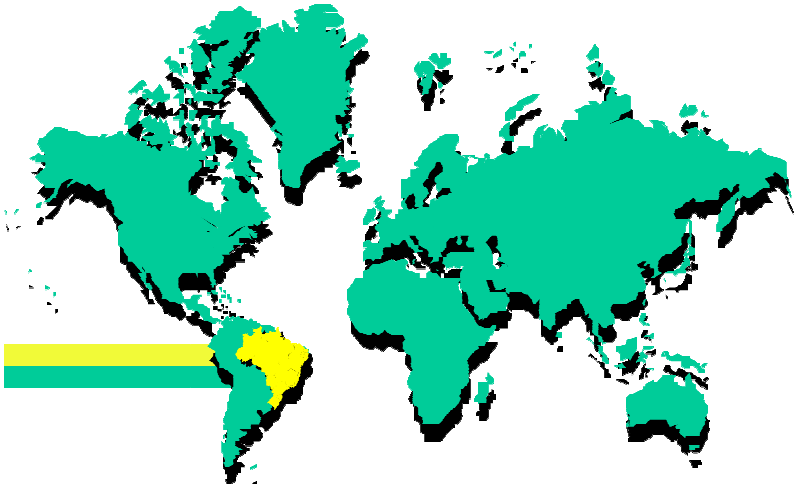
Brazilian Agricultural Research Corporation



The Brazilian Agricultural Research for Development (ARD) System*

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INTRODUCTION

With an area of 8,511,965 km², Brazil is one of the largest countries in the world, with an extensive surface of continuous land, a large supply of fresh water, abundant solar energy, and a rich biodiversity. Among the 250,000 species of higher plants, nearly 60,000 are native to Brazil. Besides the world's largest tropical forest, the country has over 200 million hectares of Savannas (known as "Cerrados") with immense agriculture and livestock production potential.

Brazil has used its diversity and resources to successfully become a world leader in many sectors, including agriculture. The wide range of climatic conditions, from temperate to tropical, together with advanced capacity in technology development, allowed considerable diversification of the agricultural production, which have made Brazil the world's largest producer of citrus fruits, frozen concentrated orange juice, sugarcane, and coffee. The country is also a serious global competitor for many other products — soybeans, tobacco, poultry, corn, beef, biofuels — as well as self-sufficient in the production of most agricultural goods.

Technology development for tropical agriculture has been one of Brazil´s main strengths, as illustrated by the evolution of soybean cropping systems in the country, since the 1960´s (Figure 1). Today, Brazil is the second producer in the world, with a volume, in 2009, of 58 million tons, only exceeded by the United States. Introduced in a commercial scale in the years 1960-70, it adapted well only to temperate regions in the Southern part of the country. Technology in breeding and genetics, crop and soil management, and biological nitrogen fixation, developed by the Brazilian Agricultural Research Corporation - Embrapa and other partner organizations, allowed adaptation of this legume crop to low latitudes, in the Savannahs and in other agro ecological zones located in Central, Northeastern and Northern Brazil. Over the past 30 years, average soybean yields have increased more than 130 percent, with quality as high as any produced in the world.

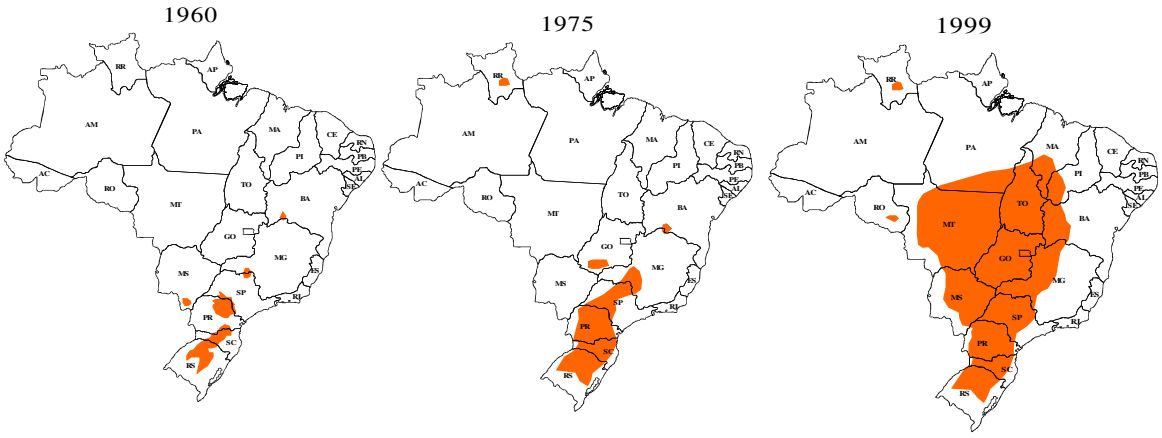

Figure 1. Evolution of soybean cultivation in Brazil – from 1960 to 1999.

THE EVOLUTION OF THE AGRICULTURAL SECTOR IN BRAZIL

Historians describe organized agricultural research beginning in Brazil in the 19th century, at the Botanical Garden of Rio de Janeiro, that was established in 1808. During that period, Brazil's predominant agricultural products were coffee and sugarcane. By the end of that century, the Imperial government established the Agronomic Station of Campinas, a federal institute that was transferred to the state government of São Paulo in

1891. Renamed as Agronomic Institute of Campinas (IAC), and fully operational to this day, IAC is the oldest agricultural research organization in the country[1].

The First World War, the economic crisis of 1929 and the Brazilian Revolution of 1930 led to substantial changes in the focus of agricultural production in the country, with intensification of cropping systems other than coffee and sugarcane. Products such as cotton, corn, orange and other foodstuffs started to gain expression, supported by public policies of import substitution[2]. Increasing government support to agriculture was observed in the first half of the 20th century, with the creation of institutes and agencies such as the Office of Cocoa (1931), the National Coffee Department (1933), the Institute of Sugar and Alcohol (1931), the National Institute of Rubber (1942), among others[3]. However, agricultural innovation was limited in the country and most agricultural production remained concentrated in a relatively narrow strip along the Atlantic coastal area.

Only in the 1960´s begins a process of modernization of the agricultural sector in Brazil. In 1965, a National Rural Credit Program is created, providing financing to modern inputs and equipments. Other important support policies like Warranty Policy for Minimum Prices of various agricultural products were created, improving stock control, commercialization and logistics [4, 5, 2]. In the 1970´s the government creates PROAGRO – a Rural Insurance Program, the Brazilian Agricultural Research Corporation – Embrapa, and the Enterprise for Technical Assistance and Rural Extension – Embrater. Also, many state governments created their own agricultural research organizations at that time. Embrapa, state research institutes and agricultural universities became part of the National System for Agricultural Research (SNPA), one of the largest agricultural research networks in the tropical world[5, 6, 7, 8].

Therefore, the substantial modernization of agriculture in Brazil, observed in the 70's and early 80's, was a result of coordinated policies that led to increased R&D capacity and increased volumes of credit, tied to support policies of stock management, improved distribution and commercialization of food and agro industrial products. These coordinated policies and support mechanisms led to a better allocation of resources, increased productivity, improved product quality and reducing food prices [3,4,5,6,7,9].

However, this phase was dominated by subsidized credit, which had to be almost totally discontinued by the end of the 80´s due to successive crises and high inflation. In the first half of the 90´s, due to the scarcity of public resources, a substantial downsizing of rural extension was carried out throughout the country. Still, in the late 80´s and the 90´s some remaining compensation policies favored the expansion of production in Central Brazil, supported by development of innovative technologies to overcome the severe limitations of the savannahs, known as "Cerrado". Technologies to remove soil acidity, build soil fertility, improve crop and animal management, among others, were developed and quickly incorporated by farmers [2,5,6,7,9].

With the end of inflation and stabilization of the economy, in the second half of the 1990s, the private sector started to occupy a more active role in credit, marketing, commercialization and agricultural innovation, with increasing investments in R&D. The Government gradually moved away from functions like price controls, production management and sole provider of R&D capacity [5,6,7,9]. More recently, special attention has been given to the Agrarian Reform and to social policies to support family farming, like the creation of PRONAF – the National Program for Strengthening Family Agriculture. Also, policies and programs directed to increase sustainability in the agricultural sector are gaining increasing attention[2].

Also, and considering demands for more sustainable production models, Brazil took important leaps, in a short period of time, towards increasingly safer and sustainable agricultural systems. The country is a leader in crop

management based on no tillage, which significantly helps decrease erosion and improve general soil quality and groundwater recharge. Biological nitrogen fixation, through a inoculation technique using endophytic diazotrophic bacteria, has led to a significant decrease in the amount of chemical fertilizers applied to crops such as soybean and, more recently, sugarcane. This, in turn, has significantly reduced environmental impacts such as water resources contamination with nitrates or other harmful elements. Biological control, regularly used in a number of crops such as soybean, sugarcane, cotton and fruit-bearing plants, has also reduced the need for chemical pest and disease control in several management systems, which has had a positive impact on the environment, rural workers' quality of life and product safety and quality. Over the last decades, plant breeding programs have made it possible to mobilize genetic variability in order to adapt crops to a wide variety of environmental conditions in the tropics. This has been achieved by incorporating adaptation to different latitudes, tolerance to acid soils–especially to toxic aluminum, and increased efficiency in nutrient use (like phosphorus and nitrogen), as well as resistance and tolerance to biotic factors that are especially severe in tropical regions [10,11].

DEVELOPMENT AND CONSOLIDATION OF THE BRAZILIAN ARD SYSTEM

In order to achieve the above mentioned advances, Brazil has developed a large and complex agricultural research basis, which is composed by public institutes, universities, private companies and non-governmental organizations. This capacity stands as one of the most comprehensive and most efficient in the tropical belt of the world[5,8,9]. It is estimated that in 2006 the 27 countries of the Latin America and the Caribbean region spent a total of nearly $3.0 billion on agricultural research and Brazil alone accounted for 41 percent of this total. The country has been investing over 1.0 percent of its agricultural GDP in agricultural R&D, most of it from public sources [12].

Beginning in the 1970´s, Brazil has improved its structure and capacity substantially, developing a two-tier system of federal- and state-based agencies. This so-called National System for Agricultural Research and Innovation (SNPA), has been able to develop and promote a wide array of technological innovations that triggered the expansion of agribusiness in the country over the past four decades. The SNPA is responsible for organizing, coordinating and implementation research that objectively contribute to development of agriculture, sustainable use and preservation of natural resources in the country. Implementation of the SNPA concept led to strengthening of agricultural R&D capacity in Brazil, with improved infrastructure, human capacity, management mechanisms and support policies in a national scale [13].

State research institutes, universities and the Brazilian Agricultural Research Corporation – Embrapa are the major components of the SNPA system in Brazil. Sixteen of Brazil's 26 states operate agricultural research agencies. For example, the São Paulo Agency for Agribusiness Technology (APTA) coordinates all crop and livestock research activities in 64 experimental units and 43 research laboratories located across the state. Brazil also has a substantial number of federal and state universities that conduct research at more than 100 faculties or schools of agricultural sciences. Only a few of the private universities undertake agricultural research in Brazil, and the nonprofit sector plays only a modest role[13].

Embrapa is by far the largest component of the Brazilian SNPA System. A semiautonomous federal agency administered by the Ministry of Agriculture and Food Supply, Embrapa is the largest agricultural R&D agency in Latin America in terms of both staff numbers and expenditure [8,9,12,13]. The agency is headquartered in the capital Brasilia and operates 40 research centers throughout the country.

EMBRAPA: A CASE OF SUCCESSFUL INSTITUTIONAL INNOVATION

Embrapa is a case of successful institutional innovation that has many distinctive characteristics: a public corporation model of organization; scale of operation at national level; spatial decentralization; specialized research units; enhanced training and remuneration of human resources and a vision of an agriculture based on science, technology and innovation. Dr. Eliseu Alves, a scientist and visionary leader that helped create and consolidate Embrapa provided one of the most complete overviews, to date, on Embrapa´s model and achievements[14]. Below it is summarized the main aspects of the organization´s development and consolidation process covered in his study, with emphasis to those that made Embrapa known as a successful case of institutional innovation:

Continuous support from the Federal Government: Without strong and continuous support from the federal government, Embrapa´s consolidation would not have been possible. In the early years, it took the form of the federal government having understood the importance of technology for the development of agriculture. The battle for budgets has been constant over the 36 years of the organization´s existence but once the results proved Embrapa as profitable investment for the Nation, the battle for budgets and support benefited from the corporation´s widely recognizes status of strategic organization;

Diversified R&D portfolio: Embrapa´s management has always been aware of the risk that the lack of achievements represents for an R&D organization´s future. To overcome this risk, Embrapa always had priority on short-term goals coupled to attention to the dissemination of existing results;

Timing and social support: In the beginning of the 70´s, there was in Brazil a food supply crisis, mainly caused by a rapid displacement of the population from rural to urban areas. This also caused high prices for basic foodstuffs, queues in supermarkets, social unrest. Still, the stock of knowledge was largely insufficient. So, on the macro-economic level, there was enough pressure and understanding to reform public research in agriculture: a typical case of induction of institutional reform, as provided by Hayami-Ruttan [15]. Thus, Embrapa was created, when conditions were very favorable for its success;

Option for a public corporation model: The option taken in 1972, to organize Embrapa as a public corporation, was a bold decision of the government to release Embrapa from the bureaucratic rules used in the public administration. This gave it the flexibility to administer resources and personnel, to plan, to assess performance, to implement the budget, to disseminate results and to be transparent. The model allowed Embrapa to develop its own personality, which has characterized it in the national and international scenario as unique example in the field of public research;

Scale, interactivity and decentralization: The leaders and decision makers that created Embrapa reasoned that in a country of continental dimensions like Brazil, the success of a national R&D organization would depend on its size, diversity of talents, and level of decentralization. It was very important for Embrapa to have a presence throughout the national territory. This presence helped to attract sympathy of the state governments and the National Congress. Also, it was understood that Embrapa needed to be a network with a critical mass of researchers capable to engage in active cooperation with universities, state research institutes, private sector and overseas organizations;

A concentrated organization model for the research units: Embrapa research units are distributed throughout the national territory and are specialized in products, resources and themes. Farmers and other stakeholders know

where to go with demands for information and results, which gives them ownership in the center, providing help with the political leadership and the economic area of government. This model also facilitates and encourages interaction within the network, since centers dedicated to specific products will strongly depend on effective interactions with complementary teams from thematic and resource centers;

Human resources: The human resources policy of Embrapa, which has been constantly perfected over the years, aims to develop the human capital of the corporation and it is from this capital that Embrapa derives its success. This comprehensive policy is based on several key factors, among them: the establishment of a career that stimulates the desire to study and progress; a salary that allows the researcher to have a dignified living; a retirement plan, with voluntary membership; a health plan paid by Embrapa and the employees; opportunities and stimuli for all employees to accumulate knowledge and experience; a system of a merit-based promotion, focused on individual, group and research unit´s performance; a training program at post-graduate and post-doctoral levels, that meets both the interests of the corporation and the researchers; among others;

Professional relations and coexistence with power: Politicians represent Brazilian society and Embrapa considers important that they take part in the organization´s life, especially in aspects related to definition of priorities for research and institutional development. Hiring its top managers by open public selection is an instrument that has promoted coexistence and professional relations with the political power. Therefore, Embrapa has been able to develop productive relations with the political world, while guaranteeing independent and competent leaders;

Independent reviews and evaluations of impact. Over the years Embrapa has used a diversified set of instruments to demonstrate its importance in the modernization of agriculture and the agribusiness sector in Brazil. Several aggregate studies have demonstrated the role of Embrapa´s R&D in technological change of the agricultural sector and to increase exports in Brazil [6,7,13]. Also, Embrapa publishes regularly its social balance[16], that has been showing that every Brazilian Real (R$) invested in the organization returns between R$ 12 and R$13 to the Brazilian society (US$ 1.00 = R$ 1.77). The Social balance of Embrapa in the past 10 years amounts to US$ 49.7billion;

Communication with society: Embrapa has always pursued good answers to the question: what makes a result to be easily understood by society? This is a complex issue that involves a range of concepts and strategies. And it also demands talent and abilities to establish the connection between the media and the organization with the minimum possible of noise. From the beginning, Embrapa invested in professionals able to create strong ties with the media, making its results well publicized, both in Brazil and abroad. And more than one can imagine, Embrapa has become a symbol of pride and national success;

Foresight and institutional flexibility: Embrapa has always invested a great deal of effort in foresight [17,18] strategic planning and improvement of institutional processes [19,20,21,22,23]. During its 36 years of existence, the organization experienced three different models of R&D management, in response to changing times and innovation trends and methods [24]. The implementation of its current model, called SEG – Sistema Embrapa de Gestao [25], was an important move towards stronger networking to tackle great national and international challenges. This R&D management process introduced an internal competitive system strongly sustained in peer review[25].

OPENING UP TO THE WORLD – THE INTERNATIONALIZATION OF EMBRAPA

Embrapa was open to the outside world very early in its life, when the external exposure of Brazil was still very incipient. After the creation of Embrapa, a strong post-graduation program sent hundreds of young professionals abroad, the majority to the United States and Europe, and to a lesser extent to the United Kingdom, Canada, Spain, Holland, Germany and Australia. The good performance of these students helped to form important relationship bridges with the academic world abroad. Projects financed by the World Bank, Inter-American Development Bank and the Japanese government have been very important to finance this human development program and also to equip the research units. Because these programs have been well designed and implemented, they solidified the image of Embrapa as a serious and responsible organization[14].

Currently Embrapa has 78 bi-lateral agreements with 89 institutions in 56 countries. It has also Multilateral Agreements with 20 International Organizations. At project level, there are numerous agreements involving several countries, organizations and research networks. For example, the ties of Embrapa with the CGIAR system extend to its origin, and the relationship with the International Centers has brought many good results. This relationship, especially at the beginning of Embrapa, was very important to set directions for research and for training scientists. Embrapa recognizes that important shares of the Brazilian seed market of wheat, maize, beans and rice is held by varieties that were improved using genetic material received from CGIAR centers[13]. Even in Embrapa´s mature phase, the relationship with the CGIAR system is still very important, especially for joint work in Africa, Latin America and Asia[14].

In 1998 Embrapa developed and implemented the innovative concept of Virtual Laboratory – or Labex, as means of increasing its scientific and technological ties with advanced research organizations around the world[14,26]. Instead of building its own platform abroad, Embrapa uses the concept of virtual lab, or lab without walls, to negotiate access to its partner organizations' existing facilities. The concept has been tested and validated in the United States, in partnership with the Agricultural Research Service (ARS-USDA). Given the success of Labex in the United States, Labex Europe was created based in Montpellier (France), with further presence in Holland and England, more recently, by separate agreements with these countries. In 2009 it has been extended to Asia, in partnership with the Rural Development Administration – RDA, of South Korea[27]. The development of the Labex concept was based on the evidence that Embrapa scientists needed to strengthen contacts with the best research organizations abroad, not only by training students, as Embrapa had been done for more than three decades, but also involving its senior staff in international cooperation[14].

The success of Brazilian tropical agriculture motivates countries with similar problems and challenges to seek information and support for technology transfer from Embrapa. Besides the traditional instruments of support, Embrapa has decided to outpost researchers in less developed countries, creating Embrapa Africa, in Accra (Ghana) in 2006, Embrapa Venezuela, in Caracas, in 2007. In 2010 Embrapa will install Embrapa Americas in Panama with deployment of one researcher and one technology transfer analyst to support the organization´s collaboration in Mexico, Central America, the Caribbean, Colombia, Ecuador and Peru.

Both the Labex model - research initiatives with developed countries – and the structures of transfer of technology in developing countries are flexible models that can be expanded with new scientists or by transfers of scientists among countries, according to identified common interests. The goal is both benefiting agriculture and helping to combat hunger in developing countries [14, 26].

FUTURE CHALLENGES AND OPPORTUNITIES

Sustainable development is one of the most challenging goals for mankind, and is vital to Brazil. The technological standards of global agribusiness are now being substantially modified by the introduction of new technologies brought forth by recent scientific advances. A new body of knowledge is starting to configure an agriculture that, besides aiming at food production, is also designed to meet a set of requirements that might form a new technological standard. These requirements include: a) attention to the environmental services needed to enhance the sustainability and productivity of the natural resources base that underpins agriculture; b) competitive products whose added value stems from differentiation and specialization; c) safe and healthy products, differentiated in order to meet consumers nutritional, health and convenience needs; d) production of renewable energy, feedstock and bioactive molecules for different industries, so broadening the scope and usefulness of agricultural systems, especially in the interface with the nascent bioindustry [10,11,18].

Climate change will impose additional stresses to many delicately balanced agro-ecosystems, especially in tropical areas, where significant intensification of biotic and abiotic stresses is expected in the next decades. If the expected trends in climate change are confirmed, severe constraints will be imposed on future advances the research community could achieve, using conventional methods and tools of innovation. Therefore, a paradigm change is much needed to address this emerging agricultural problem, especially in the tropical belt of the world[10,11]. The genomics revolution of the past decade has dramatically improved our understanding of the genetic makeup of many agriculturally important species. Together with the achievements represented by complete genomic sequences, high-throughput and parallel approaches are available for the analysis of transcripts, proteins, pathways and, more importantly, to help extract useful variability from the wealth of resources stored in our germplasm banks. New genomic technologies coupled to breeding approaches bring opportunities to reduce the impacts of biotic and abiotic stresses on agricultural system´s productivity and to improve safety, quality and functionality of crop and animal products[11,18].

Agricultural innovation has to be understood as part of a complex process. Complementarities, mix of technologies and capabilities, together with effective approaches to networking must be viewed as key ingredients in developing this process. One of the key problems limiting the effective implementation of a complex process is the difficulty to build effective teams and networks [29]. Approaches to networking and partnerships have become important means of enabling organizations attain otherwise unattainable goals, add value to their products and processes and reduce costs. In order to face these challenges it is crucial to establish wide alliances, bringing together professionals from different areas of expertise. Also, the demand for efficiency and relevance presses R&D programs to move in the direction of cooperation efforts. Therefore, the need for an expanded networking approach to agricultural R&D will always be an objective to be pursued.

The future configuration of any ARD system is dependent on knowledge to guide strategic decisions about structures, methods, and capacities, in order to take advantage of new opportunities and technological niches that can benefit from strong innovation programs. More prospective efforts must be directed to thinking the future of agricultural research and innovation around the world, especially in developing countries. Research organizations need information that is not currently available, about current and future changes and influences and their impact in the countries key activities [10,11,18]. To obtain and organize this information, prospective studies on the present and future performance of the innovation system and their related activities will have to be intensified and systematically improved. These prospective studies and priority setting mechanisms, together with cost benefit analysis will be valuable to guide informed decisions in the future.

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