ASTI Agricultural Science & Technology Indicators

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty

ASTI Country Brief No. 39 • November 2008

COLOMBIA

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Quantitative data are important in measuring, monitoring, and benchmarking the inputs, outputs, and performance of agricultultural science and technology (S&T) systems. They are an idispensable tool when it comes to assessing the contribution of agricultural S&T to agricultural growth, and more generally, to economic growth. S&T indicators assist research managers and policymakers in policy formulation of and decision making about strategic planning, priority setting, monitoring, and evaluation. They also provide information to government and other institutions (e.g., policy research institutes, universities, and the private sector) involved in the public debate on the state of agricultural S&T at the national, regional, and international levels. This brief reviews the major investment, capacity, and institutional trends in in public agricultural research in Colombia since 1981, using data collected under the Agricultural Science and Technology Indicators (ASTI) initiative (IFPRI 2007–08).[1] It provides important updates on trends in Colombia's public agricultural research previously published by Beintema, Romano, and Pardey (2001, 2006).

INTRODUCTION

Colombia is the only South American country that borders both the Caribbean and the Pacific. The country extends over both sides of the equator and the Andes, stretching from sea level to permanently snow-covered peaks of nearly 6,000 meters. This diverse topography allows the cultivation of a wide variety of crops and livestock items. Cacao, sugarcane, oil palm, coconuts, bananas, plantains, rice, cotton, tobacco, cassava, and most of the nation's beef cattle are produced in the hot regions below 1,000 meters elevation. The temperate regions—between 1,000 and 2,000 meters—

Table 1—Composition of public agricultural research expenditures and research staff, 2006

Type of agency	Total spending, 2006: 2005 Colombian pesos (*billion*)	Total spending, 2006: 2005 international (PPP) dollars (*million*)	Total research staff, 2006 (*fte's*)	Share: Spending (*percent*)	Share: Research staff (*percent*)	Agencies in sample[a] (*number*)
CORPOICA	60.0	55.5	273.0	34.7	27.3	1
Other government[b]	20.0	18.5	190.3	12.6	19.1	6
Producer associations[c]	53.4	49.4	353.1	34.0	35.3	13
Higher education[d]	31.5	29.1	182.5	18.7	18.3	18
Total	**164.9**	**152.4**	**998.9**	**100**	**100**	**38**

Sources: Compiled by authors from ASTI survey data (IFPRI 2007–08) and a number of agency websites.
[a] See note 3 for a list of the 38 agencies included in this sample.
[b] Expenditures for IDEAM and IIAP are estimates based on average expenditures per researcher at the other government agencies. Staff employed in the six other government agencies spent between 15 and 100 percent of their time on research, resulting in 190.3 fte researchers.
[c] Expenditures for CENIBANANO, FEDECACAO, FENALCE, VECOL, and CIPAV are estimates based on average expenditures per researcher at the other producer associations for which financial data were available. Staff employed in the producer associations spent between 30 and 100 percent of their time on research, resulting in 353.1 fte researchers.
[d] Expenditures for the higher education agencies are estimates based on average expenditures per researcher at the government agencies. Staff spent between 15 and 75 percent of their time on research, resulting in 182.5 fte researchers.

KEY TRENDS

- The share of CORPOICA in total Colombian agricultural R&D spending and capacity has gradually declined over the past decades in favor of producer associations, other government agencies, and the university sector.
- Agricultural R&D spending in Colombia remained stable during 1996–2002 but has contracted substantially in recent years due mainly to severe cuts in CORPOICA's budget.
- More than 90 percent of research carried out by the four principal producer associations is financed through commodity taxes levied on private sector production or exports. CORPOICA, on the other hand, received more than three-quarters of its funds from the Colombian government.
- Colombia's private sector is involved in only limited agricultural R&D although it plays an important (indirect) role in financing R&D.

ABOUT ASTI

The Agricultural Science and Technology Indicators (ASTI) initiative comprises a network of national, regional, and international agricultural R&D agencies and is managed by the International Service for National Agricultural Research (ISNAR) division of the International Food Policy Research Institute (IFPRI). The ASTI initiative compiles, processes, and makes available internationally comparable data on institutional developments and investments in public and private agricultural R&D worldwide, and analyses and reports on these trends in the form of occasional policy digests for research policy formulation and priority setting purposes.

Funding for the ASTI initiative's activities in was provided by the Inter-American Development Bank (IDB), the World Bank via the Consultative Group on International Agricultural Research (CGIAR) and IFPRI.

are better suited for coffee, certain flowers and fruits, maize, and vegetables. The cooler elevations—between 2,000 and 3,000 meters—allow the production of wheat, barley, potatoes, cold-climate vegetables, flowers, dairy cattle, and poultry. In addition, all regions yield forest products, ranging from tropical hardwoods in the hot regions to pine and eucalyptus in the cooler elevations. Coffee has been by far Colombia's most important commercial crop since the beginning of the 20th century. Roughly 10 percent of the world's coffee is grown in the country, making Colombia the third largest coffee producer in the world after its neighbor Brazil and Vietnam (FAO 2008). There are approximately 560,000 coffee-growing farms in Colombia, extending over a total area of close to 900,000 hectares. These farms produced 724,000 tons of mostly high-quality coffee in 2006 (MADR 2008).

Despite the importance of agriculture to Colombia's economy, the relative contribution of agriculture to the country's national income fell from 20 percent in 1981 to 12 percent in 2005 due to more rapid growth of the industrial and services sectors. Nonetheless, agriculture remains an important source of income for Colombia's rural population, and agricultural exports still account for close to one-half of Colombia's total exports (World Bank 2008). Colombia is set to enter a Free Trade Agreement of the Americas (FTA) with the United States shortly. Some economists believe that the FTA will have a tremendous impact on the country's agricultural sector, expecting it to suffer falling prices and import competition.[2] However, others argue that the FTA may present an invigorating challenge to the agricultural sector. Receiving increased investment and becoming competitive and more efficient, the Colombian agricultural sector may see higher income in the long run. It goes without saying that agricultural research and development (R&D) can also play a tremendous role in this regard. It is key to improving agricultural productivity, and it has shown very high returns on investment in all regions across the world. Improved productivity and enhanced crop and livestock varieties can make Colombia ultimately more competitive in international markets. A well-developed national agricultural research system and adequate levels of investment are important prerequisites for achieving these ends.

A Short History of Government and Nonprofit-Led Agricultural Research

Institutional agricultural research in Colombia began in 1879 with the establishment of a livestock acclimatization farm as part of the Institute of Agriculture at the Botanical Gardens in Bogotá. In 1925 the creation of the first experiment station under the Ministry of Agriculture and Commerce initiated crop research; this was followed by the establishment of additional experiment stations over the next two decades. The Colombian government invited the Rockefeller Foundation to establish a cooperative program to improve Colombian food crop production along the same lines as a successful program established by the foundation in Mexico. The Colombian program began in 1950 when the Office of Special Research (OIE) was created. It initially focused on wheat and maize breeding, but the scope of its research soon expanded to include a large range of other crops as well as livestock. In 1955, with the impetus of the Rockefeller Foundation program, a Division of Agricultural Research (DIA) was created under the Ministry of Agriculture and became responsible for all the ministry's experiment stations.

In an effort to integrate agricultural research, extension, and education—and with the assistance of the Rockefeller, Ford, and Kellogg foundations—the Colombian government established the Colombian Agricultural Institute (ICA) in 1962. ICA inherited DIA's network of experiment stations and was given semiautonomous status. ICA was reorganized in 1968 and 1976, and the change ultimately resulted in a more complex and decentralized structure. The orientation and relevance of ICA's research and extension activities were increasingly criticized in the late 1970s, particularly for the lack of coordination and communication between ICA researchers and farmers. ICA also experienced serious funding problems during this period because financial contributions from the government were substantially curtailed and legal restrictions made it difficult—if not impossible—for ICA to secure other sources of funding, especially from the private sector.

In the mid-1980s ICA was further reorganized, resulting in two separate subdirectorates—one for research and technology and one for services. Despite the reorganization and initial funding from the World Bank and other international donors, ICA maintained a broad range of activities with insufficient funds to support them. In 1990 ICA was again reorganized, and its research mandate was broadened to include biotechnology and natural resources research. To give greater coherence to ICA's multiple functions and to improve its efficiency, in 1993 the agency was separated into two institutes. ICA maintained responsibility for plant and animal health and quarantine, input regulation, and public research coordination and supervision. The research and technology-transfer activities were relocated to a newly created institution, CORPOICA. CORPOICA was established as a joint venture between the Colombian government and various producer associations, universities, and regional institutions. The goal was to create an institute with greater flexibility in its organization, planning, and staff recruitment policies that would, ultimately, have opportunities for collaboration with the private sector.

Research activities conducted by producer associations have been, and still are, an important component of Colombian agricultural R&D. The first producer association to initiate research was FEDECAFE (created in 1928), which in turn established CENICAFE in 1938 to study the main problems of coffee production in Colombia. Cotton producers created the Institute for Cotton Development (IFA) in 1948, primarily to assess the performance of various cotton varieties introduced from the United States and elsewhere. In 1968 IFA was closed, and ICA assumed the more basic aspects of cotton research while applied research (such as the testing of new varieties) became the responsibility of the National Federation of Cotton Producers (FEDERALGODON). The National Federation of Rice Producers (FEDEARROZ) was established in 1948 but initially focused most of its activities on extension. It began to undertake significant research in 1968 in a joint program with ICA and CIAT. ICA and CIAT jointly developed new rice varieties that were field-tested by FEDEARROZ.

In 1962-63 additional producer associations were created for cacao (FEDECACAO), oil palm (FEDEPALMA), and cereals (FENALCE), but it took several decades before these associations initiated programs of research. The Colombian Enterprise for Veterinary Products (VECOL) was established in 1974 to conduct research on and produce vaccines for foot-and-mouth disease. In 1977 the country's sugar mills created CENICAÑA, which assumed responsibility for all sugarcane research previously conducted by ICA. ASOCOFLORES (established in 1976) formed a technical division in 1987. Other, more recent research initiatives by producer groups are the Grape Research Center (CENIUVA), established in 1989; FEDEPAPA, which began research on potatoes in 1991; and the Colombian Research Center for Aquaculture (CENIACUA), established in 1993.

Source: Beintema, Romano, and Pardey (2000)

SCIENCE AND TECHNOLOGY POLICY

Colombia's S&T system began with the establishment of the National Science and Technology Council (CONCyT), which was formed as an advisory body for the government in 1968. The Colombian Institute for the Development of Science and Technology (COLCIENCIAS) was set up during the same year and is responsible for the promotion and development of S&T. COLCIENCIAS's mission is to plan, promote, and communicate Colombia's research needs and translate these needs into actions. In addition, COLCIENCIAS is charged with allocating funds to Colombian agencies involved in S&T. COLCIENCIAS's budget—which comes mostly from public funds, Inter-American Development Bank (IDB) credit, and its own resources—funds strategic programs and projects; training and capacity building; the creation of information systems, technology dissemination, and communication; and the internationalization of Colombian S&T. COLCIENCIAS supports national S&T programs in 11 priority areas: agriculture, health, social and human sciences, basic sciences, environment, telecommunications and computer sciences, manufacturing, education, maritime sciences, biotechnology, and energy and mining. The director of COLCIENCIAS has been calling for the creation of a ministry of S&T in Colombia. Instead of creating such a ministry, however, the Colombian government has recently decided to take COLCIENCIAS out of the National Department of Planning (DNP) and have it report directly to the presidency of the country. In addition, the national government has recently announced its intention to increase its annual S&T budget to reach 1 percent of GDP in a few years.

Total (agricultural and nonagricultural) S&T spending increased gradually from just under 300 billion Colombian pesos in 1998 to 423 billion in 2003 (in 2003 constant prices). In 2004 Colombia invested 0.38 percent of its gross domestic product (GDP) in S&T, up from 0.30 percent in 1995. Despite taking steps to boost the agricultural sector in recent years, Colombia is making slow progress in increasing its S&T spending (OCyT 2004). Other countries in South America, such as Brazil (0.82 percent), Chile (0.68 percent), and Argentina (0.46 percent) spent larger shares of their GDP on S&T. Peru (0.16 percent) and Ecuador (0.07 percent), on the other hand, spent shares that were considerably lower (RICyT 2008).

Agricultural S&T is only a small portion of total S&T conducted in Colombia. In 2003 the country's agricultural S&T sector comprised an estimated 11 percent of S&T staff in Colombia. In comparison, social and human sciences and natural and exact sciences accounted for 31 percent each of S&T staff, and engineering and technology and medical sciences accounted for 14 percent each (OCyT 2004).

Each of the 11 priority programs under COLCIENCIAS has its own council. The Council for Agricultural Science and Technology (CNCTA) is charged with the coordination, planning, policy formulation, and promotion of agricultural S&T. The council consists of representatives of the Ministry of Agriculture and Rural Development (MADR), COLCIENCIAS, DNP, the Colombian Agricultural Institute (ICA), the National Service of Training (SENA), a number of universities and research institutes, as well as individual agricultural scientists. A technical secretariat provided by COLCIENCIAS supports CNCTA.

At the present time, the most important challenges that Colombia's agricultural S&T sector is facing are increased economic liberalization and the imminent FTA, which will increase competition in both national and international marketsfor many Colombian commodities. In anticipation of this, a number of new initiatives in agricultural S&T have been launched, including the formation of sectoral development centers and the provision of various sorts of (competitive) funds through COLCIENCIAS. These funds are intended to stimulate private sector involvement and investment in agricultural research in ways that reinforce public sector research as well as to develop linkages among the numerous participants in the national agricultural R&D system.

INSTITUTIONAL DEVELOPMENTS IN AGRICULTURAL R&D

This study identified 38 public sector agencies involved in agricultural research in Colombia in 2006.[3] Combined, these 38 agencies employed 999 full-time equivalent (fte) researchers and spent 165 billion constant 2005 Colombian pesos on agricultural R&D, the equivalent of 152 million international dollars in 2005 constant prices using purchasing power parity indexes (see Table 1 on page 1).[4] 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. Over the past four decades, the structure of Colombian agricultural research has evolved from one depending almost entirely on a single national agricultural research institute to one that is much more diverse. Colombia's public agricultural R&D agencies underwent a major reform in 1993 with the creation of the Colombian Corporation for Agricultural Research (CORPOICA)[5]—a joint venture of the government and producer associations, universities, and regional institutions (See *A Short History of Government-Based Agricultural Research* on page 2). CORPOICA is a nonprofit, private corporation although it still has traits of a public agency. It is contracted by MADR to provide public goods and services, but, as a private organization, it can set its own administrative policies (on, e.g., management, staff recruitment, and salary structure). Staff are no longer government employees but are hired on a contract basis. CORPOICA also has more freedom to obtain additional funding from the private sector through research contracts and the like than did ICA, CORPOICA's predecessor. ICA continues to exist but is no longer involved in agricultural R&D. Instead, it functions as a regulatory body whose responsibilities include plant and animal health, biosafety, and agricultural extension.

CORPOICA is by far the largest agency involved in agricultural R&D in Colombia. In 2006 the corporation employed 273 fte researchers and spent $56 million (in 2005 constant prices), accounting for more than one-quarter of the country's agricultural researchers and more than one-third of Colombia's agricultural R&D spending. CORPOICA is managed by a national board of directors, an executive director, two technical subdirectorates, one financial subdirectorate, and one general secretary. In addition, CORPOICA's general assembly directs and controls the corporation, and its members include representatives from MADR, farmer organizations, regional governments, universities, other research agencies, and

the agribusiness sector. CORPOICA is headquartered in Bogotá and operates 15 national centers and experiment stations, the directors of which report to the executive director. CORPOICA's research staff focuses largely on crops (including fruit crops), forestry, agro-energy, and livestock and dairy.

Although CORPOICA is not technically a government agency in the strict sense of the word, it is considered as one in this study following international guidelines for S&T statistics (OECD 2002).[6] Six other government agencies were identified as conducting agricultural R&D in Colombia. Combined, they accounted for 19 percent of the country's agricultural R&D staff and 12 percent of its agricultural research spending. Five of these agencies in this category are under the Ministry of Environment, Housing, and Territorial Development (MAVDT). The Institute for Marine and Coastal Research "José Benito Vives de Andréis" (INVEMAR) is the largest agency in this category, with research staff totaling 72 fte's in 2006. INVEMAR is headquartered in the Caribbean port city of Santa Marta. As its name implies, the institute is involved in oceanic sciences, which range from fisheries to environmental themes. The Research Institute for Biological Resources "Alexander von Humboldt" (IIRB) employs 42 fte scientists, who focus their research on natural resource and biodiversity themes. The three remaining government agencies under MAVDT involved in agricultural R&D are much smaller, each employing fewer than 10 fte's in 2006. The Fisheries and Aquaculture Division of the Colombian Institute of Rural Development (INCODER), known as the National Institute of Fisheries and Aquaculture (INPA) until 2003, is Colombia's principal body charged with fisheries research. It is headquartered in Bogotá and operates under MADR. In 2006 the division employed 61 fte researchers.

The important role that producer associations play in crop research differentiates Colombia's agricultural R&D from that of most other South American countries. Thirteen such producer associations were identified as being involved in agricultural research.[7] In 2006 these producer associations accounted for roughly one-third of Colombia's agricultural research staff and spending. In many cases, the research activities of these associations complement CORPOICA research or replace the research activities undertaken by ICA in earlier years. Many producer associations have joint research projects with CORPOICA as a result.

The research activities of Colombia's producer associations are organized in various ways. Some producer associations have built their own research infrastructure and have sufficient financial and human resources to conduct their own research. The Coffee Research Center (CENICAFE) under the National Federation of Coffee Producers (FEDECAFE), the Oil Palm Research Center (CENIPALMA) under the National Federation of Oil Palm Producers (FEDEPALMA), the Sugarcane Research Center (CENICAÑA) under the Association of Sugarcane Producers (ASOCAÑA), and the Federation of Rice Producers (FEDEARROZ) all belong to this group. Other associations have sufficient financial resources to support some of their own professional staff but are involved mainly in testing varieties and transferring technologies developed largely by CORPOICA. Examples of this type of producer association are the Center for Technological Development of the Food Chain of the Potato (CEVIPAPA) and the Federation of Cacao Producers (FEDECACAO). Another group of producer associations import most of their technologies from abroad, and conduct limited research themselves. The Colombian Center for the Innovation in Floriculture (CENIFLORES) is an example of a producer association that belongs to that group.

The principal four producer associations in terms of R&D staff and expenditures (CENICAFE, CENIPALMA, CENICAÑA, and FEDEARROZ) warrant further elaboration. As previously mentioned, coffee is Colombia's principal export crop; thus, it is not surprising that CENICAFE is the largest research center among the producer associations. Its research activities are organized into 17 programs and disciplines. In 2006 CENICAFE employed 170 fte researchers. The center's headquarters and main research station are located in Chichiná, Caldas. In addition, the center has a network of eight small substations throughout Colombia's coffee-growing region. CENICAFE's research involves mainly the development of new varieties, but it is also active in solving various production problems, technology transfer, and the production and sale of coffee seeds.

CENIPALMA generates and transfers technological solutions for Colombia's oil palm industry, which is rapidly gaining ground in the country. The center is involved in the development of improved varieties of oil palm, agronomy, research into new uses for palm oil and oil palm products, and technology transfer to oil palm farmers. During its first years, CENIPALMA was a "virtual institute"; research activities were implemented in the fields and laboratories of other research centers, universities, or private plantations. Over the past decade, however, CENIPALMA established laboratories specialized in leaf, soil, and oil analysis, as well as in biotechnology. The center also opened a trial field in La Vizcaína, where it operates the national oil palm germplasm bank. The agency employed 49 fte researchers in 2006.

CENICAÑA is located in Florida, Valle del Cauca, and does not have any experiment stations at other locations. In 2006 CENICAÑA employed 35 fte researchers. Historically, the research agenda has been established by the owners of the sugar industry, represented by a board of trustees of 12 members (one for each of the 11 sugar mills and one representing the sugar producers). The backbone of CENICAÑA's research agenda has been the development of enhanced sugarcane varieties that will mature earlier and be more resistant to diseases. Since the 1990s, increased emphasis has been placed on the development of defoliating sugarcane varieties and erect varieties, which will facilitate mechanical harvesting.

FEDEARROZ's research activities date back to the 1960s. The association's research activities are not constituted as a "CENI" (i.e., a research center) but rather as a research division within the producer association. FEDEARROZ is headquartered in Bogotá, but it also maintains four experiment stations throughout the main rice-producing areas of Colombia. Farmers in these regions are actively encouraged to identify local problems and constraints so that FEDEARROZ's research agenda is not structured to meet a single national objective but to confront local problems instead. FEDEARROZ's research is carried out by 38 fte researchers, and the development of new rice varieties plays an important role in the research. The nine remaining nonprofit agencies in our survey sample were much smaller, each employing 16 or fewer fte scientists in 2006.

Eighteen higher education agencies are involved in agricultural R&D activities in Colombia. Combined, these agencies employed 183 fte researchers in 2006—18 percent of

the country's total agricultural research staff. A distinction can be made between public and private universities. Research efforts at public universities are financed largely through public funds, whereas private universities finance their research for the most part with student fees and private contracts, even though they are also eligible for COLCIENCIAS funding. Colombia's public universities typically focus on basic research, whereas their private counterparts—like the producer organizations—tend to be more involved in solving specific problems that (private sector) producers encounter.

Colombia's main university is the public National University of Colombia (UNC), which has Faculties of Agricultural Sciences in Bogotá, Palmira, and Medellín and the Faculty of Veterinary Medicine and Zootechnics in Bogotá. The university also houses the Biotechnology Institute in Bogotá. Combined, these five UNC units employed 75 fte's in 2006 or more than 40 percent of research staff in Colombia's higher education sector. Other important research units in the higher education sector include the Faculty of Veterinary Medicine of the (private) University of La Salle (22 fte's) and the Faculty of aAgricultural and Natural Resource Sciences of the Technological University of Los Llanos (17 fte's). The 11 remaining higher education agencies each employed between 2 and 11 fte researchers in 2006, and their research focus covered a wide array of research themes including crops, livestock, forestry, and fisheries.

The private for-profit sector plays a limited role in Colombian agricultural research. The traditionally low level of homegrown innovation is partly due to the Colombian private sector's preference for foreign technology. Nonetheless, the multinational companies (which deal in seeds and agrochemicals) have increased their presence in the country over the past decade with a varied technological supply, including genetically modified organisms, especially of cotton and maize. Many multinational agrobiotech companies use Colombia as a base of operations for the Andean and Central American region but have a comparatively small local R&D component that focuses largely on the testing and screening of improved germplasm developed elsewhere. Among these are AgrEvo, BASF, Dupont, Monsanto, Novartis, and Syngenta, all of which are involved in applied research. Floramerica, a Colombian private flower grower and exporter, has been involved in flower research since 1982. It played a key role in the establishment of CENIFLORES in 2004, and most of its research is currently carried out by this newly established research center.

National and International Linkages and Cooperation

Colombia's agricultural R&D agencies participate in a significant amount of collaborative research nationally, regionally, and on an international basis. As previously mentioned, at the national level, important collaborative research works are in place between CORPOICA and some producer associations. CORPOICA maintains general technical agreements with CENICAÑA and CENIPALMA to improve training, research, and technology transfer. Important linkages also exist between CORPOICA and a number of Colombian universities, including Universidad Jorge Tadeo Lozano, Universidad de la Salle, and UNC. CORPOICA works closely with UNC, for example, on a project on the genetic variability of lulo, a subtropical fruit. CORPOICA also works closely with numerous private sector multinationals. Monsanto, for instance, recently tested its YieldGuard technology for genetically modified maize on CORPOICA's experimental field in Palmira, Valle del Cauca. At the regional level, CORPOICA's linkages are particularly strong with the Brazilian Agricultural Research Corporation (EMBRAPA) and the National Institute of Agricultural Research (INIA) of Venezuela. CORPOICA also has close ties with the Inter-American Institute for Cooperation on Agriculture (IICA) and a number of centers under the Consultative Group on International Agricultural Research (CGIAR). The headquarters of the International Center of Tropical Agriculture (CIAT) are located in the Colombian city of Cali, and the International Maize and Wheat Improvement Center (CIMMYT), Bioversity International, and the International Livestock Research Institute (ILRI) all maintain regional research programs in Colombia. The country's producer associations also maintain important links with other institutes. Besides working closely with Colombian government, nonprofit, and higher education agencies, CENIPALMA, for example, reported close collaboration with CIAT, the Malaysian Palm Oil Board (MPOB), the French Agricultural Research Centre for International Development (CIRAD), the Nigerian Institute for Oil Palm Research (NIFOR), the Institute of Agricultural Research Development (IARD) of Cameroon, the Angolan National Institute of Coffee (INCA), and EMBRAPA. It also works closely with foreign multinationals such as Syngenta and Kali-Monómeros. CENICAFE conducts joint research with a large number of Colombian universities and international bodies such as the International Coffee Organization (ICO) and Bioversity International. CENICAÑA has a collaborative agreement with the U.S.-based Sugar Processing Research Institute (SPRI) to work on the development of new products, laboratory techniques, training, and frontier topics in sugarcane.

HUMAN AND FINANCIAL RESOURCES IN PUBLIC AGRICULTURAL R&D

Overall Trends

The total number of public fte agricultural researchers in Colombia rose at an average rate of 2.6 percent per year, going from 540 in 1981 to 999 in 2006 (Figure 1a).[8] However, growth did not occur evenly over time and among the various agency categories. Staff developments at CORPOICA and its predecessor ICA show a particularly erratic trend. During 1981–89 research staff totals at ICA rose by 7.1 percent per year on average. However, between 1989 and 1992, ICA transferred its rural development and small farmer technical assistance activities to the municipal governments, with the result that many professional research staff departed. During 1989–1992 alone, professional research staff at ICA declined from 693 to 422 fte's. CORPOICA was established in 1993, and the number of researchers temporarily exceeded 500 fte's during 1994–96. However, CORPOICA's total number of research staff has gradually declined since and reached 273 fte's in 2006 (down from 519 in 1996). Severe budget restrictions leading to employment termination at CORPOICA are the reason behind this sharp decline. One of the motivations behind CORPOICA's creation was to gain the flexibility to compete for qualified staff with other, often private sector, agencies by offering more attractive salaries and other benefits, but budget limitations have

caused CORPOICA's salary levels to fall well below those of the universities and private sector. Many CORPOICA scientists have, therefore, taken up positions at the producer organizations and universities, either voluntarily or out of necessity after being laid off. As a result, the cut in staff at Colombia's largest agricultural R&D agency had only a limited effect on the number of research staff in the country as a as a whole.

CORPOICA is currently facing serious challenges in retaining its capacity. Its most experienced scientists are well over 50 years old and are approaching retirement age. Because many of these scientists have been government employees for numerous years, they have built up good retirement plans. However, since the establishment of CORPOICA, research staff are hired on a contract basis. Younger scientists typically receive short-term contracts for one or two years and are not entitled to pension benefits, making it very difficult for CORPOICA to provide ongoing training and to maintain a critical mass of highly qualified research staff. Besides, building up a long-term research program becomes increasingly difficult. Many younger scientists, therefore, perceive CORPOICA as a less attractive employer than some of the producer associations or universities, which offer better salaries and work conditions.

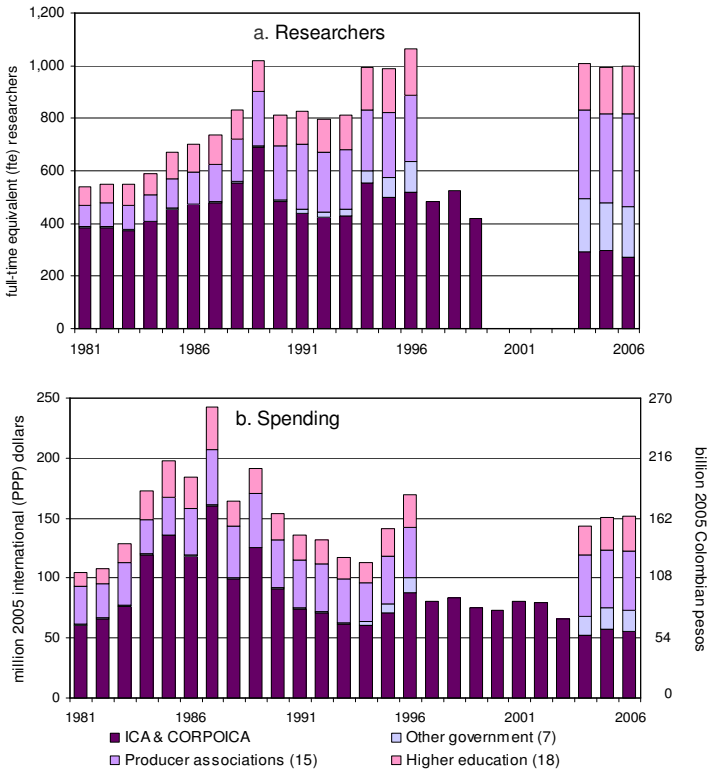
The other government agencies category experienced the strongest growth in its research staff during 1981–2006, albeit from an extremely small base. The number of fte researchers in this category remained stable at around 3 during much of the 1980s but rose rapidly during the 1990s and reached 190 in 2006. This was due mainly to the founding of new government agencies under MAVDT after the reorganization of government-led agricultural research and the establishment of CORPOICA in 1993.

Colombia's agricultural R&D agencies in the nonprofit and higher education sectors also showed steady growth in their research staff totals during 1981–2006, with annual growth rates of 5.9 and 4.0 percent, respectively. Nonetheless, growth in research capacity in the higher education sector has stalled since 2000, with researcher totals stabilizing at around 180 fte's. Modest growth in human research capacity was still recorded for Colombia's producer associations in recent years, with all the larger agencies in the nonprofit category reporting steady growth in their research totals. Although Colombia did not start to grow oil palm on a large scale until the 1980s, today it is the world's fourth largest exporter of palm oil and other oil palm products, following Malaysia, Indonesia, and Nigeria. This strong growth is reflected in CENIPALMA's researcher totals, which doubled from 25 ftes in 1998 to 49 in 2006. CENICAFE also reported steady growth in its research staff numbers. Its total research capacity increased by more than 50 percent from 112 fte's in 1996 to 170 one decade later.

The institutional structure and focus of agricultural R&D in Colombia are much more diversified now compared with the early 1980s because of a rapid fall in researcher totals at CORPOICA and increased agricultural research activities undertaken by producer associations, higher education agencies, and government agencies other than CORPOICA. In 1981 ICA/CORPOICA researchers accounted for 71 percent of Colombia's total agricultural R&D staff. This share has gradually fallen over the years to 53 percent in 1991, 36 percent in 2001, and just 27 percent in 2006. Concurrently, the share of R&D staff at the producer associations increased substantially, from 15 percent in 1981 to 35 percent in 2006. This was the result of staff increases by the three largest producer associations and the initiation of research by other nonprofit institutions. The combined share of agricultural R&D staff of the other government agencies in Colombia was negligible during the 1980s (less than 1 percent). However, it increased rapidly during the 1990s and reached 19 percent in 2006 due to the aforementioned establishment of the agencies under MAVDT and an increased focus on fisheries research with the move from INPA to INCODER. Colombia's higher education sector accounted for 18 percent of agricultural R&D staff in 2006, up from 13 percent in 1981.

Total public agricultural research expenditures in Colombia rose rapidly in constant prices during 1981–2002, from $105 million in 1981 to $161 million in 2003 (Figure 1b). Overall, ICA/CORPOICA's expenditures fell 1.2 percent per year during this period, but like the organizations' research staff developments, spending showed an erratic trend. From 1983 onward, ICA's expenditures were rapidly augmented with funds brought about by the introduction of the National Plan for Agricultural Technology Transfer (PLANTRA), which are financed by World Bank loans and additional funding from

Figure 1—Composition of public agricultural R&D staff and spending, 1981-2006



Sources: Compiled by authors from ASTI survey data (IFPRI 2007–08), Beintema, Romano and Pardey (2000), and a number of agency websites.

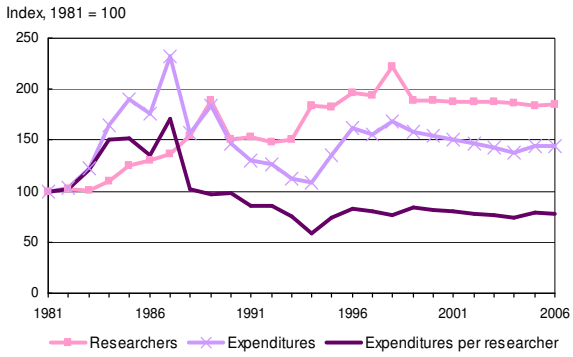
Notes: See Table 1. Figures in parentheses indicate the number of agencies in each category. Agency totals are higher than in Table 1 due to the inclusion of agencies that are no longer involved in agricultural R&D: Other government includes the Agency for the Development of Renewable Natural Resources (INDERENA), which stopped conducting R&D in 1993. Producer associations includes the Andean Fruits Center (CFA) and FEDERALGODON, which stopped conducting R&D in 2000 and 1991, respectively. Staff and expenditure data were unavailable for 1997–2003 for all agencies, except CORPOICA. Staff data were unavailable for CORPOICA for 2000–03.

other international donors. Most of the 1980s were prosperous for ICA, but starting in 1989 expenditures declined substantially in constant prices. Following the 1994 transfer of ICA's research and technology-transfer activities to CORPOICA, the financial situation improved slightly (although it was well below levels recorded in the mid-1980s) and remained more or less stable at averages of $80 million per year. However, spending levels at CORPOICA dropped sharply after 2002 and reached $55 million in 2006 due to the above mentioned budget restrictions, which resulted from a general national government fiscal deficit. Because CORPOICA is heavily reliant on government support (see *Financing Agricultural R&D*), the government's fiscal deficit measures have affected CORPOICA more than they have other Colombian agricultural R&D agencies. The disbursement of government funds to CORPOICA has also changed over the years, moving away from a virtually exclusive reliance on open-ended block-funding arrangements toward more time-bound research contracts.

Spending at Colombia's producer associations shows different growth trends. During 1981–2004, agricultural R&D expenditures in this category increased by an average of 2.0 percent per year, but spending totals declined during 2004-06. Spending $18 million in 2006, CENICAFE has had by far the highest R&D expenditures of the producer associations. Nonetheless, the agency's expenditures have shown a rapid fall in recent years, going down from $22 million in 2004. CENICAFE's recent decrease in spending is offset by CENIPALMA's sharp increase in agricultural investments. CENIPALMA's expenditures doubled from $3 million to $6 million between 1996 and 2006. As mentioned before, Colombia's oil palm industry has experienced tremendous growth since the 1980s, and the country is now the world's fourth largest exporter of oil palm products. Because CENIPALMA is financed through a levy based on total production of the country's oil palm sector, the institute's research budget rose proportionally to the growth in Colombia's oil palm production. Most of CENIPALMA's funds were allocated to the development of integrated pest and disease management and soil improvement practices, which once again contributed to further productivity enhancement of the oil palm sector (Estrada, Posada, and Hofmann 2002). Agricultural R&D expenditures by CENICAÑA and FEDEARROZ, the other two large nonprofit agencies, have remained relatively unchanged (in constant terms) over the past decade. Combined agricultural research spending of the six agencies in the other government category rose rapidly from just $1 million in 1993 (the year in which CORPOICA was founded) to $18 million in 2006.

Colombia's erratic development in research staff and expenditure totals throughout 1981–2006 resulted in a decline of average spending per scientist from $193,000 in 1981 to $153,000 in 2006 (Figure 2). The Colombian average, however, masks a wide variation in spending per scientist among the different agency categories and the agencies within each category. Average 2006 expenditures per researcher at CORPOICA ($203,000), for instance, were nearly twice the level recorded for the other government agencies combined ($96,000). Similar discrepancies were observed within the nonprofit sector. Research staff at CENICAÑA had the most financial resources at hand ($309,000 on average in 2006). In contrast, their colleagues at CENICAFE, FEDEARROZ, and CENIPALMA spent on average $105,000, $183,000, and $130,000, respectively, during the same year.

Figure 2—Trends in public agricultural R&D expenditures, researchers, and expenditures per researcher, 1981-2006

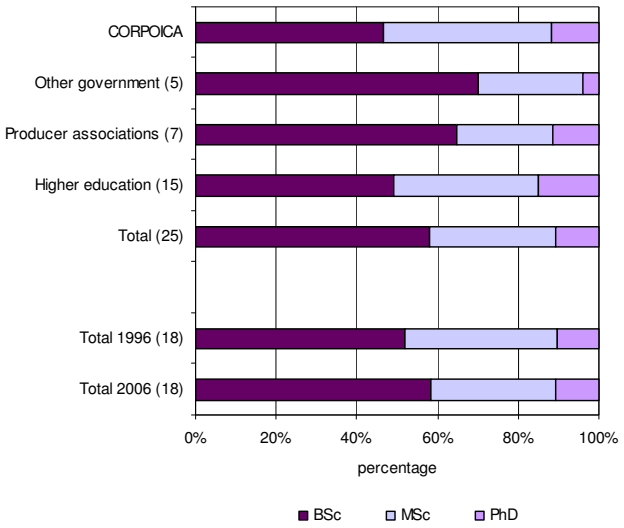


Sources: See Figure 1.
Notes: See Figure 1. Spending and researcher data for 1997–2002 were estimated.

Human Resources

In 2006 42 percent of the 903 fte researchers in a 25-agency sample were trained to the postgraduate level, and 11 percent held PhD degrees (Figure 3). Although CORPOICA had the highest share (54 percent) of researchers trained to the postgraduate (i.e., PhD or MSc) level, the higher education sector had the highest share (15 percent) of researchers with PhD degrees. The latter is a consistent finding across most countries in the region and in developing countries around the world. Postgraduate shares of research staff in the other government sector are relatively low at 30 percent (with just 4 percent holding a PhD degree). Time series data were available for 18 public sector agricultural R&D agencies in Colombia. Average qualification levels of staff at these 18 agencies combined have actually deteriorated over the past decade. This trend contrasts sharply with average qualification level improvements of agricultural research staff in other countries in Latin America. In 1996, 48 percent of fte researchers in Colombia's public sector held postgraduate degrees. A decade later, this share had fallen to 42 percent. The average proportion of postgraduate researchers to total research staff at the other government agency category declined particularly fast. This was due to the enhanced recruitment efforts of these agencies, which largely filled their vacancies with BSc holders.

Figure 3—Educational attainment of researchers by institutional category, 1996 and 2006



Source: Compiled by authors from ASTI survey data (IFPRI 2007–08) and Beintema, Romano, and Pardey (2000).
Notes: Figures in parentheses indicate the number of agencies in each category. Time series data were available for 18 agencies. Combined, these 18 agencies accounted for 83 percent of Colombian agricultural R&D staff in 2006.

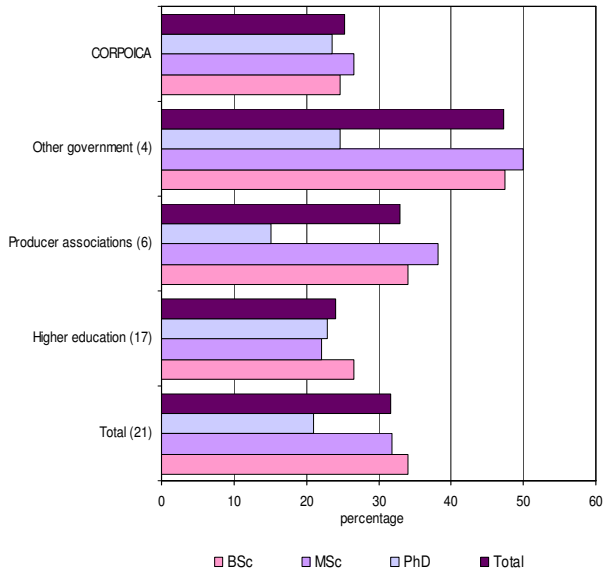
The same is true for the producer associations. The absolute number of BSc holders rose more rapidly than the absolute number of PhD- and MSc-qualified researchers (which both showed modest growth during 1996–2006), resulting in a drop in the share of postgraduate researchers. CORPOICA experienced an improvement of average qualification levels of its research staff during 1996–2006 despite the fact that its total research capacity was halved throughout this period. The total number of PhD-qualified agricultural researchers in Colombia is very low (96 PhD's out of 999 fte's in 2006) compared to other countries in South America with much smaller total agricultural research capacities, such as Chile (149 PhD's out of 583) and Uruguay (95 PhD's out of 402) (Stads and Covarrubias Zuñiga 2008; Stads, Cotro, and Allegri 2008). Colombia's relatively low share of PhD-qualified agricultural research staff can be explained partly by the fact that the country's universities did not offer PhD courses before 1994 (OCyT 2004). In contrast, other countries in Latin America, such as Chile and Venezuela, began their PhD programs in the 1970s. Today, Colombian universities offer over 40 PhD programs in agricultural and nonagricultural sciences. However, Colombia's relatively late start in offering PhD training still has a noticeable impact on average qualifications of agricultural research staff until this day (OCyT 2004).

Most agricultural R&D agencies in Colombia lack official training programs for their research staff. Nonetheless, agencies like CORPOICA do allow their scientists time to study once they have managed to obtain study grants from COLCIENCIAS or other Colombian or foreign agencies. CORPOICA officially requires its scientists to return to Colombia upon completion of postgraduate training abroad. However, due to the fact that most young scientists at CORPOICA have 1- to 2-year contracts, it has become increasingly difficult for scientists to obtain grants for long-term postgraduate training.

The larger producer associations have special agreements with the principal universities in Colombia for collaborative research and training at the MSc and PhD levels but also send some of their staff abroad for postgraduate training. Two CENIPALMA staff members, for instance, are currently in Brazil and Malaysia for MSc degree training. The center also has plans to send some of its more promising scientists for PhD training at universities in Colombia, France, and the United States. In addition, CENIPALMA is working closely with UNC and CIRAD to develop a MSc program in perennial crops at UNC.

Despite a rise in the number of women pursuing scientific careers worldwide, women still tend to be underrepresented in senior scientific and leadership positions (IAC 2006). Colombia is no exception. In 2006, 32 percent of Colombia's total fte researchers in a 21-agency sample were women, 21, 32, and 34 percent of whom held, respectively, a doctorate, MSc, or BSc degree (Figure 4). Colombia's share of female agricultural researchers as a percentage of total research staff is higher than corresponding shares recorded in other countries in the region—such as Chile (30 percent), Costa Rica (26 percent), and Panama (14 percent)—but lower than the share recorded in Uruguay (42 percent) (Stads and Cotro 2008; Stads and Covarrubias Zuñiga 2008; Stads et al., 2008). The four other government agencies combined (47 percent) and the nonprofit agencies (33 percent) employed relatively more female researchers than the higher education agencies (24 percent) and CORPOICA (25 percent).

Figure 4—Share of female researchers, 2006



Source: Compiled by authors from ASTI survey data (IFPRI 2007–08).
Note: Figures in parentheses indicate the number of agencies in each category.

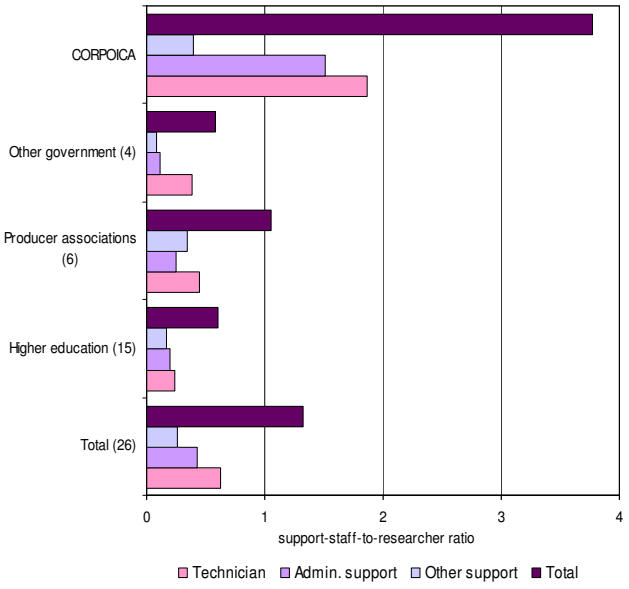
Colombia's proportion of female agricultural researchers has steadily increased during 1996–2006. In 1996 only 25 percent of the country's agricultural research staff were women; currently 32 percent are, as mentioned above. The share of female research staff grew particularly fast at CENICAFE, from just 16 percent in 1986 to 26 percent in 1996 to 41 percent in 2006. CORPOICA's share also showed steady growth, from 15 percent in 1991 to 25 percent in 2006.

Not surprisingly, the percentage of female researchers with postgraduate degrees (MSc or PhD) in a sample of 28 agencies

is lower than the corresponding percentage of men. In 2006, 40 percent of all Colombian female researchers were trained to the postgraduate level compared to 46 percent of all Colombian male researchers, and there were nearly twice as many men as women holding PhD degrees. The gender gap in PhD qualification is most pronounced at the nonprofit and other government categories.

In 2006 the average number of support staff per scientist in a 26-agency sample for which data were available was 1.3, comprising 0.6 technicians, 0.4 administrative personnel, and 0.3 other support staff such as laborers, guards, and drivers (Figure 5). Average support staff per scientist was much higher at CORPOICA (3.8) than at the institutions in the other three categories. Overall, average support-staff-per-scientist levels have fallen sharply in Colombia over the past decade. Beintema, Romano, and Pardey (2000) reported an overall share of 2.7 support staff per scientist in 1996. Retrenchments have occurred in all three support staff categories.

Figure 5— Support-staff-to-researcher ratios, 2006

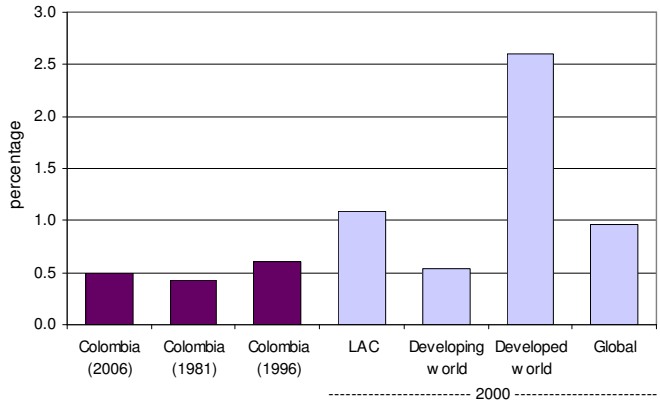


Source: Compiled by authors from ASTI survey data (IFPRI 2007–08).
Note: Figures in parentheses indicate the number of agencies in each category.

Spending

Total public spending as a percentage of agricultural output (AgGDP) is a common research investment indicator that helps to place a country's agricultural R&D spending in an internationally comparable context. In 2006 Colombia invested $0.50 in agricultural research for every $100 of agricultural output, which was lower than the corresponding ratio in 1996 (0.61) but slightly higher than the 1981 ratio (0.43) (Figure 6). By comparison, the 2006 intensity ratios for other countries in the region such as Chile (1.22) and Costa Rica (0.93) were much higher (Stads and Covarrubias 2008; Stads et al., 2008). The 2000 ratio for Colombia was also lower than the reported 2000 average for Latin America and the Caribbean (1.19), the developing world (0.56), and the global average (0.98) (Beintema and Stads 2008).

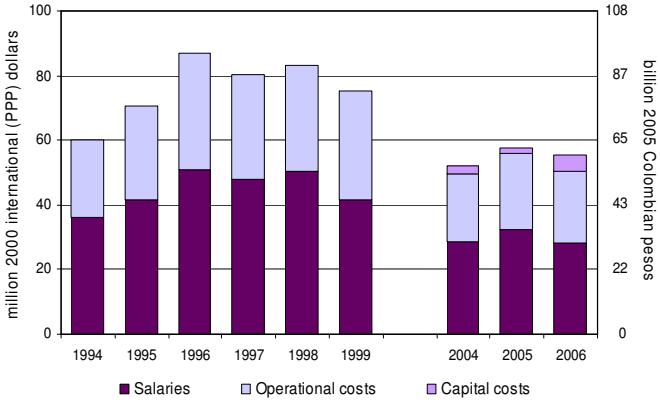
Figure 6—Colombia's public agricultural research intensity compared regionally and globally



Sources: Colombia data are compiled from Figure 2; AgGDP data are from World Bank (2008); all other intensity ratios are from Beintema and Stads (2008). LAC stands for Latin America and Caribbean.

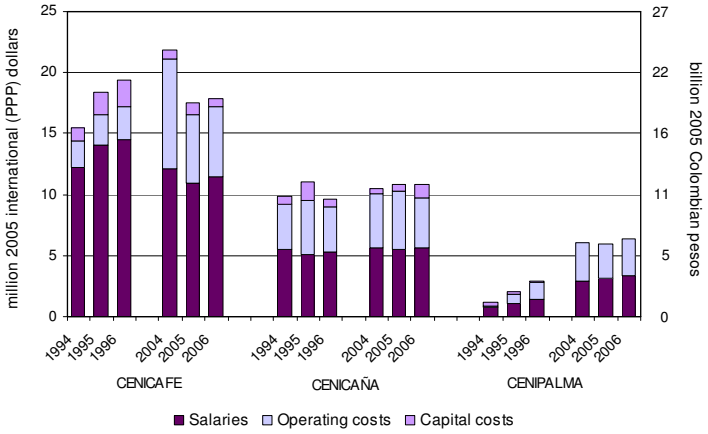
The allocation of research budgets across salaries, operating costs, and capital costs affects the efficiency of agricultural R&D; and, therefore, detailed data on cost categories of government agencies were collected as part of this study. The share of salary spending in total expenditures, for instance, ranged from 51 percent at CORPOICA to 68 percent at the other government agency category. Capital spending shares showed similar variation. CORPOICA spent a relatively higher share on capital in 2006 (9 percent) than did the other government (1 percent) and nonprofit (5 percent) agencies. However, capital spending at CORPOICA was highly volatile. In 2005 capital expenditures accounted for just 3 percent of CORPOICA's total spending (Figure 7). Most of CORPOICA's capital expenditures were on equipment and maintenance. CENICAFE spent a larger share on operating costs during 2004–06 than it did a decade earlier (Figure 8). The relative shares spent on salaries, operating costs, and capital costs at CENICAÑA have not changed much over the years. CENIPALMA, on the other hand, accelerated its operating expenditures during 1994–2006.

Figure 7— Cost-category shares in CORPOICA's expenditures, 1994–2006



Sources: Compiled by authors from ASTI survey data (IFPRI 2007–08) and Beintema, Romano, and Pardey (2000).
Note: Data on capital expenditures were unavailable for 1994–99.

Figure 8— Cost-category shares in producer associations' expenditures, 1994–2006



Sources: Compiled by authors from ASTI survey data (IFPRI 2007–08) and Beintema, Romano, and Pardey (2000).

The exact budget allocated to each of the Colombian R&D agencies is centrally determined through annual general appropriations, which specify the amounts allocated to salaries, wages, and personnel benefits; maintenance and other operating expenses; and capital outlays for the implementation of various programs/projects in a given year. CORPOICA can set its own administrative policies with regard to salaries, as previously mentioned. In reality, however, the corporation's salary expenditures are still largely dependent on government allocations. Given that CORPOICA staff are no longer government employees but hired on a (short-term) contract basis, they find themselves negotiating their salaries every (second) year.

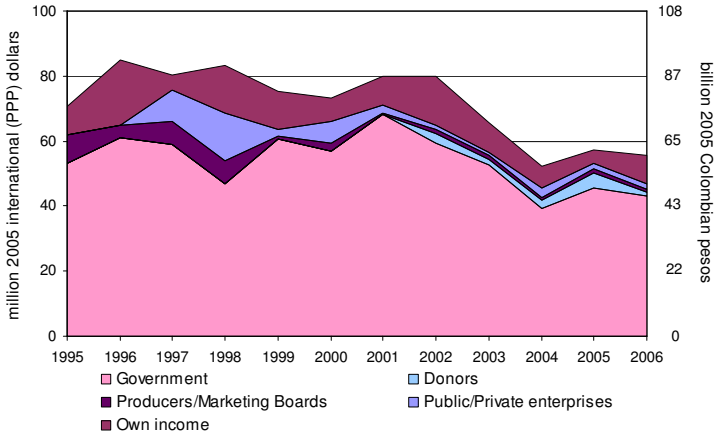
FINANCING PUBLIC AGRICULTURAL R&D

Colombia has diverse sources of funding for agricultural research, but government contributions continue to dominate. Government contributions are distributed in a variety of ways, including block grants to various institutions, special programs, cofinancing, external loans and donations, and competitive funds awarded through COLCIENCIAS and the National Program for the Transfer of Agricultural Technology (PRONATTA). The private sector is increasing its participation in funding agricultural R&D through direct financial support and through levies. However, as mentioned, the fiscal deficit in recent years has led to a reduction in the government contributions available to agricultural research. Donor funding has also decreased in recent years, especially for the producer associations.

CORPOICA

CORPOICA and the other government agencies have relied largely on financial support from the national government. In 2006 more than three-quarters of CORPOICA's funds were provided by the Colombian government, 15 percent came from the organization's internally generated resources, and the remainder came from public and private enterprises, foreign donors, and producer and marketing boards (Figure 9). During 1996–2006 government contributions as a percentage of CORPOICA's total funding remained relatively unchanged, despite significant fluctuations in the absolute totals of government support from one year to the next. The relative shares and total values of the other funding categories varied widely from year to year.

Figure 9—Funding sources of CORPOICA, 1995-2006



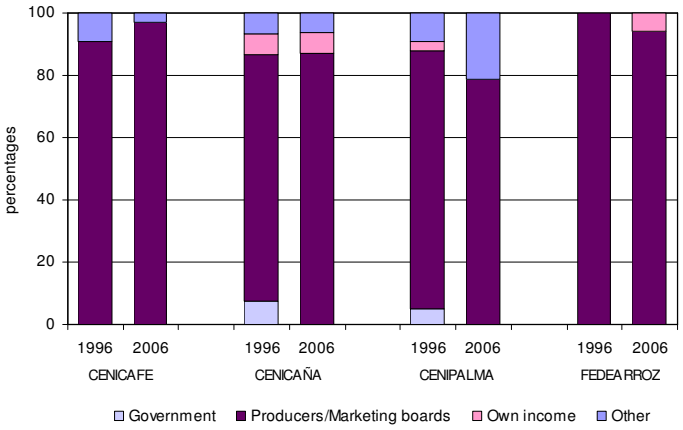
Sources: Compiled by authors from ASTI survey data (IFPRI 2007–08) and Beintema, Romano, and Pardey (2000).

About 80 percent of "direct" government funds to CORPOICA came in the form of line item payments from the national budget, and the remaining funds came in the form of contracts for specified projects. The proportion of project funding has increased in recent years, causing financial difficulties for CORPOICA because project funds are not allowed to go toward the recovery of overhead costs or the salaries of permanent staff; project funds are allowed to pay for contract labor only. CORPOICA also received government contributions through COLCIENCIAS's and PRONATTA's competitive grant schemes, but their combined share of total funding has declined considerably in recent years. Contributions to CORPOICA from producer organizations have remained relatively small (less than 2 percent of the agency's total funds in 2006) despite the goal of increasing private sector involvement that precipitated CORPOICA's creation. This is not surprising, however, given that the main focus of the producer organizations is short-term, highly targeted adaptive research, whereas CORPOICA conducts more basic or strategic research (Beintema, Romano, and Pardey 2000). Interestingly, donor funding seems to have gained prominence in recent years. Donors to CORPOICA include the governments of Japan, the Netherlands, and Switzerland as well as the United Nations Development Program (UNDP).

Producer associations

Most of Colombia's producer associations finance the bulk of their research activities through a mandatory cess or tax (*parafiscal* or *cuota de fomento* in Spanish) that is imposed by law on the production of certain crops. A few associations, such as the Association of Colombian Flower Producers (ASOCOFLORES) and the Federation of Potato Producers (FEDEPAPA), have not introduced commodity taxes but instead receive voluntary contributions from their members. In 2006 CENICAFE's, CENICAÑA's, CENIPALMA's, and FEDEARROZ's dependence on cess proceeds ranged from 79 to 97 percent (Figure 10). During 1996–2006 government and cess funding as a percentage of total funding for Colombia's four principal producer associations remained more or less unchanged. The Colombian government ceased its contributions to CENICAÑA and CENIPALMA completely over this period.

Figure 10—Funding sources of producer associations, 1996 and 2006



Sources: Compiled by authors from ASTI survey data (IFPRI 2007–08) and Beintema, Romano, and Pardey (2000).

In Colombia, production taxes (cesses) are currently in place for coffee, sugarcane, oil palm, rice, cereals, cotton, raw sugar, cocoa, and fruits. Tax collection mechanisms used and revenue shares allocated to R&D differ from one commodity to the next. Colombia's coffee levy on exports was established in 1934. Revenues from this levy are used to promote production through credit, to build marketing and export infrastructure, and to finance coffee research. The levy is administered by the National Congress of Coffee Producers. Annual allocations to coffee research average around 12 percent of total export revenues collected, although the exact percentage varies from year to year depending on global coffee prices. (Estrada, Posada, and Hofmann 2002).

In 1963 rice producers followed the coffee model when a rice levy was introduced. This levy is determined by law and is currently at 0.5 percent of the production value of rice. The rice levy is managed under a national council, which has equal representation from producers and government officials. The revenues from this levy are distributed among research, technology transfer, and marketing. FEDEARROZ must present an annual program and budget that allocates resources across these activities (Estrada, Posada, and Hofmann 2002).

CENICAÑA is financed through voluntary levy funds paid by the sugar mills and individual sugar producers that constitute ASOCAÑA. The annual budget allocated to CENICAÑA represents 0.65 percent of total sugar and ethanol sales and averaged about $12 million per year (in 2005 constant prices) during the 2004–06 period. This budget has been on the rise in recent years as a result of the expansion in sugarcane production as well as a recent increase in the percentage of total sugarcane sales allocated to CENICAÑA (Estrada, Posada, and Hofman 2002).

Research funds for CENIPALMA also come largely from levy funds equivalent to about 1 percent of the total value of oil palm production complemented with small allocations from other investors, which represent about one-tenth of the levy funds. Starting early this year (2008), the levy was raised to 1.5 percent based on a grower initiative.

The coffee, rice, sugarcane, and oil palm cesses have provided a stable source of revenue for research. As mentioned above, in 2006 more than 90 percent of agricultural research funding for Colombia's four principal producer organizations combined came directly from the private sector in the form of these commodity taxes. These commodity taxes are successful because the private sector is directly involved in the research programs of the producer associations and the majority of the board members at the producer associations are representatives from large plantations or private sector smallholders. In addition, the commodity tax collection mechanism is very well established and works efficiently. However, R&D financing mechanisms for certain other crops in Colombia are much less well established.

Higher education agencies

Agricultural research funding for Colombia's higher education sector depends largely on the character of the university. Public universities are financed mainly by general government appropriations and student fees, with additional R&D funds coming from COLCIENCIAS and MADR. Each university can internally specify the amounts allocated to research, training, and extension activities, but the final budget needs ultimate approval from the Ministry of Education's "Superior Council." Research activities at private universities are financed largely through student fees and research contracts with the private sector. Like their public counterparts, private universities can compete for COLCIENCIAS funds. Both public and private universities sign research contracts with producer associations, but in reality such contracts are scarce and irregular. Donor funding generally plays a limited role in financing agricultural R&D at Colombian universities. Nonetheless, in recent years UNC has secured funding from the Tropical Science Research Institute (IICT), the Spanish Agency for International Cooperation (AECI), and the Regional Fund for Agricultural Technology (FONTAGRO).

Competitive Funds

In the early 1990s the government of Colombia committed itself to decentralizing technology development and transfer to bring applied agricultural research and extension closer to the priority problems of target beneficiaries, who would participate in characterizing, prioritizing, and solving their problems. In 1995 PRONATTA was designed with World Bank support (and counterpart funding from the Colombian government) to assist this decentralization process by offering funding for regional

research funding and institution building. The project's four key objectives were to promote a pluralistic technology system, support demand-driven and decentralized approaches, diversify financing through cofinancing by users and research providers, and provide incentives for reforming public agricultural R&D. The project involved the creation of a competitive fund in which resources were assigned to proposals responding to the needs of small rural producers. In addition, local institutional mechanisms to allow stakeholders, particularly small producers, to participate in addressing problems of agricultural system productivity and competitiveness were also stressed under PRONATTA. Competitive project selection for grants is done largely at the regional level. The program has maintained high-quality standards for awarding grants. PRONATTA's budget totaled US$56 million. During the course of the project (1995–2003), 3,786 proposals were submitted, and just 616 grants were awarded. A total of 179 implementing agencies have been involved in project execution. Of the grants, CORPOICA has received 39 percent, universities 9 percent, producer associations 6 percent, and alliances among different institutions 26 percent. The remainder of the funds was disbursed to nonprofit organizations, government agencies, and others. Although PRONATTA has not fundamentally changed the way research is conducted, it is deemed a success in economic, organizational, and institutional terms. The disbursed funds had an average internal rate of return of 86 percent. PRONATTA is also believed to have contributed to more decentralized and demand-driven agricultural research, and it has become a model for other competitive funds (MADR 2004).

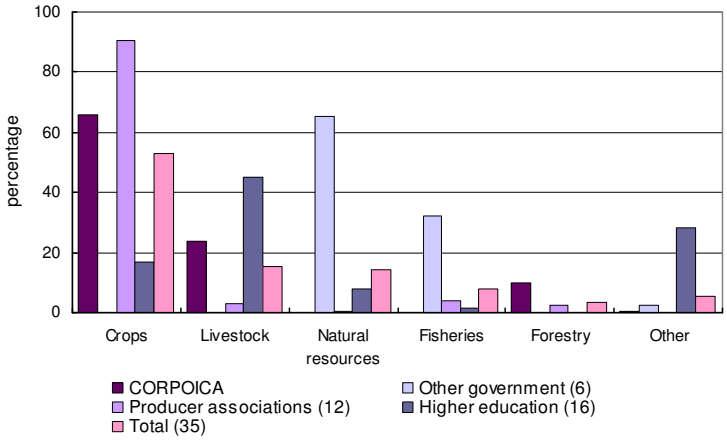
In 2005 the World Bank launched the Agricultural Transition Project. This project aims to strengthen national agricultural S&T and sanitary and phytosanitary systems by supporting the joint participation of the public and private sectors. Through the mechanism of production chains, the project contributes to the competitiveness of Colombian agriculture and improves the accessibility of export potential products to international markets. The US$30 million project consists of a US$22 million Knowledge Generation and Innovation component and is due to run until 2009. The aim of this component is to support the provision of technology and innovation by (1) strengthening agricultural production chain actors in the definition, cofinancing, and implementation of R&D; (2) preparing participatory and demand-driven R&D agendas for certain production chains; and (3) implementing and cofinancing these agendas through a competitive fund similar to PRONATTA (World Bank 2005). Based on specified criteria, MARD will target those chains likely to be most affected by the economic opening and integration process resulting from the Free Trade Agreement with the United States for the allocation of resources within the framework of this component, with the view of increasing their competitiveness. Significant importance is assigned to those programs and subprojects envisioning the transfer of technology to small growers as one of the expected benefits (World Bank 2005).

Besides the competitive funds that were introduced as part of World Bank projects specifically for the agricultural sector, COLCIENCIAS also manages several competitive S&T funds, five of which are of relevance to agricultural research: the National Program for Basic Sciences, the National Program for Agricultural S&T, the National Program for Biotechnology, the National Program for Maritime S&T, and the National Program for Environmental S&T. However, compared to PRONATTA and the Agricultural Transition Project, competitive funds managed by COLCIENCIAS are small (World Bank 2006).

RESEARCH ORIENTATION

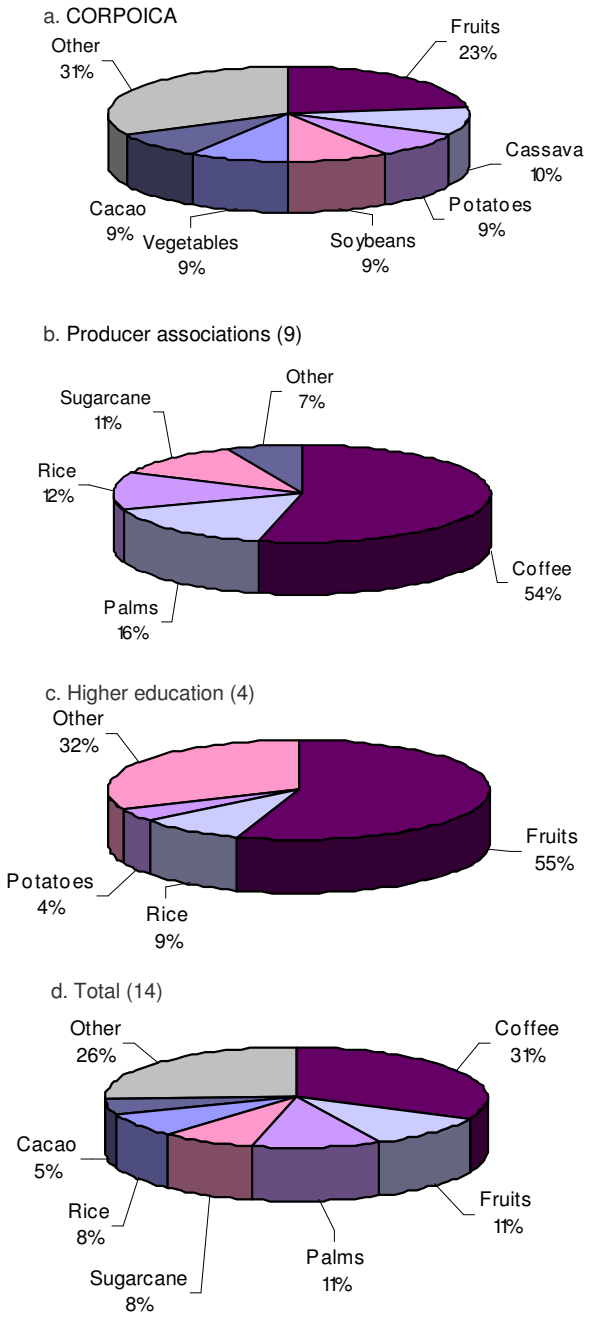
The allocation of resources across various lines of research is a significant policy decision; hence the survey collected detailed information on the number of fte researchers working in specific commodity areas. In 2006 more than one-half of the 968 fte researchers in a 35-agency sample conducted crop research. Livestock research accounted for 15 percent of the total, natural resources research for 14 percent, and fisheries research for 8 percent (Figure 11). Research staff at the nonprofit agencies and CORPOICA spent relatively more time on crop research than did their counterparts at the other government and higher education agencies. Of note are the relatively high focus on livestock by researchers in the higher education sector agencies included in our sample (45 percent) and the high focus on natural resources and fisheries by the other government sector (65 and 32 percent, respectively). The latter is not surprising given that the Institute of Hydrology, Meteorology, and Environmental Studies (IDEAM), IIAP, IIRB, and INVEMAR focus solely on natural resources and INCODER focuses exclusively on fisheries. Coffee—Colombia's major export crop—accounted for close to one-third of all research conducted on crops in the country. Fruits and palms accounted for 11 percent each, sugarcane and rice for 8 percent each, and cacao for 5 percent (Figure 12).

Figure 11—Commodity focus by major item, 2006



Source: Compiled by authors from ASTI survey data (IFPRI 2007–08).
Notes: Figures in parentheses indicate the number of agencies in each category.

Figure 12—Commodity focus by major crop item, 2006

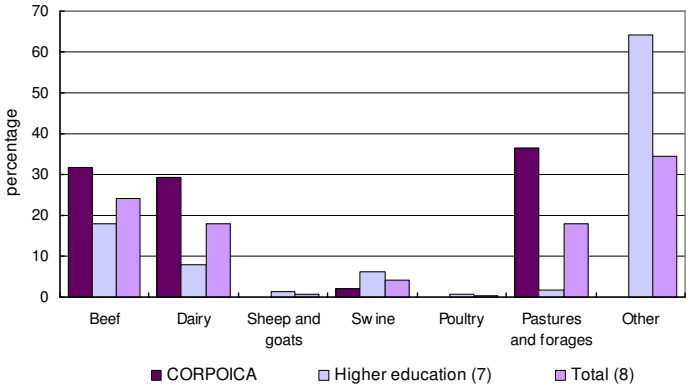


Source: Compiled by authors from ASTI survey data (IFPRI 2007–08).
Notes: Figures in parentheses indicate the number of agencies in each category.

Coffee research by CENICAFE dominated research in the nonprofit sector; accounting for 53 percent of all crop research in this category. Fruits were the most researched crop in the higher education sector, with 55 percent of all researchers in this sector involved in fruit research. CORPOICA's researchers also focused heavily on fruits (23 percent), followed by cassava (10 percent), and potatoes, soybeans, vegetables, and cacao (9 percent each). Most livestock researchers focused on beef (24 percent), pastures and forages (18 percent), and dairy (18 percent) (Figure 13). The higher education sector carries out more than one-half of Colombia's livestock research.

The congruency or parity model is a commonly used method of assessing the allocation of research resources. This usually involves allocating funds (or, in this instance, research personnel) among research areas in proportion to their corresponding contribution to the value of agricultural production. For example, if the value of rice output were twice that of maize, then congruence would be achieved if research on rice were to receive twice as much funding (or, say, employ twice as many scientists) as maize. The model assumes that an additional dollar spent on research would yield a higher return if spent in areas with a relatively low ratio of research funding to output value; therefore, funds should flow toward programs with relatively low research intensities and from those with high research intensities. If research spending or scientist shares were congruent with the corresponding value of output for a particular commodity, then the congruency ratio for that commodity—measuring the commodity share of researchers to the corresponding share of output—would be equal to 1.0.[8]

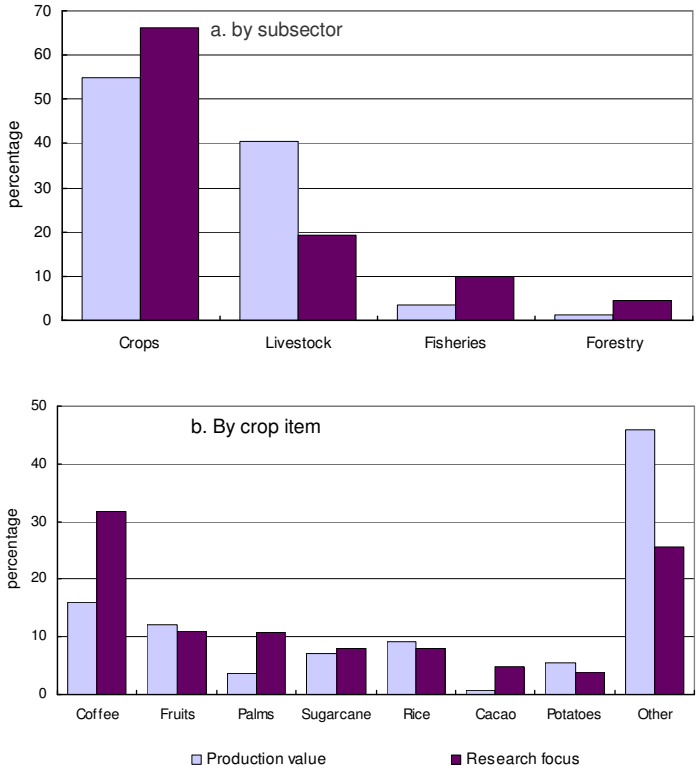
Figure 13—Commodity focus by major livestock item, 2006



Source: Compiled by authors from ASTI survey data (IFPRI 2007–08).
Notes: Figures in parentheses indicate the number of agencies in each category.

Figure 14a shows the shares of crops, livestock, fisheries, and forestry in gross value of agricultural production with the corresponding share of research staff in these areas. In 2006, 66 percent of the researchers in our subsample (which excludes postharvest and natural resources research) undertook crops research—significantly higher than the share of crops in Colombia's total value of production (55 percent). In contrast, the share of livestock researchers was lower than its share in total production value, resulting in a congruency ratio of 0.5. The congruency ratios for forestry and fisheries were very high (2.9 and 3.8, respectively).

Figure 14—Congruence between agricultural R&D and production value, 2005–06



Source: Compiled by authors from ASTI survey data (IFPRI 2007–08). Production values are from MADR-IICA-OAC (2006).
Notes: Postharvest and natural resources research themes are not included. Production values are for 2005; research focus values are for 2006.

There were major incongruencies between the shares of researchers and output values revealed at the individual crop level (Figure 14b). Coffee, for example, accounted for 17 percent of the total value of crop production in 2006, but 32 percent of Colombia's crop researchers in the sample conducted coffee research (resulting in a congruency ratio of 1.9). The congruency ratio for cacao was also particularly high at 6.1. Most other crops, with the exception of palms, had congruency ratios around 1.0. For the category "other crops," the congruency ratio was 0.53, indicating a less intensive research effort than a consideration of crop values would justify. Crops like cut flowers, potatoes, bananas, and plantains all take a relatively important part in the country's total crop value, but relatively limited research in these crops is currently carried out in Colombia. As mentioned previously, CENIFLORES imports most of its technologies from abroad; so the extremely low congruency ratio for cut flowers is not necessarily a reason for concern.

CONCLUSION

After a decade of strong growth during the 1980s, the expansion of overall agricultural research capacity in Colombia stalled in the mid-1990s. In 2006 the country as a whole employed roughly 1,000 fte scientists involved in agricultural R&D. A rapid fall in the number of research staff at CORPOICA combined with increased agricultural research activities undertaken by producer associations, higher education agencies, and government agencies other than CORPOICA have increasingly diversified the institutional structure and focus of agricultural R&D in Colombia.

A similar shift was seen in the composition of agricultural research spending. The share of CORPOICA, and its predecessor ICA, in total Colombian agricultural R&D spending has gradually declined over the past decades in favor of producer associations, other government agencies, and the university sector. Agricultural R&D spending in Colombia remained stable during 1996–2002 but has contracted substantially in recent years due mainly to severe cuts in CORPOICA's budget. In 2006 Colombia invested $152 million (in 2005 constant prices) in agricultural R&D, or 0.50 percent of the country's agricultural output. In terms of public sector intensity of investment in agricultural R&D, Colombia rates well below many of its Latin American counterparts.

Although Colombia's private sector is involved in very limited agricultural research itself, it plays a rather active role in (indirectly) financing it. More than 90 percent of research carried out by the country's four principal producer associations is financed through commodity taxes levied on private sector production or exports. CORPOICA, on the other hand, received more than three-quarters of its funds from the Colombian government, with the remainder coming from internally generated resources, the private sector, and foreign donors. In recent years, competitive funds have become increasingly important in financing agricultural R&D in Colombia.

Many challenges lie ahead for Colombia. The international integration process of the Colombian economy, and of the agricultural sector in particular, is taking place in a global setting in which knowledge and technological development and innovation are becoming increasingly important factors. The Free Trade Agreement with the United States currently pending approval presents an opportunity for Colombia to increase trade access for its products. Agricultural research is key to improving the productivity and competitiveness of Colombia's agricultural sector. The current pattern of declining agricultural R&D spending and bias toward short-term research needs to be reversed. A boost in agricultural research spending and a clear long-term national research strategy that involves both the public and private sector are therefore called for if Colombia's agricultural sector is to compete in a new global market.

NOTES

1. The authors are grateful to numerous colleagues in Colombia for their time and assistance with the data collection and thank Jifar Tarekegn for his capable research assistance, and Irma Baquero, Nienke Beintema, Ramiro Orozco, and Pedro Rocha for their useful comments on drafts of this brief.
2. With falling output in agriculture, an increase in the number of displaced workers may occur as more agricultural workers move from rural to urban areas. This in turn may lead to a rise in urban unemployment.
3. The 38-agency sample consisted of:
   - 7 government agencies/units: the *Corporación Colombiana de Investigación Agropecuaria* (CORPOICA), the *Instituto de Hidrología, Meteorología y Estudios Ambientales* (IDEAM), the *Instituto de Investigaciones Ambientales del Pacifico* (IIAP), the *Instituto de Investigaciones de Recursos Biológicos "Alexander von Humboldt"* (IIBG), the *Instituto de Investigaciones Marinas y Costeras "José Benito Vives de Andréis"* (INVEMAR), the *Subgerencia de Pesca y Acuicultura of the Instituto Colombiano de Desarrollo Rural* (INCODER), and the *Instituto Amazónico de Investigaciones Científicas "SINCHI"* (SINCHI);
   - 13 nonprofit agencies: *Centro de Innovación de la Floricultura Colombiana* (CENIFLORES), the *Centro de Investigación de la Acuicultura de Colombia* (CENIACUA), the *Centro de Investigaciones del Banano* (CENIBANANO), the *Centro Nacional de Investigaciones de Café* (CENICAFE), the *Centro de Investigación de la Caña de Azúcar de Colombia* (CENICAÑA), the *Centro de Investigación en Palma Aceite* (CENIPALMA), the *Corporación Nacional de Investigación y Fomento Forestal* (CONIF), the *Federación Nacional de Arroceros* (FEDEARROZ), the *Federación Nacional de Cacaoteros* (FEDECACAO), the *Centro de Desarrollo Tecnológico de la Cadena Agroalimentaria de la Papa* (CEVIPAPA), the *Federación Nacional de Cultivadores de Cereales* (FENALCE), the *Empresa Colombiana de Productos Veterinarios S.A.* (VECOL), and the *Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria* (CIPAV);
   - 18 higher-education agencies/units: the *Facultad de Agronomía*, the *Facultad de Medicina Veterinaria y de Zootecnia*, and the *Instituto de Biotecnología* under the *Universidad Nacional de Colombia* (UNC); the *Facultad de Ciencias Agropecuarias* of UNC-Medellín; the *Facultad de Ciencias Agropecuarias* of UNC-Palmira; the *Centro de Investigaciones y Asesorías Agroindustriales* of the *Universidad Jorge Tadeo Lozano* (UJTL), the *Facultad de Ciencias Agrícolas* and the *Facultad de Medicina Veterinaria y Zootecnia* under the *Universidad de Córdoba*; the *Facultad de Medicina Veterinaria y Zootecnia*, the *Facultad de Ingeniería Forest*al, and the *Facultad de Ingeniería Agronómica* under the *Universidad de Tolima*; *the Facultad de Medicina Veterinaria y Zootecnia* of the *Fundación Universitaría San Martín*; the *Facultad de Ciencias Agropecuarias y Recursos Naturales* of the *Universidad Tecnológica de Los Llanos*, the *Facultad de Medicina Veterinaria*, the *Facultad de Administración de Empresas Agropecuarias*, and the *Facultad de Zootecnia* under the *Universidad de la Salle*; the *Departamento de Biología* of the *Facultad de Ciencias* of the *Universidad del Valle*; and the *Facultad de Ingeniería Agro-Industrial* of the *Universidad Pontificia Bolivariana*.
4. Unless otherwise stated, all data on research expenditures are reported in 2005 international dollars or in 2005 Colombian pesos.
5. English translations of agency names have been used throughout the brief except in note 3, where the original Spanish is provided.
6. However, following the institutional classification in the Frascati Manual (see OECD 2002), a research agency that is not administered by but receives more than one-half of its annual funds from the government—like CORPOICA—is classified as a government agency.
7. Producer organizations are classified as nonprofit organizations following the institutional classification in the Frascati Manual (see OECD 2002).
8. It is important to note, as Alston, Norton, and Pardey (1998) describe, that the model overlooks key factors affecting the payoff to R&D, such as the differences in probability of research success, likely adoption rates, and the likely extent of research-induced productivity gains. It also does not account for the spill-in of technologies from other countries or differences in the costs per scientists among different areas of R&D. So, although the congruence rule is a useful tool for allocating resources and a distinct improvement over precedence and some other shortcut methods, congruency ratios that differ from 1.0 are not necessarily a cause for concern.

METHODOLOGY

- Most of the data in this brief are taken from unpublished surveys (IFPRI 2007-08) and Beintema, Romano, and Pardey (2000).
- The data were compiled using internationally accepted statistical procedures and definitions developed by the OECD and UNESCO for compiling R&D statistics (OECD 2002; UNESCO 1984). The authors grouped estimates using three major institutional categories—government agencies, higher-education agencies, and business enterprises, the latter comprising the subcategories private enterprises and nonprofit institutions. The researchers defined public agricultural research to include government agencies, higher-education agencies, and nonprofit institutions, thereby excluding private enterprises. Private research includes research performed by private-for-profit enterprises developing pre, on, and postfarm technologies related to agriculture.
- Agricultural research includes crops, livestock, forestry, and fisheries research plus agriculturally related natural resources research, all measured on a performer basis.
- Financial data were converted to 2005 international dollars by deflating current local currency units with a Colombian GDP deflator of base year 2005 and then converting to U.S. dollars with a 2005 purchasing power parity (PPP) index, taken from World Bank (2008). PPP's are synthetic exchange rates used to reflect the purchasing power of currencies, typically comparing prices among a broader range of goods and services than conventional exchange rates.
- Annual growth rates were calculated using the least-squares regression method, which takes into account all observations in a period. This results in growth rates that reflect general trends that are not disproportionately influenced by exceptional values, especially at the end point of the period.

See the ASTI website (http://www.ASTI.cgiar.org) for more details on methodology.

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