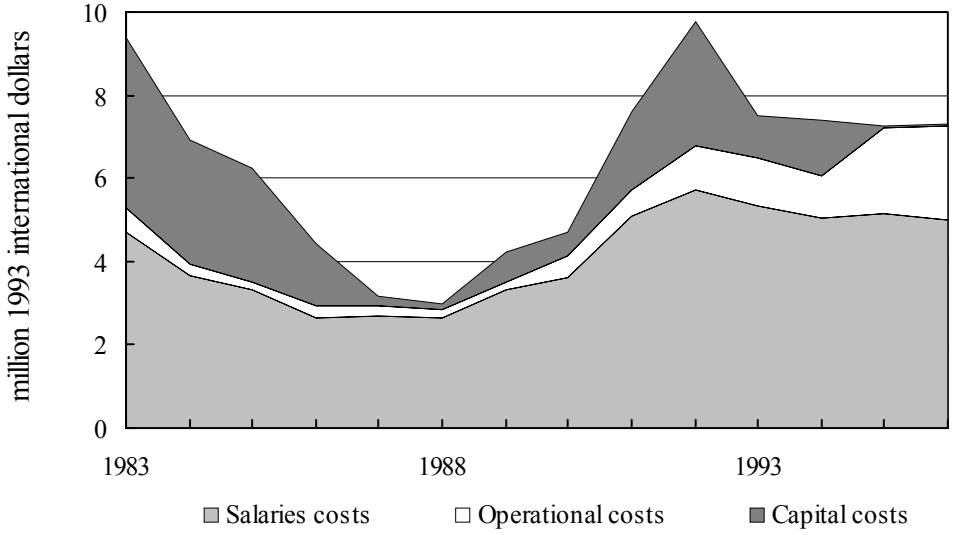
Cost Structures

The breakdown of the various cost categories for DIA and DIPA for 1983-96 clearly shows the effects of the investments in infrastructure made as part of PIDAP II (figure 5). In 1983 capital costs accounted for 45 percent of total expenditures of the two agencies combined. In 1987, which marked the end of the IDB project, the share of capital costs was only 5 percent. Since that year, capital costs have increased, and peaked in 1992, however during 1995-96 only a fraction of total costs were spent on capital investments.

In 1996 total salary costs were $5.0 million, which is slightly higher than in 1983 when the total was $4.7 million, but considerably higher than the mid-1980s when total salary costs were well below $3.0 million (1993 international prices). The share of salaries in total expenditures increased over the years, obviously with declining capital investments in absolute terms. In 1996 the shares of salaries in total costs were 71 and 54 percent for DIA and DIPA respectively. For DIA 1998 data showed a continuation of this trend with a share of 76 percent.

The shares of operational costs have increased over the years from 6 percent in 1983 to 31 percent in 1996.

Figure 5—*DIA and DIPA's Total Expenditures by Cost Categories, 1983–96*



Source: Compiled by authors from survey data and Oram and Gieben (1984).

Note: Operational and capital costs exclude donor contributions mainly given in kind.

5. RESOURCES PER RESEARCHER

5.1. SUPPORT STAFF RATIOS

In 1996 the average number of support staff per scientist was 1.7 for four agencies (excluding CETAPAR)—0.4 being technicians, 0.7 being administrative personnel and 0.6 other support staff such as laborers, guards, drivers, and so on (table 6). DIPA had far more support staff per scientist than the other institutes, but most of its supports staff were in the "other" category: DIPA had no technicians employed in 1996 and only 0.40 administrative support staff per scientist—less than the 4-agency average. Paraguay's ratio of support staff per scientist in 1996 was slightly lower than the corresponding ratio

of 1.8 for Uruguay, but considerably lower than Colombia's ratio of 2.7 (Beintema et al. 2000a and Beintema et al. 2000b).

Table 6—*Support-Staff-to-Scientist Ratios, 1986 and 1991–98*

	DIA				DIPA	FCA	FCV	Total[a]
	1986	1991-95	1996	1998	1996			
	(fte's per researcher)							
Technicians	0.79	0.42	0.51	0.51	–	0.34	0.21	0.41
Administrative support	0.93	0.58	0.73	0.65	0.40	1.12	0.32	0.68
Other support	0.49	0.26	0.30	0.24	3.15	0.51	0.63	0.60
Total support	*2.20*	*1.26*	*1.54*	*1.40*	*3.55*	*1.97*	*1.16*	*1.69*

Source: Compiled by authors from survey data.

Note: No data were available for CETAPAR.

a. 1996 total is weighted average for the 4 agencies.

DIA's total support staff decreased by more than 20 from 1986 to 1998; 12 of those were in the "other support" category. Combined with a small increase in total research staff, the support-staff-per-scientist ratio declined from 2.2 in 1986 to 1.4 in 1998.

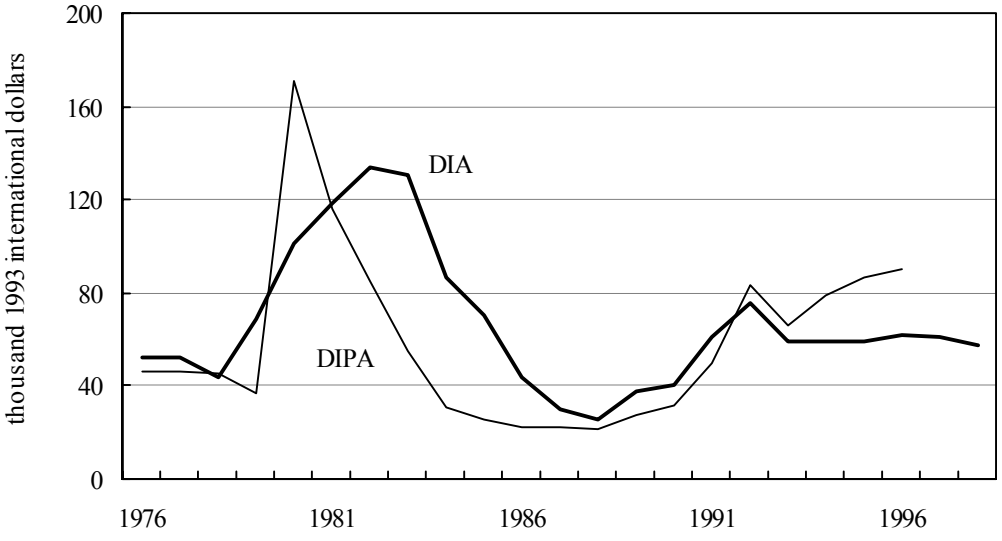
5.2 SPENDING PER RESEARCHER

Another common indicator for international comparisons of levels of agricultural R&D resources across countries is average spending per scientist. This is also an important indicator for developments over time and among institutions. Expenditure per researcher for DIA and DIPA combined decreased during 1976-96 by 1.3 percent per year and measured $65,000 (1993 international dollars) in 1996 or 39.9 million in 1993 guaranies (table 7). The trends in total expenditure per scientist for the late-1970s and 1980s mirrored the trends found for total expenditures, with a period of growth in the late-1970s followed by a period of decline during the early-1980s, but with the growth in

research staff outpacing that of expenditures, expenditures per researcher did not increase substantially during the late-1980s (figure 6). During the first half of the 1990s DIA and DIPA followed different patterns: DIA's expenditure per researcher shrank by an average of 2 percent per year while DIPA's spending per researcher increased by 10 percent over this period.

Average expenditure per researcher for the total of five agricultural R&D agencies in our sample was only available for 1996 and amounted to $67,000 (1993 international dollars), or 41.0 million 1993 guaranies. This was considerably lower than their Colombian and Uruguayan colleagues, with an average of $132,000 and $117,000 (1993 international dollars) per scientist respectively (Beintema et al. 2000a and Beintema et al. 2000b). Again, in reality average expenditure would be higher, though not as high as the other two countries, with the addition of in-kind donor contributions.

Figure 6—*Trends in DIA and DIPA's Spending per Scientist, 1976–98*



Source: Compiled by authors from survey data and Oram and Gieben (1984).

Table 7—*Trends in Non-Academic Spending per Scientist, 1976-98*

	Government agencies				
	DIA[a]	DIPA[b]	Subtotal	CETAPAR	Total
Expenditures in constant local currencies	(*thousand 1993 guaranies per year*)				
1976–80	40,945.3	46,149.0	42,353.0	na	na
1981–85	63,821.3	36,363.0	57,961.3	na	na
1986–90	21,765.3	15,241.2	20,640.4	na	na
1991–95	38,578.3	43,788.3	39,241.7	45,045.9	39,523.8
1996	38,090.3	54,936.9	39,895.3	58,160.7	41,041.7
1998	35,429.7	na	na	na	na
Expenditures in constant international dollars	(*thousand 1993 international dollars per year*)				
1976–80	66.9	75.4	69.2	na	na
1981–85	104.3	59.4	94.7	na	na
1986–90	35.6	24.9	33.7	na	na
1991–95	63.0	71.5	64.1	73.6	64.6
1996	62.2	89.7	65.2	95.0	67.0
1998	57.9	na	na	na	na
Annual growth rates[c]	(*percentage*)				
1976–81	20.34	27.00	22.65	na	na
1981–91	–12.87	–9.61	–12.34	na	na
1991–96	–1.65	9.86	–0.28	5.29	0.22
1971–96	–1.63	0.71	–1.30	na	na

Source: Compiled by authors from survey data, Oram and Gieben (1984), and Alvarez (1986).

Note: Expenditures for FCA and FCV are estimated using average expenditures per researcher for INIA and DIPA combined.

a. DIA was established in 1990; prior data are for its predecessor DIEAF. Data exclude donor contributions, which were received predominantly in kind.

b. DIPA was established in 1995; prior data are for its predecessor PRONIEGA.

c. Least squares growth rates.

Salary Levels

Remuneration packages include salaries, fringe benefits, and non-monetary benefits that differ markedly among agencies and over time, making such data difficult to measure and meaningfully interpret. For Paraguay, salary information was available for

DIA and DIPA (table 8). Present evidence of the average salary structure for DIA and DIPA show that DIA's average salary levels for researchers were slightly higher than their colleagues at DIPA in 1996. The salary levels of DIA's support staff, however, were considerable higher than those of DIPA. Given both are government agencies are restricted to similar salary structures, the reported differences in average salaries for support staff may be more apparent than real, reflecting undocumented differences across support-staff categories based on staff experience and years of service.

Table 8—*Average Monthly Salaries, 1996*

	DIA	DIPA
	(*thousand current guaranies*)	
Senior researcher	1,626	1,547
Junior researcher	1,276	1,032
Technical support	969	–
Secretary	876	619
Laborer	527	413
	(*1993 international dollars*)	
Senior researcher	1,749	1,664
Junior researcher	1,373	1,110
Technical support	1,042	–
Secretary	942	666
Laborer	567	444

Source: Compiled by authors from survey data.

6. RESEARCH ORIENTATION

The allocation of resources to the various lines of research is a significant policy decision, and so detailed information was collected on the number of fte-researchers working on specific commodity and thematic areas.

6.1. COMMODITY FOCUS

Not surprisingly given their mandate, DIA and DIPA's fte research staff focused mostly on crops and livestock research, respectively, in 1996 (table 9). In addition, 10 percent of DIA's fte scientists undertook natural resources research while 13 percent of DIPA's research staff conducted fisheries research. In the same year CETAPAR researchers focused mainly on crops research, but with some livestock (16 percent) and post-harvest (8 percent) research. FCA conducted crops and forestry research while staff at FCV conducted research projects on livestock and fisheries, but no specific data were available.

It is common to assess R&D priorities using a congruency method, wherein spending shares for research, say, on specific crops are compared with the corresponding share of that crop in the total value of crop output.[15]

[15] See Alston et al. (1998) for a more detailed discussion of this congruency method and other short-cut approaches to evaluating research priorities.

Table 9—*Commodity Orientation of Paraguayan Agricultural Researchers, 1996*

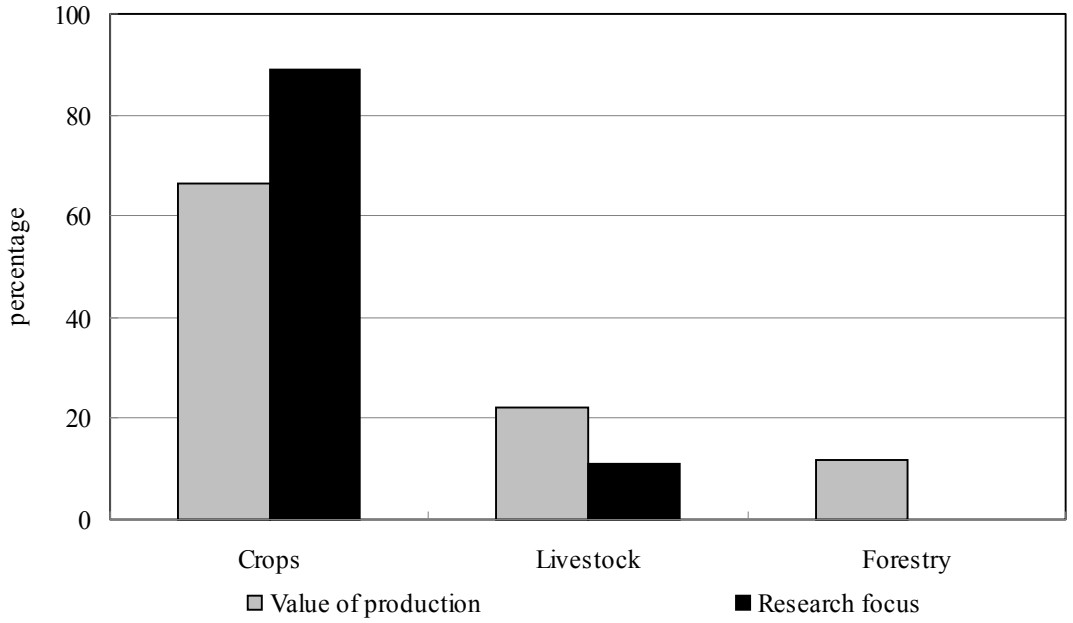
	Government Agencies			
	DIA	DIPA	CETAPAR	Total
Number of researchers in sample		*(full-time equivalent)*		
Crops	90.0	–	5.7	95.7
Livestock	–	10.5	1.2	11.7
Forestry	–	–	–	–
Fisheries	–	1.5	–	1.5
Post-harvest	–	–	0.6	0.6
Natural resources	10.0	–	–	10.0
Other	–	–	–	–
Total	*100.0*	*12.0*	*7.5*	*119.5*
Shares by commodity orientation		*(percentage)*		
Crops	90.0	–	76.0	80.1
Livestock	–	87.5	16.0	9.8
Forestry	–	–	–	–
Fisheries	–	12.5	–	1.3
Post-harvest	–	–	8.0	0.5
Natural resources	10.0	–	–	8.4
Other	–	–	–	–
Total	*100*	*100*	*100*	*100*
Shares by institutional category		*(percentage)*		
Crops	94.0	–	6.0	100
Livestock	–	89.7	10.3	100
Forestry	–	–	–	–
Fisheries	–	100	–	100
Post-harvest	–	–	100	100
Natural resources	100	–	–	100
Other	–	–	–	–
Total	*83.7*	*10.0*	*6.3*	*100*

Source: Compiled by authors from survey data.

Note: Research on pastures is itemized under livestock. Research orientation for FCA and FCV were not available.

Figure 7 shows the shares of crop, livestock, and forestry in gross value of production and the corresponding shares of research staff. The shares of fisheries in value of production and research staff were minimal (0.5 and 1.4 respectively) and are excluded from the figure. Natural resources, post-harvest, and other research areas have also been excluded given the absence of value of production data. The congruency ratio measuring the share of crop researchers to the share of crop output was 1.3 in 1996; 89 percent of the total of 107 fte crop, livestock, and forestry researchers worked on crop research, which was higher than the corresponding share of crops in total crop, livestock, and forestry production. In contrast, the congruency ratio for livestock research in relation to its corresponding share of production value was less than 1.0. Forestry accounted for 12 percent of total crops, livestock, and forestry output, but currently no forestry research is being conducted (see section 2.1). As mentioned earlier, however, FCA conducted some forestry research in 1996, but academic-based research was excluded from the figure.

Figure 7—*Congruence between Research Focus and Production Value for Crop, Livestock, and Forestry R&D, 1996*



Source: Compiled from survey data and BCP (1999).

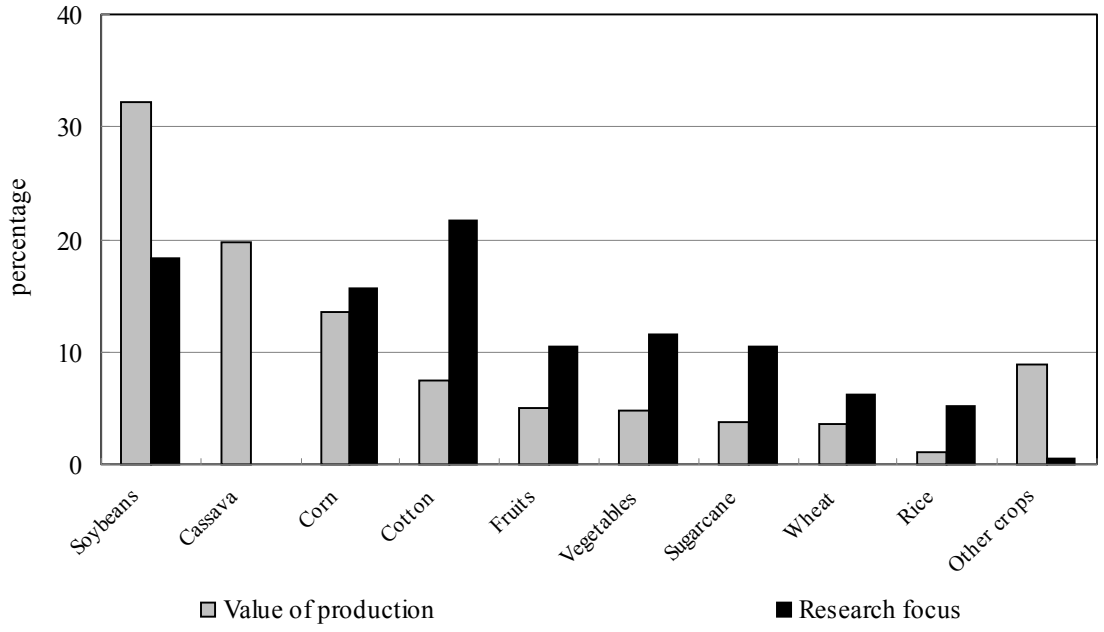
Note: Data exclude academic-based agricultural research.

No particular congruence is evident between research into the various crop commodities and their corresponding output shares for DIA, DIPA, and CETAPAR research (figure 8a). In 1996, soybeans had a congruency ratio 0.6; 18 percent of total crop researchers worked on soybeans while soybeans constituted 32 percent of the total value of crop production. Cassava accounted for 20 percent of total crop value, but currently no research is being conducted on this crop at the nonacademic research agencies.[16] The congruency ratio between corn research and the share of corn in total

[16] Previously staff at DIA (and its predecessor DIEAF) conducted cassava research, but only a cassava gene-bank remains, located at the Experimental Farm *de Chore*. MAG attempted to establish a national cassava program, but with scarce resources only a set of promotional activities got underway, not research.

output value was close to 1.0 while the ratios for the other specified crops in figure 8a were close to 2.0 or even higher.

Figure 8a—*Congruence between Crop R&D and Production Value, 1996*

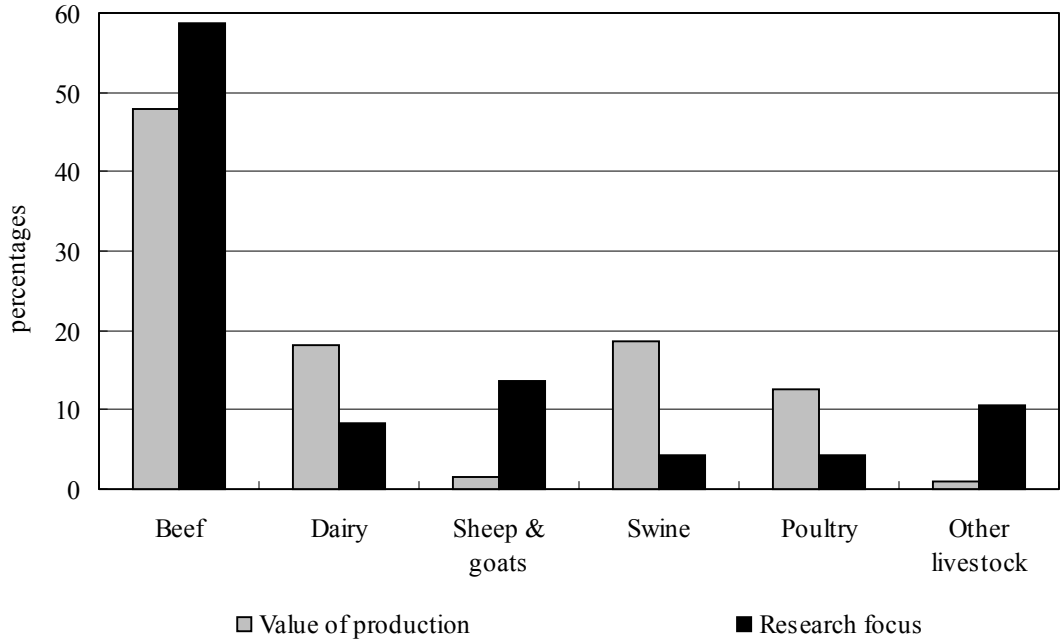


Source: Compiled from survey data and BCP (1999).

Note: Cassava includes manioc. Data exclude academic-based agricultural research.

With the exception of beef, there is a substantial lack of congruence between the allocation of livestock research and the contributions of the various categories to the total value of livestock production (figure 8b). In 1996 beef was the preponderant livestock category both in output value (48 percent) and fte research staff (59 percent) resulting in a congruency ratio of 1.2. Sheep and goats accounted for 14 percent of total livestock research compared with only a 2 percent share in the value of livestock production (a congruency ratio of 9.1). For the other specified livestock commodities the congruency ratios were significantly lower than 1.0.

Figure 8b—*Congruency between Livestock R&D and Production Value, 1996*



Source: Compiled from survey data and BCP (1999).

Note: Data exclude academic-based agricultural research.

6.2 THEMATIC FOCUS

Allocating the total 107 nonacademic fte researchers by research themes shows that, in 1996, the preponderance of research was on crop genetic improvement with a share of 42 percent (table 12). Research on crop pest and disease control and other crop areas accounted for 10 and 27 percent of total fte research staff respectively. In 1996, half of DIA's staff was focused on crop genetic improvement research and 40 percent on other crops areas. The remaining 10 percent of DIA's 100 fte researchers worked on soil improvement research. Unfortunately, DIPA's 12 fte researchers could not be allocated to the three separate livestock themes.

Table 10—*Thematic Orientation of Paraguayan Agricultural Researchers, 1996*

	Government Agencies			
	DIA	DIPA	CETAPAR	Total
Number of researchers		*(full-time equivalents)*		
Crop genetic improvement	50.0	–	–	50.0
Crop pest and disease control	10.0	–	2.0	12.0
Other crop	30.0	–	2.4	32.4
Livestock genetic improvement	–	–[a]	–	–
Livestock pest and disease control	–	–[a]	0.2	0.2
Other livestock	–	12.0	1.2	13.2
Soil	10.0	–	1.4	11.4
Water	–	–	0.2	0.2
Other natural resources	–	–	–	–
Post-harvest	–	–	–	–
Other	–	–	–	–
Total	*100.0*	*12.0*	*7.5*	*119.5*
Shares by research theme		*(percentage)*		
Crop genetic improvement	50.0	–	–	41.8
Crop pest and disease control	10.0	–	27.0	10.1
Other crop	30.0	–	32.0	27.1
Livestock genetic improvement	–	–[a]	–	–
Livestock pest and disease control	–	–[a]	3.0	0.2
Other livestock	–	100	16.0	11.0
Soil	10.0	–	19.0	9.6
Water	–	–	3.0	0.2
Other natural resources	–	–	–	–
Post-harvest	–	–	–	–
Other	–	–	–	–
Total	*100*	*100*	*100*	*100*
Shares by institution		*(percentage)*		
Crop genetic improvement	100	–	–	100
Crop pest and disease control	83.2	–	16.8	100
Other crop	92.6	–	7.4	100
Livestock genetic improvement	–	–[a]	–	–
Livestock pest and disease control	–	–[a]	100	100
Other livestock	–	90.9	9.1	100
Soil	87.5	–	12.5	100
Water	–	–	100	100
Other natural resources	–	–	–	–
Post-harvest	–	–	–	–
Other	–	–	–	–
Total	*83.7*	*10.0*	*6.3*	*100*

Source: Compiled by authors from survey data.

Note: Research orientation for FCA and FCV were not available.

a. In other livestock.

7. CONCLUSION

By world, and even regional standards, agricultural R&D investments and institutions in Paraguay are comparatively small and heavily dependent upon government-based research. DIA—responsible for crop research—is the dominant agency, accounting for close to two thirds of the total of 158 fte researchers working in agricultural R&D in 1996. In the same year total agricultural investments of the five agencies in our sample totaled $10.5 million (in international dollars). These investments, however, exclude donor contributions often received in the form of infrastructure and equipment, which are difficult, if not impossible, to estimate.

In 1996 expenditures per researcher averaged $67,000 over our five-agency sample. Paraguay's intensity ratio (measuring agricultural R&D spending relative to agricultural GDP) was only 0.2, which is well below the intensity ratios of many developing countries.

Investment trends for the two government agencies, DIA and DIPA, were strongly influenced by two IDB loans to Paraguay during the 1970s and early-1980s and an increase in government contributions during the late-1980s after the second IDB loan. Investments at these agencies fell again in the early-1990s, however, due to fiscal crisis. While the two IDB loans facilitated considerable improvement in infrastructure and in training of agricultural R&D staff, the research components of the two projects funded by the IDB loans were far from met.

Over time Paraguay's institutional structure has changed little; most changes were merely internal reorganizations and name changes. More recently a proposal has been developed to merge DIA and DIPA, together with the suspended forestry research

activities of SFN, into a national agricultural research institute (IPTA) to be run as a semipublic agency with control over public and private funding. To date, progress on enacting the legislation for the creation of this agency has been slow and was recently put on hold until at least 2002.

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APPENDIX A

Definitions and Concepts

Measuring National Agricultural R&D Efforts

The construction of quantitative and internationally comparable expenditure, personnel, and related measures of national agricultural research activities requires a precise idea of what, in fact, is being measured. Since these activities are open to a variety of interpretations, it is necessary to define rather precisely the concepts used in this paper. Our approach adheres, wherever possible, to the internationally accepted statistical procedures and definitions developed by the OECD and UNESCO for compiling R&D statistics (OECD 1994 and UNESCO 1984). For statistical purposes we adhered to the following norms:

National. The concept of "national" research used in this report refers to all research conducted by all public and private agencies that have a domestic orientation. Research activities of supranational agencies are excluded.

Agricultural. Agricultural research, as defined here, includes research on crops, livestock, forestry, fisheries, natural resources, and the socioeconomic aspects of primary agricultural production. Also included is research on pre- and post-farm aspects such as input supply and postharvest or food-processing research. Ideally, pre-, on-, and post-farm oriented research should be itemized separately to aid analysis and understanding, but the realities are that it is often difficult to identify research at this level of detail.

Research. Research is often performed in conjunction with other activities such as technology transfer, extension, education, and production. To the extent possible, research activities (in terms of expenditures and staff) are differentiated from these other activities. However, for practical reasons, if non-research activities are an integral part of an institute's research activities and account for less than 20 percent of the resources of the institute, it was expedient to classify all the activities of the institute as being research-related. Occasional or ad-hoc research activities by agencies without a clear research mandate are excluded.

Institutional Classification

The Frascati Manual (OECD1994) identifies five institutional categories of executing research agencies of which the following three are relevant to this paper:[17]

[17] The two institutional categories not included here are “private non-profit” and “abroad.” In the 1993 version of the Frascati Manual the former category has been reduced substantially and now only includes: (a) non-market, private non-profit institutions serving households; and (b) private individuals and households. Research agencies that are not directly controlled by but receive more than 50 percent of their funding from government, universities, or business enterprises should be assigned accordingly. As a result the private non-profit category has become almost negligible as a research-executing category, although it still plays some role as a source of support for research. By restricting our survey to “national” research, the institutional category “abroad” is not relevant.

(1) Government agencies. This category includes all agencies that are controlled and mainly financed by the government. Agencies that are not directly controlled, but are mainly financed by the government are also classified as government agencies.

(2) Higher education agencies. This category includes all public and private universities, colleges of technology, and other higher education institutes. Also included are all research institutes and experimental stations that are controlled directly, administrated, or associated with higher education agencies.

(3) Business enterprises. This category comprises the following three subcategories: (3a) public enterprises; (3b) private enterprises; and (3c) nonprofit institutions. The nonprofit subcategory covers research undertaken on the collective behalf of business enterprises and which they control and mainly finance—for example, research controlled and mainly financed by commodity boards and farmer organizations. A further distinction among private enterprises is that of national versus multinational, the latter considered being private enterprises with at least 50 percent of foreign ownership.

Full-Time Equivalent (fte)

A full-time-equivalent researcher year is taken to be a person who holds a full-time position as a researcher during the whole year. Adjustments to full-time equivalents have only been made when: (a) a research position was part-time; (b) a research position was not filled for the whole year; and (c) the position explicitly involved tasks other than agricultural research. In the latter case an estimate was made of the time spent on agricultural research. No adjustments were made, however, for vacation or sick leave, nor for time spent on administration, meetings, travel, or other activities that form part of the normal duties required to support research. Following this line of reasoning, professional staff in management positions was classified as research staff. Also, research staff that were on study leave, but remained fully supported in terms of salaries and benefits, were included.

The degree status of researchers is determined on the following basis: 3-4 years full-time university education (BSc), 5-6 years (MSc), and more than 6 years plus doctorate thesis (PhD).[18]

Deflators and Exchange Rates

All expenditure figures were first compiled in current local currency units. To facilitate comparisons over time and across countries, these figures were deflated with a local GDP deflator to the base year 1993, and then converted to a common currency (U.S. dollars) using the 1993 Purchasing Power Parity (PPP) over GDP. PPPs are synthetic exchange rates that attempt to reflect the purchasing power of a country's currency. The PPPs used here are derived from the 2000 World Development Indicators (World Bank

[18] Although "ingeniero" and "licenciado" qualifications often require more than 4 years of study, they were classified as B Sc degrees.

2000). For additional information on currency conversion methods in this context see Pardey, Roseboom, and Craig (1992).

Nomenclature for Tables in Text

A zero indicates an actual observation of zero; a dash indicates an observation is not relevant (due to institutional mergers, closures, and so on), while "na" indicates an observation that is not available. In the text we note any marked deviations from these data compilation norms and include points of clarification if warranted.

Annex B

Overview of Agricultural R&D Agencies in Paraguay, 1996

Supervising Agency	Executing Agency			Research Focus	Number of Researchers	
	Name (Spanish)[a]	Name (English)	Acronym		Count	fte's
Government agencies						
Ministerio de Agricultura y Ganadería (MAG)	Dirección de Investigación Agrícola (1966; 1990)	Crops Research Directorate	DIA	crops, natural resources	100	100.0
	Dirección de Investigación y Producción Animal (1969, 1995)	Animal Research and Production Directorate	DIPA	livestock, fisheries	40	12.0
Higher education agencies						
Universidad Nacional de Asunción (UNA)	Facultad de Ciencias Agrícolas (1956, 1974)	Faculty of Agricultural Sciences	FCA/UNA	crops	140	15.0
	Facultad de Ciencias Veterinarias (1956, 1974)	Faculty of Veterinary Sciences	FCV/UNA	livestock, veterinary medicine	140	23.0
Government agency, abroad						
Japanese International Cooperation Agency (JICA), Japan[b]	Centro Tecnológico Agropecuario en Paraguaya (1962, 1972)	Agriculture and Livestock Technical Center	CETAPAR	crops, livestock	25	7.5
Total					*445.0*	*157.5*

Source: Compiled by authors from survey data.

Note: There are a number of other organizations in Paraguay that conduct some research projects, but on an occasional, largely ad-hoc basis. These organizations are excluded from this table and from the data analysis in this report. For descriptions of institutional categories see Appendix A.

a. Establishment dates are given in brackets. When two dates are given, the first is the establishment date of the agency's predecessor and the second is the date the current institute was formed.

b. Following the definition in the Frascati Manual (OECD 1994), CETAPAR is categorized as a "government agency, abroad" and so would normally be excluded; however given CETAPAR's importance in the development of the Paraguayan agricultural sector, we chose to include it here.

APPENDIX C

Institutional Details of DIA and DIPA

Figure C.1—*DIA's Organizational Structure, 1999*

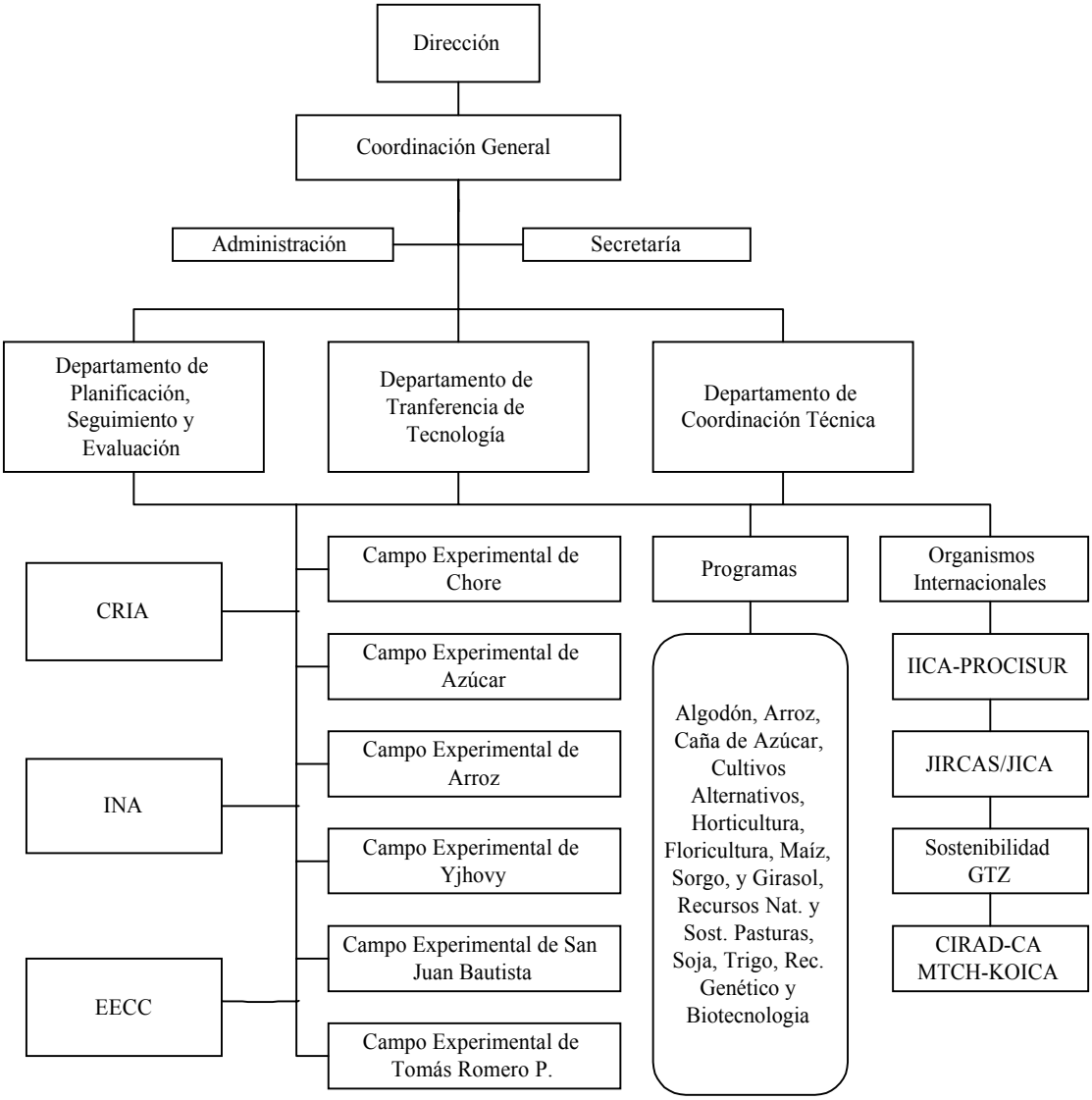

Figure C.2—*DIPA's Organizational Structure, 1996*

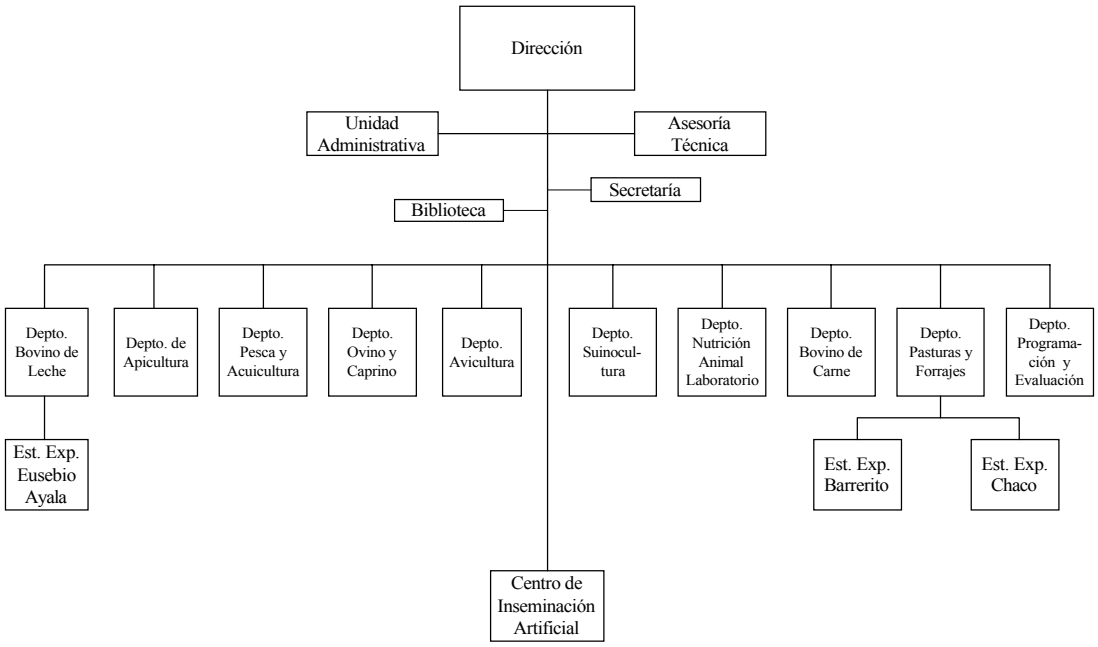

Figure C.3—*DIA's Research Areas and Programs, 1999*

		IAN	CRIA	EECC	CECH	CECA	CEA	CESJB	CEY	CETPR
Crop Production	Alternative Crops	■	■	■	■	■		■	■	■
	Corn, sorghum and sunflower nat. program		■		■				■	
	Cotton experimentation and research program	■		■	■	■		■	■	■
	Rice research program						■			
	Soybeans national program		■					■	■	■
	Sugar cane national program					■				
	Wheat national program		■						■	■
	Horticulture and fruits research program	■	■		■					
Areas	Genetic resources	■	■	■	■	■	■			
	Pasture			■						
	Meteorology	■	■	■						
	Soil conservation and management	■	■	■	■	■		■	■	■

Abbreviations:
IAN: Instituto Agronómico Nacional, (National Institute of Agronomy), Caacupé, Cordillera
CRIA: Centro Regional de Investigación Agrícola, (Regional Center for Agricultural Research), Capitán Miranda, Itapúa
EECC: Estación Experimental Chaco Central, (Experiment Station Chaco Central), Cruce los Pioneros, Boquerón
CECH: Campo Experimental de Choré, (Experiment Station Choré), Choré, San Pedro
CECA: Campo Experimental de Caña de Azúcar, (Experiment Station for Sugar Cane), Natalicio Talavera, Guaira.
CEA: Campo Experimental de Arroz, (Experiment Station for Rice), Eusebio Ayala, Cordillera
CESJB: Campo Experimental de San Juan Bautista, (Experiment Station San Juan Bautista), San Juan Bautista, Misiones
CEY: Campo Experimental de Yjhovy, (Experiment Station Yjhovy), Yjhovy, Canindeyú
CETRP: Campo Experimental de Tomás Romero Pereira, (Experiment Station Tomás Romero Pereira), Tomás Romero Pereira, Itapúa

Figure C.4—*DIPA's Research Areas and Programs, 1999*

	EEB	EECH	EEA	San Lorenzo Labs
Beef	■	■		
Milk	■		■	
Pasture	■	■		
Apiculture		■	■	
Pisciculture				
Sheep & goats		■	■	
Meat Residues				■
Veterinary diagnosis				■
Nutrition				■

Abbreviations:
EEB: Estación Experimental Barrerito (Experiment Station Barrerito), Caapucú, Paraguaní
EECH: Estación Experimental Ganadera del Chaco (Livestock Experiment Station Chaco), Río Verde, Boquerón
EEA: Estación Experimental Eusebio Ayala (Experiment Eusebio Ayala), Eusebio Ayala, Cordilleras