Ministério da Agricultura, Pecuária e Abastecimento

STATE OF THE BRAZIL'S PLANT GENETIC RESOURCES

SECOND NATIONAL REPORT

Conservation and Sustainable Utilization for Food and Agriculture

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PRESENTATION

It is my pleasure to present the second **National Report on the State of Brazil's Plant Genetic Resources for Food and Agriculture,** a document that displays the country's progress in relevant areas following the first report in 1996.

The present report is a step toward the preparation of the ***Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture.*** Furthermore, it will provide a basis for establishing national, regional and global priorities, will help design strategic policies toward the implementation of priority actions for agricultural development, and will foster conservation and sustainable use of native and exotic biodiversity resources. As a party to both the Convention on Biological Diversity and the FAO International Treaty on Plant Genetic Resources for Food and Agriculture, Brazil considers activities related to genetic resources as priorities. The country has invested in infrastructure enhancement, capacity building and transfer of technologies that can help improve food security, not only for its population but for that of other developing countries as well.

This document offers a summary of the main activities conducted by different Brazilian institutions with the goal to enrich genetic variability, as well as to ensure conservation, evaluation, characterization and documentation of plant genetic resources. It is the result of a joint effort by dozens of Embrapa researchers, technical personnel of state-level research companies, professors, and representatives of the ministries of Agriculture, Livestock and Food Supply (Ministério of Agricultura, Pecuária e Abastecimento – MAPA), of Environment (Ministério do Meio Ambiente – MMA) and of Foreign Affairs (Ministério de Relações Exteriores – MRE).

We are pleased to express our gratitude to all those who have participated in its elaboration. Moreover, we would like to thank FAO for the support provided during the development of this work.

Reynold Stephanes

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EXECUTIVE SUMMARY

The Brazilian territory has continental dimensions, ranking third in extension in the Americas. Due to its vast surface area and geographical location, Brazil is extremely rich in plant and animal varieties (biodiversity), from which derive natural resources that are utilized to build the country's economy. The high temperatures prevailing in the largest part of its territory are appropriate for virtually all crops. Brazil has a broadly diversified climate, in the range of tropical and subtropical climates and their variations; this is due to factors such as geographical position, oceanicity, continentality, altitude, relief, and air-mass dynamics. The diversity of species in the Brazilian flora stems from the edaphoclimatic peculiarities that cause the formation of vegetation types in six different biomes: Amazonian, the Cerrado, Caatinga, Atlantic Forest, Pampas (Southern fields) and Pantanal.

The country accounts for three fifths of the South American industrial production and participates in several economic blocks. Its scientific and technological development, combined with a diversified and dynamic industrial park, attracts foreign businesses. In the current decade, direct investment has averaged about US$ 20 billion/year, compared to US$ 2 billion/year in the previous decade. Brazil trades regularly with over one hundred countries; in excess of 74% of its exports are manufactured or semimanufactured goods. The country's main trade partners are: European Union (26% of the balance); USA (24%); MERCOSUR and Latin America (21%) and Asia (12%). One of the most dynamic sectors in these exchanges is agribusiness, which has kept Brazil among the countries with higher rural productivity for the last two decades.

Over the last three decades, the leap in the Brazilian agricultural production is unparalleled by any other country's. More than production itself, yield and quality of crops has reached, and in some cases surpassed, those of other top food producing nations in the world. Besides macroeconomical, sectorial, and technology policies, agribusiness organization has been a crucial success factor. Brazil is one of the world leaders in the production and export of several agricultural products. It's the first producer and exporter of coffee, sugar and orange juice. Furthermore, it leads in 2008 the ranking of external sales of soybean, beef, chicken meat, tobacco, leather, and leather shoes.

Brazil has about 44,000-50,000 species of vascular plants, which represents approximately 18% of the global plant diversity. Nevertheless, Brazilians agriculture and food security are, to a great extent, completely dependent on the introduction of genetic resources from other countries. Without the growing, systematic importation of genetic resources, virtually none of the Brazilian agricultural activities –quite diversified due to the country's own ecological variety- would be as important as they are today. This dependence will persist, because research aiming at developing new plant varieties requires genetic material with ecological adaptation characteristics -such as, for instance, resistance to local pests and diseases, adaptation to environmental adverse conditions that can derive from climate changes, and adaptation to different Brazilian soils- in order to meet the growing demand for food, fibers and energy production. Several Brazilian native species have been used as human food. Though they are used to a much lesser extent than exotic species, they are regionally and locally very important. The better-known among them are: cassava, pineapple, peanuts, cocoa, cashew, cupuassu, passion fruit, Brazil nuts, guarana, Myrciaria jaboticaba; this is also the case of some palm tree species such as Euterpe oleracea (assai), up until recently only consumed in Northern Brazil and today, in the form of frozen pulp, consumed across the country and even exported. Besides, native forage species provide support to a good part of the national livestock sector. More recently, native medicinal and ornamental plants have been increasingly valued in the Brazilian agribusiness context.

Genetic resources are crucial for breeding programs. Over the last decade, Brazil has achieved significant results in agriculture-related research thanks to a heightened investment in Science & Technology. New cultivars and varieties, adapted to the various climatic conditions prevailing in the Brazilian territory, have allowed substantial progress in food production. Thus, increased agricultural production has stemmed from increased yield, without a significant expansion of the growing area. Breeding programs account for the production of materials with higher resistance to different conditions, adapted to several climatic conditions; these are chiefly materials resistant to biotic and abiotic stresses.

Over the last ten years, Brazil has made significant progress in conservation and use of plant genetic resources, mainly those related to food production. Regarding *in situ* conservation, important progress has been made in order to create and establish conservation units for the preservation of relict native vegetation that is disappearing and vast still existing dense forests, like in the Amazon biome, where the largest conservation units have been created. Furthermore, other important government initiatives, such as research conducted to indicate priority areas for *in situ* management and the prospection of native species with a potential for sustainable use, have arisen from the ratification by Brazil of the Convention on Biological Diversity in 1994. The National System of Conservation Units has been implemented; as a result, Brazil currently has one of the most thorough systems of protected areas in the world. Today Conservation Units cover 8.2% of the territory, following an approximately five times expansion over the last two decades. Strategies for *on farm* management have been established by the Brazilian government with the goal to ensure historic-cultural conservation of a number of food plant species and varieties used by traditional farmers. However, the impact traditional populations have on genetic resources conservation is hard to quantify and to model due to the wide cultural diversity in Brazil. Participatory breeding, seed fairs, local seed banks and agrobiodiversity dissemination centers have been fostered as strategies for conservation of traditional populations' genetic resources.

Regarding the need to create and establish protected areas, important steps have been taken in recent years in order to preserve relict native vegetation that is disappearing and vast, still existing dense forests, like in the Amazon biome, where the largest Conservation Units (CUs) were created. Moreover, other important government initiatives, such as research conducted to indicate priority areas for *in situ* management and the prospection of native species with a potential for sustainable use, have arisen from the ratification by Brazil of the Convention on Biological Diversity in 1994. Of the federal CUs, 239 protect terrestrial areas, 43 are mixed, protecting terrestrial and marine areas, and 10 protect marine areas alone. These Units cover 8.2% of our territory, with 3.9% of Full Protection and 4.3% of Sustainable Use CUs. In little over two decades the country went from 15 million hectares of federal level protected areas in 1985 to approximately 70 million hectares in 2007.

The National System of Agricultural Research (Sistema Nacional de Pesquisa Agropecuária - SNPA) is under Embrapa's coordination. SNPA is made up of public federal and state level institutions, universities, private companies and foundations that conduct cooperative research in different geographic areas and scientific knowledge fields. Since its establishment, Embrapa (Brazilian Agricultural Research Corporation) was entrusted with the duty of promoting and making possible the safe introduction of genetic resources that are strategical for the country. Embrapa Genetic Resources and Biotechnology, one of Embrapa's 39 Research Centers, coordinates genetic resources conservation activities through a system called National Genetic Resources Network (RENARGEN), which will be replaced in early 2009 by a broader structure named National Genetic Resources Platform. Between 1976 and 2007, the Germplasm Exchange and Quarantine System dealt with over 500,000 samples, of which more than 400,000 were imported from all over the world. This system feeds a network of 350 Germplasm Active Banks as well as a Base Collection (long term conservation) composed of 212 genera, 668 species and in excess of 107,000 accessions. This whole system provides support to hundreds of public and private genetic breeding programs developed across Brazil. In short, the Germplasm Active Bank network and the Base Collection currently keep these assets in cold chambers, in the field and *in vitro*. Embrapa created its Curatorial system in the early 1980s; over the last decade, this system has been improved in order to define, systematize and integrate all indispensable activities for germplasm management, conservation and use. Thus, in 2008 there are 38 Product or Product Group Curators, 35 Assistant Curators, 111 Germplasm Banks Curators, as well as *Ad hoc* Curators, a total of about 200 people involved in germplasm curatorships. The establishment of Core Collections in Brazil has been prioritized by Embrapa Genetic Resources and Biotechnology, which during a first stage –based on partnerships – created cassava, maize and rice Core Collections. Following this experience, other Core Collections will be considered.

Information and telecommunications technology experienced great progress between 1996 and 2008. This allowed positive and substantial action to be taken toward documentation and informatization of genetic resources work, facilitating swift, simple remote access to centralized databases. In keeping with facilities made available by the evolution of information and telecommunications technology, the Genetic Resources Information System (Sistema de Informação de Recursos Genéticos – SIRG) was replaced in the early 2000s with the current Brazilian System for Genetic Resources Information – Sibrargen. Computers and software for Genetic Resources Documentation have been continually updated in order to keep up with growing demands from system users. The communication line, which in 1996 operated at 2 MBPS, has recently started operating at 100 MBPS -a 50 times increase in transmission speed. In 2007 Brazil was chosen by FAO to join the group of countries that would test the integration of national information systems on genetic resources through the Multilateral System Level –FAO's MLS, currently under development. This was done in order to meet the demand for germplasm exchange based on MultiCrop Passport Data (MCPD-FAO) in the framework of the International Treaty on Plant Genetic Resources for Food and Agriculture. Sibrargen is currently making available cassava accessions passport data (*Manihot esculenta* Crantz). Through Embrapa, Brazil will make these data available from 2009 to the facilitated exchange system.

The knowledge of potentially useful genes and their incorporation into elite cultivars has been very important in order to foster the use of genetic resources and broaden breeding programs' genetic base. Research involving germplasm prospection, conservation and characterization has become strategically important for Brazil. For vegetables, many efforts have been made in order to foster efficient and effective utilization of the variability conserved in GABs. Another important initiative is the Orygens project, based on a wide network of researchers from different public and private institutions in the country; it aims at promoting the use of current knowledge about rice genome to develop more competitive cultivars. For maize, a relevant example was the *Latin American Maize Project* (Lamp), which involved 12 countries. As far as coffee is concerned, pre-breeding programs have been developed for a number of years by the Campinas Agronomical Institute, yielding quite significant results for Brazil.

Pre-breeding activities have been conducted in order to select accessions with agronomical features and take advantage of the variability derived from natural crossings. Crop wild relatives are an extremely important part of Brazilian and global heritage as they developed, in the course of their evolutionary process, mechanisms allowing them to survive under extreme adverse conditions -such as drought, flood, heat and cold-, as well as pest and disease resistance. In this context, the Brazilian Ministry of Environment (Ministério do Meio Ambiente – MA) has started a pioneering project for the identification and mapping of creole varieties and wild relatives of some of the main crops grown in Brazil. This is a complex, uniquely important, strategic task, one that demands a wide involvement of several sectors of Brazilian society. .Seven subprojects involving some of the major crops in the country have already been concluded: cotton, peanuts, rice, cucurbits, cassava, maize and peach-palm.

Most of these wild relatives might either be included in the relevant crop improvement process as a part of the primary gene pool or become a new crop following the domestication process.

The Ministry of Environment coordinated the *Identification of species of the Brazilian flora of current and potential economic value utilized at local and regional levels*: *Plants for the Future* project, developed in 2005-2007 with the aim to a) prioritize new commercially underused species of the Brazilian flora, providing small farmers with possible uses; b) create new investment opportunities for entrepreneurs in the development of new products; c) identify the degree of utilization of and gaps in scientific-technological knowledge about locally and regionally used species; d) value biodiversity, clearly demonstrating to society the importance and possible uses of these resources; e) enhance food security, broadening previously available options. The outcomes of this project evince its importance, as 755 species were prioritized, 255 from the South, 128 from the South East, 131 from the Center West, 162 from the North East and 99 from the North Region.

Higher education in areas related to Agricultural Sciences has a long history in Brazil. Agronomy courses were the first ones to be created in the country in 1892. The vast majority of agricultural colleges are under federal or state governments; recently, some colleges of agronomy have been created by private universities. In 2006, a total of 143,798 students were enrolled in Agronomy and Biological Sciences undergraduate programs. Brazil has a high number of Agricultural Sciences graduate programs as well. This high number was made possible directly by investments made in the 1970s, 1980s and 1990s, when large numbers of researchers were sent abroad for training at the graduate level, especially in the United States and in Europe. As a consequence, capacity building of research in Brazil is closely linked with extensive graduate programs, which follow the American master's and Ph.D. degree program pattern. At the end of 2006, there were 3,540 professors teaching in Agronomy, Forestry, Agricultural Engineering, Botany and Genetics graduate programs (different areas). As for the students, there were 4,960 enrolled in master's degrees programs and 4,045 in Ph.D. programs. Graduate programs in the area of plant genetic resources have been established since 1997; some other graduate programs offer specific courses on subjects related to it.

In Brazil, Research and Development efforts have been essentially public. In rural areas, Science and Technology have developed chiefly in public faculties and research centers, first and foremost in federal institutions; private sector institutions, as well as those related to agricultural services play a minor, low profile role. Some research areas related to agriculture are defined as strategic, such as technological development, production and industrial policy; these areas have been directly funded by the Ministry of Agriculture and Food Supply. To plant genetic resources research and development, the Ministry of Science and Technology contributes basically a vast graduate studies system and funding to research institutions. Among Brazilian universities, research is basically carried out in public universities, at both federal and state levels; these generate approximately 90% of the country's scientific research. With a few exceptions, private universities have little to add to this scenario. University research is usually funded from non-budgetary funds provided from outside the university. Investment is required in basic infrastructures such as libraries, computers, laboratory space, and human resources. This investment is funded by the Coordination for Higher Education Personnel Training (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES), placed under the umbrella of the Ministry of Education. However, the most important funding source for university research is the Ministry of Science and Technology (Ministério da Ciência e Tecnologia - MCT), whose funds are distributed through two agencies: National Council for Science and Technology Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq) and Research and Projects Funding Agency (Financiadora de Estudos e Projetos - FINEP). Other important funding sources for research in Brazil are State Level Research Support Foundations; these are especially created to fund and provide support to research, thus allowing the national scientific base to broaden, both in qualitative and in quantitative terms.

In 1995, when the first National Report on the State of Plant Genetic Resources for Food and Agriculture was prepared, Brazil had just joined the World Trade Organization (WTO) and ratified the Convention on Biological Diversity. Back then, most of the legislation related to access to and movement of genetic resources was still under discussion. Some of the older laws, such as those concerning plant health or environment, were since then included into Brazil's legal framework. Today Brazil has a number of control mechanisms. Therefore, any intended use of genetic material, native and exotic alike, must comply with laws and delegated legislation in force. So, the use of plant genetic resources -understood as import, export, research and development- is especially regulated by legislation governing the following aspects: phytosanitary, environmental, access and benefit-sharing, as well as intellectual property. Today Brazil has a modern environmental legislation; several regulating standards having been enacted over the last ten years.

Development of technologies for tropical agriculture has been one of the main factors in strengthening Brazil. The Brazilian System of Agricultural Research has conducted studies on genetics and breeding, cultures and soil management; this has allowed the incorporation of advanced technologies into our production system, enabling it to overcome environmental challenges such as weed, pests, drought, salinity, aluminum toxicity, etc. As a country that still relies basically on agriculture, Brazil depends on a continuous supply of genetic variability and new technologies in order to increase its food production, as well as to take competitive steps at the regional level as well as in export markets.

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CHAPTER 1

INTRODUCTION TO THE COUNTRY AND THE AGRICULTURAL SECTOR

1.1. GEOGRAPHICAL LOCATION

Brazil (officially the Federative Republic of Brazil) is a country in South America, located between 5°16’20” North and 33°45’03” South and between 34°47’30” and 73°59’32 West (Figure 34). Brazil is bordered to the north by the Atlantic Ocean, French Guiana, Suriname, Guyana, Venezuela and Colombia; to the south, by Uruguay, Argentina, and Paraguay; to the west, by Peru and Bolivia, and to the east by the Atlantic Ocean, where it has several island groups, the largest being Fernando de Noronha, Abrolhos, and Trindade.

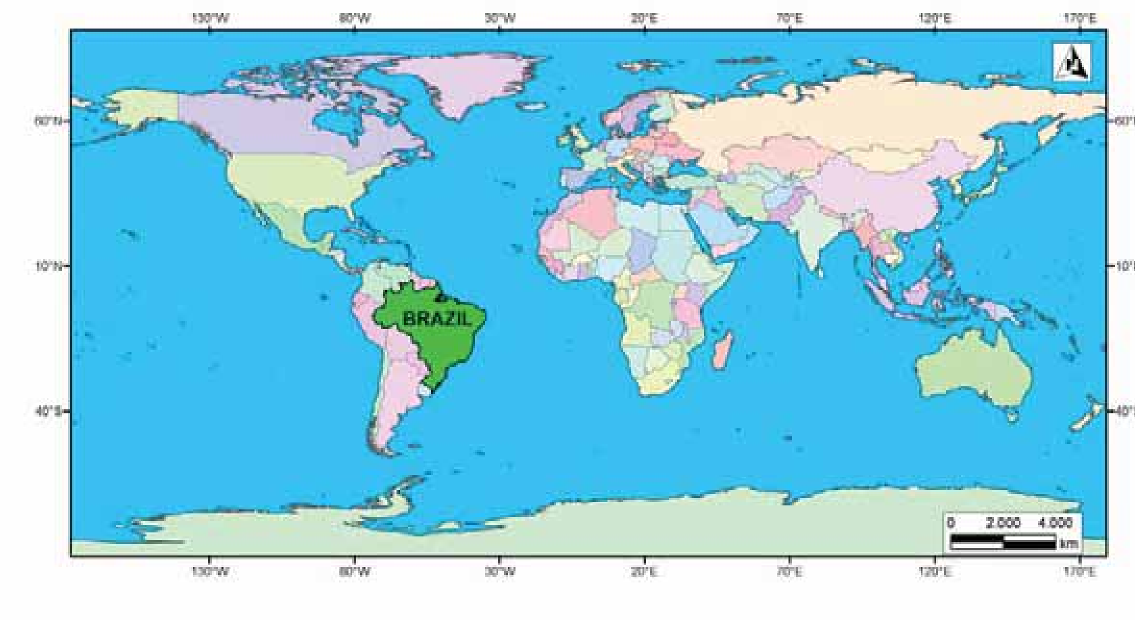

Figure: Sérgio Noronha

Figure 1: Geographical Location of Brazil

1.1.1. Surface area

With an area of 8,547,403 km^2, Brazil is by far the largest country in the South American continent. Compared to the other nations of the world, only Russia, Canada, the People’s Republic of China, and the United States surpass Brazil in terms of territorial size. Linear distances between Brazil’s extreme points are considerable, and virtually identical: 4,394.7 km North to South and 4,319.4 km East to West. The Brazilian geographical configuration is such that its borders amount to 23,086 km, of which the Atlantic coastline accounts for 7,367 km. The country’s human settlements have historically favoured the coastal area and consequently, the largest part of the land area of Brazil has low population density.

1.1.2. Climate

Brazil occupies land crossed by the Equator and the Tropic of Capricorn and the largest part of the country enjoys tropical climatic conditions. The country possesses a wide climatic diversity in the range of tropical and subtropical climates. This is due to a number of factors, such as geographic position, altitude, relief and the dynamics of air masses. The air masses that most impact the Brazilian climate are: Equatorial (Continental and Atlantic), Tropical (Continental and Atlantic) and Atlantic Polar. According to Koeppen's Climate Classification**,** predominant climate types in Brazil are, by region: North - tropical wet (Am, Aw, Aw' and Af); Northeast – tropical dry (Bsw e Bswh'); Central West - tropical wet and dry (Aw); Southeast – temperate mild dry (Cwa and Cwb); and South – temperate mild subtropical (Cfa, Cfb).

1.2. BRAZILIAN BIOMES

Brazil is privileged in the extent of its continuous lands, a great part of which is appropriate for cultivation. The country has abundant water resources (the largest fresh water reserves on the planet, 8% of the world volume), as well as different biomes, which place it among the countries with greatest biodiversity on Earth. Of the estimated 250 thousand species of higher plants in the world, about 32 thousand are native to Brazil. Although the division by biomes is most relevant to production systems, it is important to point out that Brazil is divided into five physiographic regions: the North, Northeast, Central West, Southeast and South, each one of which usually encompasses more than one biome. Figure 2 illustrates the localization of biomes, as well as the five geographic regions discussed in the report.

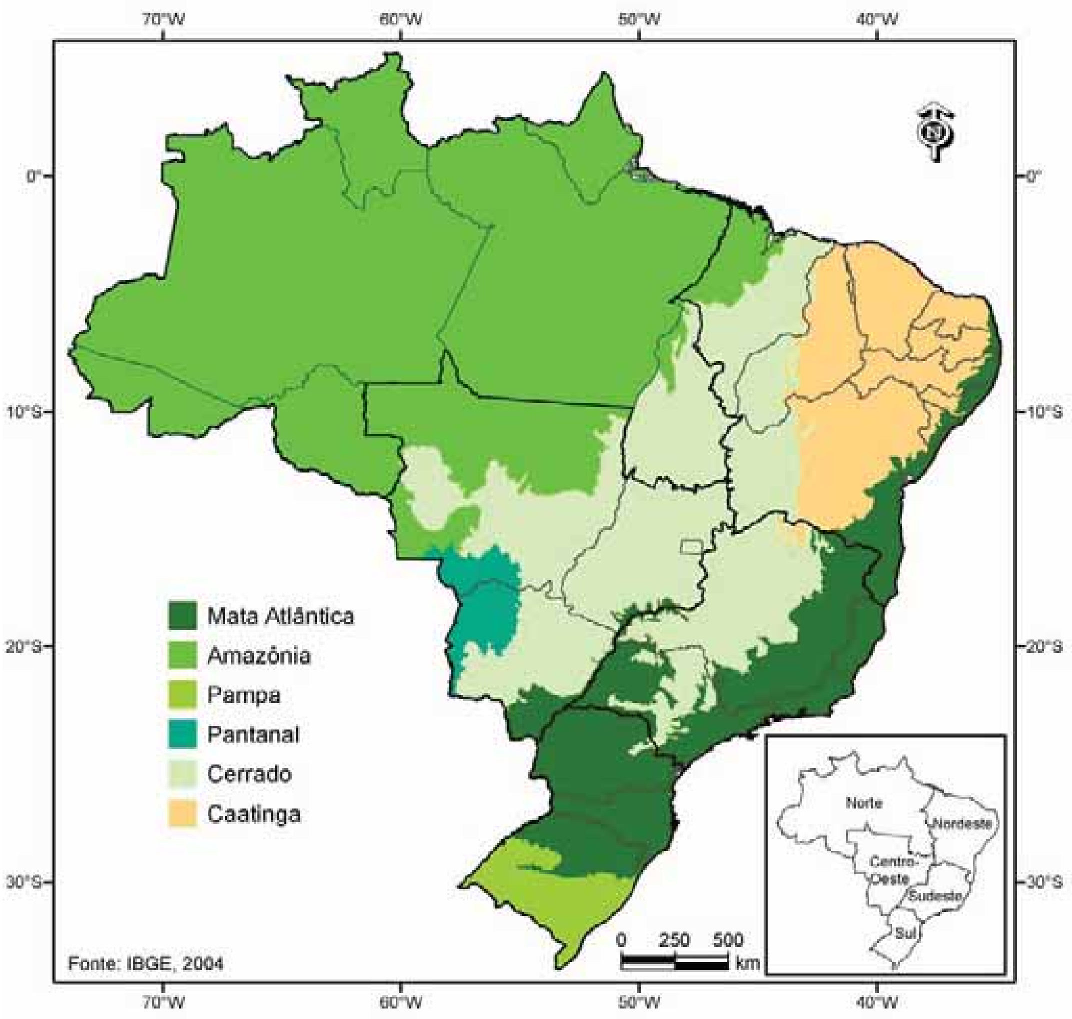

Figure: Sérgio Noronha

Figure 2: Localization of Brazilian biomes and regions

The diversity of species in the Brazilian flora is due to the edapho-climatic peculiarities that influence the vegetation types in the six different biomes: Amazon, Cerrado, Caatinga, Atlantic Forest, Pampa (Southern fields) and Pantanal, as described below**.** There is one additional biome, called the Coastal and maritime zone, which has little relevance for this document but has great ecological and economic impact and contains activities such as shrimp farming and sea fishing, which are based on animal genetic resources.

1.2.1 The Amazon

Made up of different ecoregions, the Amazon biome covers 48.1% of the territory of Brazil and represents one third of the world's tropical forests. It is a complex mosaic of different kinds of vegetation and soil that share a catchment area with the river Amazon and its tributaries. The average yearly rainfall in Amazonia is between 2,000 and 3,000 mm, but in some areas it can reach 4,500 mm. The greater part of the region is flat, with average yearly temperatures between 26 and 28°C, and high relative humidity. For centuries, human settlers established themselves in small populations near waterways and were dedicated to extracting forest products (rubber, wood, cocoa, and Brazil nuts), animals (hunting and fishing) and minerals, which were all products in high demand and of considerable economic value. From the 1960's, there was an intensive migration to the Amazon of small, medium, and large landowners and business people attracted by growing human settlements and industrial projects launched by both the government and private companies. This entailed the introduction of agricultural methods and crop varieties, which were inappropriate to local conditions, thus contributing to the worsening of social and environmental problems. The most common type of vegetation is terra firme broadleaf forest, with large areas covered by deciduous or semideciduous forests, cloud forests, flooded forests associated with eutrophic ("várzeas") or oligotrophic ("igapós") river systems, savannahs that may or may not be Cerrados, and sclerophytic vegetation on sandy soils, similar to the north-eastern Caatinga. The Amazon region has approximately 14,000 species of vascular plants, about 3,000 of which have reported uses. In terms of vertebrates, a total of 311 species of mammals, over 1,000 species of fish, 163 species of amphibians, 550 species of reptiles and more than 1,000 species of birds have been reported. There are over 100 thousand species of invertebrates, the overwhelming majority of which are insects. The Amazon is the centre of origin of cocoa (*Theobroma cacao*), rubber tree (*Hevea spp.*), Brazil nut (*Bertholletia excelsa*), peach palm (*Bactris gasipaes*) and probably cassava (*Manihot esculenta*) and pineapple (*Ananas comosus*). Over 280 species of native fruits are reported, with the endemic "guarana" (*Paullinia cupana*), "cupuassu" (*Theobroma grandiflorum*), "assai" (*Euterpe oleracea*) and "camu-camu" (*Myrciaria dubia*) slowly entering international markets. More than 600 timber species are reported for this region, 65 of which are commercially exploited, though mostly by extraction. Of these, mahogany (*Swietenia macrophylla*) is considered as endangered. Over 120 aromatic species are found in the Amazon, with rosewood (*Aniba rosaeodora*) being the only one reported as being in danger of extinction.

1.2.2. Cerrado

The Cerrado biome is a complex mosaic of many vegetation types covering about two million km^2 in central Brazil. The most distinctive characteristic of the Cerrado is its rainfall distribution, with two clearly defined seasons, rainy and dry, both lasting between five and seven months, with an average yearly precipitation of around 1,500 mm. The Cerrado is often associated with a plateau or plain type of relief and has deep, friable soils, but of low natural fertility. In general, the cerrado type of vegetation can be found in all Brazilian regions.

Research on the potential and limitations of the Cerrado, as well as the development of adequate agricultural methods and practices for the region, led to a huge increase in grain production in the area over the last thirty years. Thanks to its topography, which favours mechanization and to a good infrastructure, the Cerrado is currently the most favoured area for agricultural expansion in Brazil. Nevertheless, the environmental impact of this initiative, though hard to evaluate, has been repeatedly criticized. Important agricultural targets have been met in the Cerrado, such as the adaptation of soybean to low latitudes. Ten years of agricultural research were necessary in order to trigger the large-scale expansion of this crop in this region.

The most common type of vegetation, or Cerrado *sensu stricto*, is an open savanna formation dominated by grasses, sedges and other herbaceous species interspersed by low trees and shrubs. Many gradients of cerrado are to be found, from open grasslands ("campo limpo") to savannah areas dominated by fairly tall trees, which is then known as big cerrado or "cerradão". A distinctive cerrado feature is the fact that most of its tree species are gnarled and with very thick bark. Other types of vegetation are gallery forests following water courses, mesophytic forests, such as South-eastern (São Paulo and Paraná) peripheral savannahs and the Amazonian savannahs in the States of Pará, Amazonas and Amapá, as well as local formations, such as permanent and seasonal marshes, veredas, and “campos de murunduns”. Approximately 13 thousand taxa of vascular plants are reported for this biome, many of which also occur in other biomes.

Of the vertebrates found in the Cerrado, we can highlight fish, with at least 780 species, shared with the Pantanal, 180 species of reptiles, 20 of which are endemic, and 113 species of amphibians, 32 of which are endemic. There are many species of useful plants in the cerrado. Among the timber species, the most important are *Hymenaea courbaril, Blepharocalyx salicifolius, Ocotea* spp*., Pterodon emarginatus*, *Copaifera langsdorffii, Astronium urundeuva* and *Calophyllum brasiliense.* Many of the cerrado trees yield good quality charcoal, which quickly became a source of income for farmers who own large tracts of undisturbed cerrado. The collection of wild plants for dried flower arrangements is also locally very common. These two latter activities are essentially extractive in nature and may endanger some species in this biome. The most important fruit bearing species include “pequi” (*Caryocar brasiliense*), “mangaba” (*Hancornia speciosa*), “baru” (*Dypterix alata*), “araticum” (*Annona crassiflora*), “gabiroba” (*Compomanesia cambessedeana*) and “cagaita” (*Eugenia dysenterica*). Over 700 plant species are used in folk medicine, among the most important of which are *Lychnophora ericoides*, *Centrosema bracteosum, Pterodon emarginatus* and *Anemopaegma arvense*.

1.2.3. Caatinga

The Caatinga biome extends over an area of approximately 800,000 km^2 in the semi-arid region of the Brazilian Northeast. It is the only biome that is exclusive to Brazil and a large part of its biological heritage is not found anywhere else in the world. It covers nine states and represents about 10% of the country’s territory. The geology of the Caatinga does not differ fundamentally from that of the Upper Rio Negro region, in the Amazon. Both originated from old Precambrian rocks, severely degraded during the Tertiary and overlaid by more recent sandstones and other marine sediments. As in the Upper Rio Negro, there are remnant crystalline outcrops, including monolithic mesas and isolated mountain ranges. Approximately 50% of the Caatinga is of sedimentary origin, rich in underground water, although its rivers are mostly seasonal. The yearly precipitation rate is highly irregular and varies between 200-800 mm (seldom reaching 1,000 mm), with a 3-5 month rainy season and a 7-9 month dry season. Temperatures are isothermal, with averages between 25° and 29°C. General characteristics of the caatinga vegetation include total loss of leaves during the dry season, small and firm (xeric) leaves, intense branching of the trees from the base (giving them a shrubby appearance) and the presence of cactaceous and crassulaceous species. The Caatinga is quite heterogeneous, with 12 distinct types being recognized. Most authors describe two main types of caatinga: **dry** caatinga **("sertão")** located in the interior and more humid caatinga **("agreste")** toward the coast.

During the first half of last century, the agricultural expansion in the Caatinga was mainly due to cotton. With a more technology-based agriculture, there was a decrease in rural manpower demand, which entailed massive migrations to urban areas. The latter trend was further worsened in the 1980’s as a consequence of the emergence of a cotton pest known as the boll weevil. Thanks to the implementation of irrigated agriculture, the region is currently undergoing a strong economic expansion. As a result of this kind of agriculture, the São Francisco river valley has become a great exporter of fruit, especially grapes, papaya, and melon.

Several endemic genera of plants are found, including *Moldenhawera* and *Cranocarpus* (Fabaceae), *Fraunhofera* (Celastraceae), *Apterokarpos* (Anacardiaceae), *Auxemma* (Boraginaceae) and *Neoglaziovia* (Bromeliaceae). The Caatinga has many useful species, such as legumes and grasses like *Stylosanthes, Zornia, Macroptilium, Galactia, Vigna, Centrosema, Aeschynomene, Chamaecrista, Desmanthus, Paspalum, Panicum* and *Digitaria*, which are very important as sources of forage in arid lands. Many species are valuable edible fruit sources, such as *Talisia esculenta, Spondias mombin* ("umbu"), *Spondias tuberosa, Lecythis pisonis, Manilkara rufula* ("massaranduba"), and *Hancornia speciosa* ("mangaba"). Important timber species, some of which also occur in other biomes, include "angico" (*Anadenanthera colubrina*), "joazeiro" *(Ziziphus joazeiro),* "amburana" *(Amburana cearensis*), "aroeira" *(Astronium graveolens* and *Astronium urundeuva*), "ipe" (*Tabebuia impetiginosa* and *Tabebuia aurea*), and "brauna" (*Schinopsis brasiliensis*), as well as those found in patches of other types of vegetation, such as cedar (*Cedrela odorata*), Brazilian tulipwood (*Dalbergia frutescens*), "morototó" (*Schefflera morototoni*) and "angico-branco" (*Albizia polycephala*). Among the medicinal plants, the most important is "jaborandi" (*Pilocarpus jaborandii*) which, together with *Amburana cearensis*, is officially listed as being endangered. Palm trees are of special importance, since they constitute the backbone of the local domestic economy in many parts of Northeastern Brazil. Rural populations rely heavily on the collection of "babassu" (*Orbignya phalerata*), "carnaúba" (*Copernicia prunifera*), "tucum" (*Astrocaryum aculeatissimum*) and, to a lesser extent, "macauba" (*Acrocomia aculeata*) and many species of *Syagrus, Scheelea*, and *Attalea*.

1.2.4. Atlantic Forest

The Atlantic Forest biome houses 70% of the Brazilian population as well as the largest cities and industrial centres of the country and is closely linked with Brazilian history. Extending from Rio Grande do Norte southward to Rio Grande do Sul, along a narrow fringe between the ocean and the dry uplands, with some of the richest soils in the country, only 2-5% of the Atlantic Forests' original 1,360,000 km^2 is still in its original state. Threats to the Atlantic Forest include timber exploitation, plantations, cattle raising, subsistence agriculture, pulpwood plantations and urban expansion. As in the case of other biomes, the Atlantic Forest is a complex mosaic of vegetation types, including mangroves, coastal "restinga" forests, mesophytic forests, low and high altitude mountain forests, rainforests, liana forests and high altitude savannahs ("campos rupestres" and "campos de altitude").

In this region, agriculture is highly mechanized, and sugar cane and eucalyptus plantations for the pulp and paper industry, have replaced over 90% of the native vegetation. The Atlantic Forest displays high biodiversity and has many endemic species. According to *Conservation International*, it is one of the 25 world *hotspots*, as it occupies the fourth place in amphibian and vascular plant diversity: a total of 1,807 species of mammals, birds, reptiles, and amphibians occur in the region, of which 389 are endemic. Including the Brazilian Shield, the flora of the Atlantic Forest is one of the oldest in the world, with many relic elements of the Gondwana flora and may be the centre of origin of many neotropical taxa. Over 50% of the tree species are thought to be endemic to the Atlantic Forest, including the genera *Rodriguesia*, *Arapatiella*, *Harleyodendron (*Fabaceae), *Santosia (Asteraceae)*, as well as ligneous or herbaceous bamboos belonging to genera such as *Atractantha*, *Anomochloa*, *Alvimia* and *Sucrea* (Poaceae).

The Atlantic Forest has a large number of useful species, many of which are shared with other habitats. Among the timber species are "ipe" (*Tabebuia* spp.), "peroba" (*Paratecoma peroba*), cedar (*Cedrela odorata*), "vinhatico" (*Plathymenia reticulata*), "aderno" (*Astronium concinnum*), and "putumuju" (*Centrolobium microchaete*). Two species are especially important: Brazilwood / “pau-brasil” (*Caesalpinia echinata*), after which the country was named and Brazilian rosewood / jacaranda (*Dalbergia nigra*), which are among the most valuable timber species in South America. Both are endangered due to over-exploitation. Two palm trees, *Euterpe edulis*, from which the heart-of-palm is extracted, and “piassava” (*Attalea funifera*) are important elements of the local economy and may also be endangered. Traditional medicine uses many plants, including “arnica” (*Lychnophora ericoides*), "chapé" (*Hyptis lutescens*), "paneira" (*Norantea adamantium*), "quina-de-vaca" (*Remijia ferruginea*), "sambaibinha" (*Davilla rugosa*), and "catuaba" (*Anemopaegma arvense*).

In the southern states of Paraná and Santa Catarina, as well as in the northern-most half of Rio Grande do Sul state, the Atlantic Forest biome widens toward the West and encompasses significant ranges of araucaria forest, dominated by *Araucaria angustifolia*, alternating with patches of grasslands. Apple (*Malus domestica*) growing is expanding in southern Brazilian states, in parts of the Atlantic Forest biome. In recent years, the natural grasslands are under intense pressure from the establishment of exotic timber plantations using *Pinus* for pulp production.

1.2.5. Pampa

The southern grasslands (Pampa) are a biome with open formations, covered almost exclusively with herbaceous species, mainly grasses, with some sparse trees and shrubs next to streams or in thick tree-shrub formations in areas with a more undulating relief. It is essentially located in the southern half of Rio Grande do Sul State, but extends also into neighbouring Argentina and Uruguay.

Its climate is subtropical, with mild temperatures, rainy, and with little variation through the year. The soils are generally fertile and extensively used for agriculture, where are concentrated the largest flooded rice plantations in the country. Although arable farming has expanded, cattle-raising, for both milk and beef production, is still the main agricultural activity. The best herds of European cattle breeds in Brazil are found in this region, based mainly on natural open grasslands, rich in grasses and high quality native fodder legumes, to which have been added winter cultivated grazing lands, based on European exotic species, such as ryegrass (*Lolium multiflorum*), annual clovers (*Trifolium* spp.) and bird’s foot trefoil (*Lotus corniculatus*).

Ecologically, this biome is characterized by vegetation composed of grasses, low plants and some trees and shrubs of low abundance. In the Brazilian part of this biome, there are about three thousand species of vascular plants, of which approximately 400 are grasses, among which species of *Paspalum*, *Axonopus* and *Andropogon* greatly predominate, and, in the cold season, species of *Stipa* (needle grass) are important. At least 385 species of birds, such as woodpeckers, monk parakeets, smooth-billed ani and 90 terrestrial mammals, such as raccoons, deer and armadillos are also native.

In recent years, temperate fruit production, previously concentrated on peach, has made significant progress, further increasing pressure on native vegetation. Lately, forestry companies have further increased this pressure by replacing natural lands with eucalyptus plantations for pulp production.

1.2.6. Pantanal Mato-grossense

Occupying an area of over 110,000 km2, the Pantanal Mato-grossense is a geologically depressed region, which slowly and heterogeneously filled with various sediments coming from its periphery, resulting in a mosaic of diverse environments. The source of the waters of the Pantanal are in the Cerrado, and its terrestrial biota is closely linked to the Cerrado biome. This vast sedimentary plain is located in the basin of the Paraguay River and includes territorial areas of three different countries: Brazil, Bolivia, and Paraguay. The water cycle controls life in the Pantanal, where the annual floods in the region are due to pluvial and fluvial water. The yearly average rainfall is around 1,100 mm, with two well-defined seasons: rainy, between October and March, and dry, from April to September.

Human settlement began in the 18th century, but had very little impact on the environment. However, since the 1970's, human disturbances, establishment of exotic pastures, irrigation and other engineering projects, such as dams, roads, and drainage have been causing the environment to change rapidly, thereby destroying native vegetation. The main agricultural activity is beef cattle, with a herd of about four million heads. Arable farming is not very important in this region, except for subsistence crops. Other remarkably important economic activities are fishing, tourism, and mining. Despite their high economic potential, the flora and fauna resources are not highly exploited.

The Pantanal flora is made up of species from the following ecosystems: Cerrado, Atlantic Forest, Amazon, with few endemic species. Over 10,000 plant species have been catalogued in this biome, including around 200 used for human and animal food, as well as for local industry. The Pantanal vegetation is highly variable, and is determined by local soils and flooding. The main types of vegetation are found around borders of temporary or permanent lakes of various sizes, with many species of aquatic plants, including species of Eichhornia and Pontederia intermingled with Cyperaceae; crests (cordilleras) formed by small unflooded pockets, with cerrado, cerradão or forest vegetation; "cambarazal", a flooded forest dominated by Vochysia divergens; "campos" or floodplains dominated by grasses, which are the most important elements in the Pantanal; and "capão" or patches of trees that form islands in the "campos".

1.3. PHYSIOGEOGRAPHIC REGIONS OF BRAZIL

This topic includes a brief description of each of the five physiographic regions into which Brazil is divided: North, Northeast, Central West, Southeast and South. Generally, more than one of the biomes described above is found in each one of these regions.

1.3.1. The North

Inserted in the Amazonian biome, with small inclusions of cerrado and other types of savannahs, the Northern Region represents almost half of the national territory. The Northern region covers parts of both the Brazilian and the Guiana Shields, as well as a very large area of sedimentary plains. Native fruit, mainly "assai" and "cupuassu", have great export potential, especially as frozen pulp. Brazil nut and heart-of-palm are additional products from this region which are quite well known on the world market but still have a strong extractive component.

1.3.2. The Northeast

Most of the Northeast, which occupies over one million km^2, experiences semi-arid conditions and is almost 90% caatinga. The other 10% is composed mainly of Atlantic Forest and cerrado. Following investment in technology, this region has become one of the main Brazilian fruit export areas. Adapted soybean varieties are successfully grown in some northeastern areas.

1.3.3. The Central West

In this region are found Cerrado and Pantanal biomes, and also a small part of the Amazon biome in northern Mato Grosso state. This region has almost 35% or over 57 million heads of the national cattle herd, of which almost 90% are beef cattle. Except in areas susceptible to flooding, the animals in the Pantanal are reared mainly on cultivated pastures, dominated by African grasses, such as *Brachiaria brizantha* and *B. decumbens* (or *Urochloa brizantha* and *U. decumbens*), and *Panicum maximum* (*Megathyrsus maximus*). Grain production, and especially soybean, cotton, rice, corn and sunflower, are also a large part of the region's agriculture.

1.3.4. The Southeast

Located mainly in the Atlantic Forest, with part of the Cerrado in Minas Gerais and São Paulo states, the Southeastern region is home to the largest urban and industrial, agroindustrial, technological and financial centres in the country. It is home to 21.26% of the Brazilian cattle herd, or 35.6 million heads, of which 71.64% are beef cattle. The region also provides more than 45% of Brazilian poultry, composed of laying hens as well as broilers. The Brazilian dairy industry is also concentrated in this region, as well as the biggest dairy processing plants and important slaughterhouse networks, grain warehouses, and food processing plants. With the development of ethanol production, sugar cane, which was already important for the production of sugar, assumed a prominent role as a high value-added crop for the region. Coffee, an important product for both the internal and export markets, is grown almost exclusively in this region. Citriculture is another important activity for this region's economy, due largely to orange juice exports.

1.3.5. The South

Situated in the Atlantic Forest area, including *Araucaria* forests and patches of high altitude savannahs, as well as in the Pampa (Southern fields) area, the South is the largest producer of broiler chicken meat in the country, with an annual production of 4 million tons (55.8% of Brazilian production). The region contains abundant pastures with high nutritional value, dominated by native species of *Paspalum*, and supplemented with winter-cultivated pastures including clovers and European grasses. Historically, the South was distinguished for its cattle production, where it supplied a great part of the country with processed meat. With the development of extensive arable farming, mainly soybean and rice, this region started to contribute significantly to the export of agricultural products and today it has only 16% of the Brazilian bovine livestock, composed mainly of European breeds due to its temperate climate. This region also stands out as the main producer of temperate climate fruit. It is also important to stress the magnitude and high technological level of the region's industry for processing and industrialization of meat and meat products, as well as of agricultural products.

1.4. POPULATION DATA. URBAN AND RURAL POPULATIONS

According to the Brazilian Federal Constitution, from October 5, 1988, the Federal Republic of Brazil consists of the Union, the Federal District, States and Counties (*Municípios*), which all are autonomous entities. The Federal District is the seat of the Federal Government, with its three branches of power: Executive, Legislative, and Judicial. Brazil has 26 states and 5,507 counties. In 2007, the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística – IBGE) estimated the Brazilian population at 183.9 million people. In recent years, there has been considerable migration to large urban centres, so that today about 77% of the country's population lives in cities and only 23% in rural areas.

1.5. AGRICULTURAL SECTOR: INTERNATIONAL MARKET

Over the last three decades, the explosive growth in Brazilian agricultural production is unmatched by any other country. Productivity and quality of crops also reached, and in some cases surpassed, those of other top food producing nations in the world. Besides macroeconomic, sector and technological policies, agribusiness organization is a crucial factor in this success. Brazil is one of the world leaders in the production and export of several agricultural products. It is the biggest producer and exporter of coffee, sugar and orange juice. Moreover, in 2008, Brazil led the ranking of exports of soybean, beef, chicken, tobacco, leather and leather shoes. Projections indicate that very soon the country will also be the largest world cotton and biofuels producer, the latter of which is made from sugarcane and vegetable oils. Corn, rice, fresh fruit, cocoa, nuts, as well as swine and fish are also prominent in Brazilian agribusiness, which currently employs over 17.7 million field workers alone. These data show that the country is strongly competitive on the international market and emphasizes the importance of agriculture for the national economy.

National grain production was estimated at 143 million tons for the 2007/08 harvest, an 8.7% increase on the previous years´ harvest. Of this total, 96.8% are from the summer harvest, and 3.2% from the winter harvest. This increase was due to good climatic conditions and to more technology-intensive practices. The area cultivated with grain was approximately 47 million hectares for the 2007/2008 harvest. In the Central South region, where 79% of total grain growing is located, the harvest increased 2% over the previous year. Of this total, the South region cultivated 46%, the Southeast 13%, and Central West 41%. The North and Northeast regions cultivated the remaining 21% of the country's grain, a 2.2% increase on the previous harvest. The Northeast contributed 83% of both regions combined production and the North, the remaining 17%.

Table 1. Agribusiness exports by sectors, 2007

Product	Value (US$ millions)
Soybean complex	11,381
Meat	11,295
Forest products	8,820
Sugar-alcohol complex	6,578
Leather and other animal products	3,968
Coffee and coffee products	3,892
Fruit juices	2,374
Tobacco and tobacco products	2,262
Grains and grain preparations	2,220
Fibres and textiles	1,558
Other plant products	1,160
Fruit (including nuts)	968
Cocoa and cocoa products	365
Fish	311
Dairy products	300
Live animals	285
Drinks	252
Oil products (excluding soybeans)	201
Animal feed	104
Vegetables, roots, and tubers	102
Apiculture products	26
T O T A L	58,422

Source: AgroStat Brasil based on SECEX / MDIC data
Made by: CGOE / DPI / SRI / MAPA

The Brazilian Gross Domestic Product (GDP) has fluctuated highly. In 1998, Brazil had the 8^{th} largest GDP in the world and in 2003, the 15^{th}. In 2007, the country's position in the world ranking improved again, going up to the 8^{th} or 10^{th} places, according to the calculation methodology that was used. Despite this noticeable improvement, Brazil still lags behind countries with fewer natural resources and lower population, such as South Korea and the Netherlands. The difference between these countries and Brazil stems from the importance the former attach to knowledge and financial resources generation by means of technology and innovative products.

The share of agricultural products in Brazilian exports has increased significantly. In 2002 it was US$ 24.86 billion, or 41.2% of the country's total exports, and in 2003 it had reached US$ 30.64 billion, a 23% increase on the previous year. In 2007 agribusiness exported US$ 58 billion, an increase of approximately 89% on 2003 (Table 1). All surveys show that

Brazilian Agribusiness is the economic mainstay of the country and is called its “green anchor”.

1.6. ECONOMIC AND ENVIRONMENTAL ASPECTS

Between 1945 and 1990, world food production and other human activities caused the degradation of approximately 1.2 billion hectares of vegetation, approximating an area of land equal to that of China and India combined, with two thirds of the most degraded areas being in Africa and Asia. Thus, the world’s great challenge is to increase food production, which must be able to meet the demand generated by population growth, and at the same time use environmentally sustainable technologies for agricultural systems. For Brazil, one of the main targets is the eradication of hunger. In order to achieve this goal, it is crucial to strengthen agribusiness, leading to a decrease in food prices.

Although the country has one of the greatest biodiversities in the world, Brazilian society has only recently become aware of the potential of these abundant natural resources to very rapidly become a source of wealth and employment. Sustainable agricultural development is also a recent issue in Brazil. The main areas of concern are disorderly land use, the expansion of the agricultural frontier into the cerrados and the Amazon, excessive use of water in agricultural activities and uncontrolled, and sometimes irrational, use of pesticides.

Markets traditionally most value environmental assets, which can be directly and immediately used, such as wood, water, oils and essences, seeds, etc., at the expense of environmental services, and overlooking their interdependence. The establishment of specific markets for environmental services, such the carbon credit market, is a relatively recent phenomenon. Nonetheless, the potential importance of these new markets underlines the urgency of their economic evaluation, also serving as a means to avoid unchecked and irresponsible exploitation of natural resources. Moreover, recognition of these markets encourages the adoption of ecologically correct practices by society at large.

A growing number of countries are now participating in the world carbon credit market and have launched new projects for climate mitigation or promised a reduction of their GHG (greenhouse gases) emission rates. With the ratification of the Kyoto Protocol, new targets have been established for GHG emissions reduction for countries according to their historical responsibilities (by an average of 5.2% of 1990 levels). In October 2005, 13 of the 82 projects under the Clean Development Mechanism (CDM) submitted by Brazil had been approved, making the country second in the global rankings. These 82 projects aimed at a reduction of over 17.9 million tons of CO_2 per year.

CHAPTER 2

THE STATE OF DIVERSITY

2.1. INTRODUCTION

Brazil has about 44,000-50,000 species of vascular plants, which represents approximately 18% of the world's plant diversity (considering the world's flora as having about 257,400 species). Nevertheless, Brazilian agriculture and food security are, to a large extent, dependent on genetic resources native to other countries. Virtually none of the Brazilian agricultural activities, which are diversified due to the country's environmental diversity, would be as important as they are today without the exchange of and the systematic and increasing introduction of genetic resources. This dependence will persist because research aimed at developing new plant varieties requires genetic material with adaptable ecological characteristics, such as resistance to local pests and diseases, survival of adverse environmental conditions derived from climate changes, and suitability for different Brazilian soils; in order to meet the growing demand for food, fibres and energy production. Much less commonly used than non-native species, but very important regionally and locally, a number of native species have been used as human food. The most well known of these are: cassava, pineapple, cashew (pulp), cupuassu, passion fruit, Brazil nut, guaraná, jabuticaba, peanuts, cocoa, some palm species, and other fruit trees. Additionally, native forage species are predominantly used in the raising of livestock, such as cattle. More recently, native medicinal and ornamental plants are being increasingly valued in the context of Brazilian Agribusiness.

Nationally, research on genetic resources and plant breeding is one of the most important among innovative activities that have contributed significantly to the qualitative and quantitative progress experienced by Brazilian agriculture in recent decades. Brazilian plant breeding is among the most efficient in the world and has made significant contributions during the 20th century, notably to human resources training and to the development of a wide diversity of plants, which have been adapted to tropical conditions. The genetic breeding process relies heavily on the extension of the available genetic base, which in turn is influenced by the available germplasm collections stored in germplasm banks in the form of collected and characterized materials. The latter are important inputs for the development of new cultivars. Access to these materials containing variability, either by collection or by introduction and exchange, is a key factor for any plant breeding program to be successful.

2.2. THE STATE OF DIVERSITY AND RELATIVE IMPORTANCE OF MAJOR CROPS FOR FOOD SECURITY

Despite Brazil's great richness in native species, most agricultural activities are based on exotic plants, such as sugarcane, which originates from New Guinea; coffee from Ethiopia; rice from the Philippines; soybean and oranges from China; wheat from Asia Minor; and even cocoa varieties (one native species) originating from Mexico. National forestry relies on eucalyptus, from Australia, and pine trees, from Central America and the Caribbean. Cattle raising relies on bovines from India, horses from Central Asia and to some extent on african grasses. Fish farming relies heavily on carp, from China, and tilapia, from Eastern Africa. Apiculture is based on varieties deriving from crossbreeding of honey bees of genus *Apis*, originating from Europe and Tropical Africa.

2.2.1. Exchange and collection of genetic resources

The international exchange of genetic resources was practiced during the 19th century without great formality, based on reciprocity between countries and organizations. Such a process benefited, among others, public institutions involved in research and development, universities, international agricultural research centres, and private seed producing companies. This easy access to genetic resources played a crucial role in the evolution of Brazilian agriculture.

Since its establishment, the Brazilian Agricultural Research Corporation, Embrapa was entrusted with the duty of promoting and facilitating the safe introduction of genetic resources, strategic for the country. Under the coordination of Embrapa Genetic Resources and Biotechnology, a system of germplasm exchange and quarantine dealt, from 1976 to 2007, with over 500,000 samples, of which more than 400,000 were imported from all over the world. This system feeds a network of 350 Active Germplasm Banks as well as a Base Collection (for long term preservation) composed of 212 genera, about 668 species and over 107,000 accessions. This whole system provides support to hundreds of public and private genetic breeding programs developed all over Brazil.

Embrapa Genetic Resources and Biotechnology has also led, since its beginning in the mid-1970s, the collection of germplasm. This process is defined as the set of activities that aim at obtaining live materials containing the genetic composition of an organism or a sample of the population of one species (sample that is able to duplicate). Since then, over 800 collecting missions have been undertaken all over Brazil, to explore natural populations directly in the field. In this enterprise, which has been carried out in all the main Brazilian biomes, cultivated materials have also been obtained from farmers and cattlemen in fairs, regional markets, and other localities.

Collecting has generally been done in partnership with other research institutions. Some plants have been the subject of ongoing projects since then, such as pineapple, cotton, peanut, rice, sweet potato, cashew, yam, native forages (grasses and legumes), beans, cassava, maize, palms, peppers, rubber tree, various ornamentals, forest trees, and medicinal plants. Besides focusing on specific products, since the 1990s projects have aimed at recovering germplasm in areas facing environmental impacts that entailed loss of genetic resources. This work has been particularly focussed on areas affected by planned hydroelectric installations.

Today, both germplasm collection and recovery in areas under impact have been introduced in the country, with a number of institutions and universities carrying on these activities in different Brazilian regions. New species/products are being sought as potential alternatives for the agricultural sector, especially in forestry, through investigation and collection of native germplasm. Among other reasons, this is done in order to overcome the dependence of the main economically important crops on exotic germplasm.

2.3 THE STATE OF DIVERSITY AND RELATIVE IMPORTANCE OF OTHER CROPS

The utilization of Brazil's biological assets has garnered special attention in the country, notably due to the impact that genetic resources, which originate from biodiversity, have on agricultural activities, and more recently on biotechnology. Although Brazilian agriculture is mainly based on exotic species, investment in biodiversity research can increase the availability of raw materials, thereby leading to the generation of new technologies that will bring forth new products and new markets. According to the Brazilian Ministry of the Environment, plant-derived medicines currently account for approximately 25% of the world market for products derived from genetic resources.

Due to the fact that Brazilian biodiversity is vast, the use of indigenous genetic resources is still scarcely explored. In order to achieve this goal, studies and investments are needed on the commercial use of species that can add value to agribusiness products, especially to those that can potentially have an impact on food security. In addition to the large number of semi-domesticated species or species under domestication that can be of great value for agriculture, diverse species can also offer genes that can resist biotic and abiotic factors, as well as genes that will prove important to increase the nutritional quality of food. Native species, many of which are already used at the local or regional level, may provide alternatives for market insertion, due to the growing demand for new product options, notably those related to a healthy diet. Brazil, through its Ministry of the Environment, has been undertaking actions to identify, prioritize, and spread information about the currently underutilized benefits of native plant species for society at large, as well as their current or potential economic importance. These actions are aimed at the utilization of biological and genetic resources of the Brazilian flora, in an effort to achieve sustainable development. Initially, an inventory is being taken of the techno-scientific knowledge about the species in the different Brazilian geopolitical regions and biomes. The goal of this activity is to both aggregate and make available to the agricultural sector information from different sources and to create new investment opportunities through the generation of new products.

Surveys carried out in 2006 by IBGE (Instituto Brasileiro de Geografia e Estatística – the Brazilian Institute of Geography and Statistics) showed that production, plant harvesting and forestry, including the value of the country's primary forestry production, equalled R$ 10.9 billion. Of this amount, 66% (R$ 7.2 billion) originate from forestry (utilization of cultivated forests) and 34% (R$ 3.7 billion) from plant harvesting. Within the extractive segment, timber production, represented by charcoal, cordwood, logs, and pine-tree-knots, was worth R$ 3.2 billion, whereas non-timber extractive activities totalled only R$ 539.2 million. Out of a total of 37 non-timber items or products that were surveyed, only nine stand out due to the magnitude of their value: assai fruit (R$ 103.2 million), babassu kernels (R$ 102.2 million), piassava fibers (R$ 88.9 million), native maté leaves (R$ 86.9 million), wax powder and carnauba wax (R$ 48.6 million and R$ 13.3 million respectively), Brazil nuts (R$ 43.9 million), native heart of palm (R$ 9.9 million), coagulated *Hevea* or rubber tree latex (R$ 7.9 million). These products combined are responsible for 93.7% of the total value of the country's non-timber extractive production (R$ 539.2 million).

2.4. STATE OF THE DIVERSITY OF PLANT GENETIC RESOURCES

Brazil is taking important measures that aim to expand knowledge of its genetic resources. Some projects have been developed which aim at identifying wild relatives and landrace varieties of various crops such as cucurbits, cotton, peanuts, rice, cassava, maize and pupunha. Landrace varieties were included in the inventory as they display genes that are potentially adaptable to specific environments, which can be useful in genetic breeding programs. The main goals of this initiative are to obtain biogeographical data about these species, to assess their conservation conditions, and to establish what actions are needed in order to both maintain this genetic resource and to use it more intensively. Similarly, the country requires public policies that protect its native genetic heritage. As the country develops, its citizens demand greater variety of food on their table. The growing importance of adding new species to the population's daily diet is directly proportional to improved standards of living. Thus, it is necessary to know more about native plants that have the potential to meet this demand. Moreover, an infrastructure is required for their conservation, domestication, characterization, pre-breeding and breeding. Equally necessary are adequate marketing channels, since these plants have a high potential for use in family agriculture, and also in different market niches such as organic, conventional, plasticulture and hydroponics among others.

In situ management is highly advisable for the protection of variability in natural populations of arboreal species. Pressure on biomes and the need for readily available germplasm require concomitant ex situ management. In extra-Amazonian biomes, a significant part of biodiversity is found in small fragments amidst the anthropic matrix, most of which is in private hands and is poorly studied. In the Atlantic Forest, reduced to 8% of its original area, most fragmented forest remnants are of less than 10 ha and over half the preservation units are smaller than 500 ha. Fragments of this size are not large enough to maintain many arboreal species. It should be stressed that many tropical arboreal species, which are cross-pollinated, occur at low density. Where they are isolated to small forest patches, they might inbreed, with the consequent loss of genetic variability. In the short term, it is crucial to implement measures targeting the recovery of the germplasm of the most important species remaining in these remnant patches and its storage in germplasm banks in order to conserve genetic variability (see Chapters 3 and 4).

In Brazil, there is still much room for expansion of in situ and on farm management of genetic resources, if they are conducted in coordination with one another. In the latter case, some steps have been taken with local and traditional communities by means of joint initiatives with the Ministry of Agricultural Development. Innovative work has recently been carried out by the Ministry of the Environment in mapping the importance of natural resources for food, agriculture, and biomedicine. To this end, Embrapa was appointed to conduct independent studies on some species. This work is ongoing and its results are to be translated into programs for the conservation and development of the listed species. In situ management, which could be based on the federal permanent conservation units, which total nearly 1 million km^2, is just beginning. The mapping of the occurrence of native species or wild relatives is also yet to be done. The country must take advantage of this potential and educate its society on these issues, putting forward unquestionable reasons for maintaining its own conservation areas.

2.4.1. Analysis of diversity of cultivated varieties

Modern biotechnology is one of the most extraordinary scientific and technological development strategies, and affects a great number of areas and subjects as diverse as human and animal health, agriculture, cattle raising, the food industry, environment and ecology and services. Both this new technology, with its gene manipulation and transfer tools, and more recently, the study of complete genomes, hold much promise for the enhancement of traditional genetic breeding methods. This in turn can ensure the rapid and efficient development of new plant and animal varieties, enabling the incorporation of a great diversity of attributes at a previously unimaginable speed and scale. Molecular markers have proven effective for solving a number of biological, operative and logistic issues, which affect *ex situ* germplasm conservation. Finally, molecular markers are commonly used for the molecular characterization of plant germplasm in order to: a) analyze the genetic identity of the accession, checking if each accession in the collection can be genetically differentiated from the others; b) estimate the genetic similarity between accessions based on the calculation of the relative degree of genetic proximity or distance in the collection; c) gain insight into the genetic structure of the collection, establishing how the genetic variation is distributed among accessions in the collection; d) estimate the allele richness of the collection by calculating the number of alleles in different loci among the accessions in the collection, which would even make it possible to detect economically important alleles; e) assess the representativeness of the collection by comparing the diversity of the crop to its wild relatives.

Much work with molecular markers is ongoing in Brazil, amongst which stand out projects for the molecular characterization of 22 species of peppers and sweet peppers using RAPD and CAPS markers, with the description of nine new species, carried out by Embrapa Genetic Resources and Biotechnology. Other work involves the use of RAPD markers in species from the genera *Heliconia*, *Ananas* and *Anthurium*. Some species are well characterized based on the RAPD technique, with 14 species and 1353 samples having been analyzed for genetic variability in populations (Table 2). Embrapa Genetic Resources and Biotechnology is also developing molecular markers for native species. Today SSR markers have already been developed for 23 species, for both characterization and the study of population genetics. These species are: *Caryocar brasiliense* (pequi), *Copaifera langsdorffii* (copaíba), *Euterpe edulis* (heart of palm), *Swietenia macrophylla* (mahogany), *Caesalpinia echinata* (Brazil wood), *Capsicum* spp. (peppers and sweet peppers), *Cedrella fissilis* (cedar), *Ceiba pentandra* (sumauma), *Carapa guianensis* (andiroba), *Amburana* *cearense* (cerejeira), *Manilkara huberi* (massaranduba), *Symphonia globulifera* (anani), *Cocos nucifera* (coconut), *Araucaria angustifolia* (araucaria), *Hymenaea courbaril* (jatoba), *Bagassa guianensis* (tatajuba), *Jacaranda copaia* (parapara), *Dipteryx odorata* (cumaru), *Bactris gasipaes* (pupunha), *Annona crassiflora* (araticum), *Bertholletia excelsa* (Brazil nut), *Orbignya phalerata* (babassu) and *Ilex paraguariensis* (erva maté).

Table 2. Species characterized using RAPD molecular markers, displaying the genetic variability of samples

Species	Common name	Number of samples	Genetic variability (%)
Butia eriospatha	Butiá-da-serra	100	89,9*
Clethra scabra	Caujuja	74	50,0
Dicksonia sellowiana	Xaxim	290	84,5*
Dorstenia tenuis	Figueirilha	66	83,7*
Dyckia distachya	Bromelia	100	40,0
Erythrina falcate	Corticeira	83	60,0
Ficus enormis	Figueira	48	60,0
Maytenus ilicifolia	Cancorosa	120	60,0
Myrocarpus frondosus	Cabreúva	49	50,0
Podocarpus lambertii	Pinheiro-bravo	106	92,5*
Sinningia lineate	Rainha-do-abismo	51	40,0
Trithrinax brasiliensis	Buriti	50	40,0
Zeyheria tuberculosa	Ipê felpudo	120	64,0*
Bauhinia pulchella	Bauhinia	96	67,2*

*Variability within populations

At the national level, attempts to increase the use of genetic resources available in the country have been encouraged through initiatives that aim at developing pre-breeding programs. Embrapa's research program includes several projects involving genera with great genetic variability that are present over much of the country's territory, such as *Anacardium, Ananas*, *Arachis*, *Capsicum* and *Manihot*. Other genera that are commercially very important for the country have also been included in pre-breeding programs (see Chapter 5). Among these, two projects stand out: Orygens, which studies the *Oryza* (rice) genome (http://genoma.embrapa.br/orygens/index.html), and Genolyptus(http://ftp.mct.gov.br/especial/genolyptus.htm), which studies the Eucalyptus genome. These two projects rely on a wide network of contributors. The Genolyptus project is an excellent example of partnership between the public and the private sectors, which is highly desirable for pre-breeding programs to be successful.

In a complex international environment, influenced by strategic interests in biological resources, by advancements in technological avenues that rely heavily on genetic variability, and by the consolidation of the legal framework for the protection of knowledge, relations between countries as well as between organizations within each nation are bound to change as far as the access to genetic resources is concerned. In particular, the provisions of the Convention on Biological Diversity, which has led to the adoption of national legislation that asserts sovereignty over biological resources, have hindered and reduced the flow of these resources worldwide (see Chapter 8).

Hence, it is crucial to understand that genetic breeding activities in Brazil will remain highly dependent on the size of the available genetic base in the form of materials stored in germplasm banks. Such materials are critical inputs to the uninterrupted development of the national agribusiness. Brazil requires public policies for the protection of its genetic heritage. In the same way, it is also extremely important to protect and increase exchange with other countries so as to make sure that the nation can access and benefit from exotic genetic variability as well as from international progress in genetic resources research.

Ten years from now, rural and agribusiness activities will have substantially increased and will include new high added value products such as ornamental plants, aquaculture products, functional foods (nutraceuticals), and biopharmaceuticals as well as new products derived from agricultural products that will replace those from non-renewable or polluting sources. In rural areas, natural resources will play an important new role in socioeconomic activities such as ecotourism and conservation. Likewise the evolution of emerging agricultural activities such as floriculture, raising of wild animals, medicinal and aromatic herbs cultivation and diversified horticulture, which target specific market segments, will create opportunities for social inclusion, employment and income generation.

2.4.2. The impact of technology on genetic diversity and food production

Over the last three decades, the area of land cultivated in Brazil has not increased, however, crop productivity has skyrocketed (Figure 3). This result stems from the genetic breeding and management work carried out by Brazilian agricultural research institutions and universities. Genetically modified plants have been developed by means of molecular genetic techniques, making it possible to provide farmers with new genetic materials (GMOs – genetically modified organisms). Brazil has invested not only in GMO development technologies but also in research about environmental impact of these organisms. Brazilian legislation, keeping up with scientific advancements, has adjusted to the new scenario, adopting laws and regulatory mechanisms for governing GMOs (see Chapter 7).

An issue of recent international concern has been the competition between biofuels and food production for land. The Brazilian experience with biofuels, especially its ethanol production from sugarcane, has been very positive and has become an example to the world. In 2007/2008 the country produced 487 million tons of sugarcane, processed by approximately 350 sugar mills. Sugarcane is cultivated on 7.8 million hectares, which represents only 2.3% of the total cultivable land in the country (Figure 3). For the present, there is no competition in Brazil between the area dedicated to biofuel production and that used to grow crops used to feed the population, which might otherwise affect our food security.

Figure 3: Production of grains, legumes and oilseeds in Brazil and increase in cultivated area.

2.4.3. Factors affecting the diversity of cultivated plants in Brazil

The development of new cultivars, ever more attractive to farmers because of their productivity or for some other reason, can lead to genetic erosion, which can also be caused by deforestation, either for timber extraction or for the expansion of the agricultural frontier. The Brazilian government is striving to control these negative aspects by adopting legal and regulatory mechanisms for the environmentally sustainable development of agriculture (see Chapter 8). Beyond genetic erosion, a further problem is the loss of knowledge associated with local or traditional cultivars (local varieties or landraces). Such knowledge is lost when these materials are no longer conserved. The Ministry of the Environment has recently started to support projects aimed at the identification, collection, and preservation of wild crop relatives and landraces. Through Embrapa, the Ministry of Agriculture, livestock and supply, has also developed actions with small farmers, who usually hold these materials, aiming at ensuring the long-term conservation of the material, in order to avoid problems caused by genetic erosion. Germplasm recovery actions by means of active collections (scanning) in areas under impact have also been used to bypass this problem (see Chapters 3 and 4).

Brazil has a vast system of protected federal areas where biodiversity is conserved. These areas include over 6% of the country's territory in conservation units and over 12% in indigenous people's lands, in addition to Permanent Conservation Areas and Reserved Forests. This network of protected areas includes 646 Conservation Units covering a total of over 50 million hectares. It should be stressed that 8.3 million hectares have been added to the country's protected area since 2003, which is a 19% increase on the previously protected area (see Chapter 3). These advancements clearly show the importance and the relevance of this issue to Brazil.

Brazil has also taken decisive measures regarding the implementation of national preservation policies and the sustainable utilization of biodiversity. Brazil stands out among nations rich in biological resources, known and identified as megadiversity countries. This entails an absolutely essential responsibility at both the national and the global levels. Likewise, the Brazilian government recognizes the need for urgent, concrete and permanent actions aimed at reversing the continuing degradation of biodiversity. The country is making great efforts in order to implement the Convention on Biological Diversity. Recent decisive actions have been taken to achieve this goal, such as the expansion of legally protected areas for biodiversity conservation, the fostering of sustainable utilization of genetic resources, and advancements in the adoption of policies aimed at giving access to and sharing benefits derived from the use of these resources (see Chapter 8). It is crucial for the country to both strengthen the implementation of research programs for a better utilization of its biodiversity and to continue to have access to exotic genetic resources.

CHAPTER 3

THE STATE OF *IN SITU* MANAGEMENT

3.1. INTRODUCTION

In situ management of plant genetic resources, which also includes on-farm management, has received increasing attention and been extensively discussed in recent years, due in part to the Convention on Biological Diversity - CBD. Public policies, actions by governmental and non-governmental institutions, legislation changes, recognition and appreciation of traditional and indigenous populations and their role in genetic resources conservation, as well as the establishment and extension of protected areas are some of the factors that have recently influenced such conservation. These factors differ in importance, and therefore in their level of impact (positive or negative) on *in situ* management. Despite the rhetoric on sustainable development, conservation is still a secondary consideration compared to almost all other public policies for development, which indicates that its priority is not yet consolidated.

One feature of this conservation strategy is that it yields benefits that are not easy for society to perceive. For instance, the preservation of associated ecological processes is vital and includes pollination, seed dispersion, preservation of water and soil quality, and nutrients cycling. Moreover, this strategy can also offer other advantages: continuity of evolutionary processes that are essential for adaptation mechanisms; conservation of whole communities, often including a diverse set of genetic resources associated with them; and long term preservation of viable populations. *In situ* management is particularly crucial when a species is considered as a genetic resource that is also a key species for a given ecosystem and whose absence or population decline could have an impact on other species and jeopardize ecological processes. Endangered, endemic and/or rare genetic resources are also in great need of this conservation strategy.

Particularly in the case of on-farm management, the human component, farmers, are the most important factor for the success of this strategy. Farmers influence both the historical and cultural conservation of a number of food species and varieties in use and the preservation of particular management techniques that they practice (see explanation table in Figure 4), which influence plant genetic resource diversity conservation, selection and generation. However, the impact that these populations have on genetic resource conservation is hard to quantify and model due to the wide cultural diversity in Brazil (227 indigenous ethnicities, as well as *quilombolas*, *pantaneiros*, *caiçaras*, *ribeirinhos, seringueiros, castanheiros*, babassu coconut breakers, *geraizeiros* and *catingueiros*, among others). Each one of the numerous communities and ethnicities in the country has its own cultural and historic characteristics, associated with the diversity of biomes and the food genetic resources that they manage.

The importance of this kind of conservation can be estimated based on the number of traditional farmers, as they are known to manage certain amounts of native and exotic genetic resources. The number of farmers are who can be identified as traditional (point still requiring inventories and surveys), is estimated at between 3 and 4 million individuals, or 13% of the Brazilian agricultural population.

3.2. *IN SITU* MANAGEMENT

With its 44,000-50,000 species of higher plants, Brazil has one of the most diverse floras in the world. Nevertheless, only a few of these species are used in large-scale production systems, and some native plant genetic resources have lost their importance over time.

With the need for the creation and establishment of protected areas, important steps have been taken in recent years in order to preserve disappearing relic native vegetation and to conserve the vast, extant tracts of dense forest. A number of examples can be found in the Amazon biome, where the largest Conservation Units (CUs) have been created. Moreover, other important government initiatives, such as surveys conducted to identify priority areas for *in situ* management and the search for native species with potential for sustainable use, have arisen from the ratification by Brazil of the Convention on Biological Diversity in 1994.

Table 3 displays official data on CUs at the federal and State level, with two main categories defined and regulated by SNUC (National System of Conservation Units). These categories are (i) Full Protection Units, where human interference is limited and natural resources should not be directly used, and which have, as their number one goal, their conservation; and (ii) Sustainable Use Units, where different degrees of human interference are allowed in order to reconcile with the conservation of natural resources.

Of the federal CUs, 239 protect terrestrial areas, 43 are mixed, protecting terrestrial and marine areas, and 10 protect marine areas alone. These CUs cover 8.2% of Brazil's territory, of which 3.9% are Full Protection Units and 4.3%, Sustainable Use Units. Despite many deficiencies regarding the ideal size of the areas and the problems of structure and management, in a little over two decades the country went from 15 million hectares of federally protected areas in 1985 to approximately 70 million in 2007 (Figure 4).

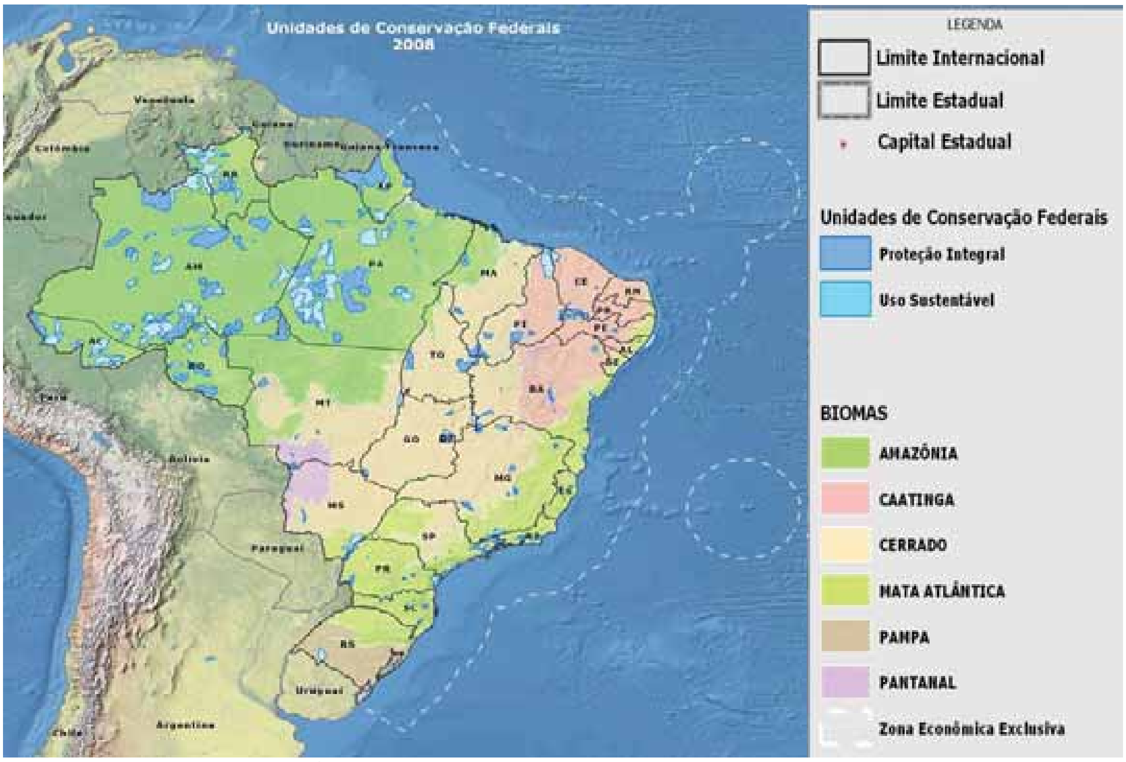

Figure 4: Brazilian Federal Conservation Unit
Source: Ministry of the Environment

At the State level these areas represent approximately 1.0% (Full Protection) and 2.5% (Sustainable Use) of the national territory. Of these, 269 are located in terrestrial environments, 36 include both terrestrial and marine environments, and 3 are exclusively marine.

Table 3. Number and Size of Federal and State Conservation Units and Indigenous Peoples' Reserves.

Category	Federal no. and area (thousand ha)	State no. and area (thousand ha)	Total area (thousand ha)
Full Protection Units	128 (33,238.2)	184 (8,365.0)	312 (41,603.2)
Sustainable Use Units	164 (36,491.5)	124 (21,755.8)	288 (58,247.3)
Indigenous Peoples' Reserves.	611 (105,672.0)	-	611 (105,672.0)
Total	903 (175,401.7)	308 (30,120.8)	1211 (205,522.5)

Brazil has a total of 1,343 protected areas, of which 292 are at the Federal level, 308 at the State level and 743 are designated as Natural Heritage Private Reserves (NHPRs). Combining federal CUs in the Full Protection (3.9%) and Sustainable Use (4.3%) categories, State CUs in the two classifications (1.0% and 2.5%, respectively) and NHPRs (0.06%), approximately 11.7% of Brazilian territory is dedicated to the conservation of the country's biodiversity, which amounts to over 100 million hectares. Municipal level CUs are not included in this total. Including indigenous peoples' areas, the country's total area under protection represents about 24.1% of its territory. Compared to our previous report, there have been advancements in the creation of new areas for indigenous peoples' reserves and in the expansion of existing reserves. Their number soared from 554 to 611 units, an increase of 11,026,781 ha (12%), which translates into a total area of 105,672,000 ha (although only 87.27% of this area is fully regularised). For two reasons, ensuring the protection of indigenous people's reserves is key to achieve conservation: firstly, land is one of the main factors allowing a population to preserve its traditions, including the cultivation of plant genetic resources; and secondly, these reserves also serve as *in situ* management units, where natural resources tend to be better managed within than outside their boundaries. Though these figures are significant for *in situ* management, a serious imbalance persists regarding the protection of different biomes.

The Amazon biome is widely covered by a network of Conservation Units and indigenous peoples areas. Also in effect is the Amazon Protected Areas Program (ARPA) of the Ministry of the Environment (MMA), which aims specifically to extend protected areas to 500,000 km2 and uses the concept of ecoregions as its biodiversity conservation indicator. Nevertheless, biomes such as the Cerrado, the Atlantic Forest and the Caatinga, all of which are the target of intensive human activity and having equally important natural resources, are still underrepresented within the National System of CUs. Thus, unique species and populations in these biomes might disappear or be seriously jeopardized due to the shrinking of their habitats, as has already happened in the Atlantic Forest and is currently going on in the Cerrado, the only two biomes in Brazil characterized as hotspots - i.e., biomes where high species endemism is associated with the danger of rapid loss of habitats.

Taking into account the federal and State Full Protection CUs, about 2.48% of the total area of the Cerrado biome is protected. When we consider the Sustainable Use category, crucial for specific actions targeting genetic resources for food and agriculture, this percentage drops to only 0.03% of the total area of the Cerrado biome. Furthermore, it is important to stress the concern stemming from the fact that agribusiness expansion has encroached most heavily on this biome, with the consequent conversion of vast areas of the Cerrado into monoculture plantations. Another difficulty concerning the decrease in the number of currently protected areas is that many CUs are not really established on the ground. This is due to the lack of infrastructure and personnel, as well as the lack of biotic and abiotic information, problems with regularisation of land titles and the lack of management plans and efficient administration systems.

These problems were first properly described for the Central West region in a project called "Taking inventories for the identification of institutions involved with *ex situ,* on-farm and *in situ* management of plant, animal and microorganisms genetic resources", carried out by Embrapa Genetic Resources and Biotechnology with the support and by the initiative of the Ministry of the Environment. By means of these inventories, which will also be conducted for the other Brazilian regions, it will be possible to consolidate an information system on what is being conserved, current conservation conditions and improvements needed in genetic resources conservation. Besides the identification of institutions involved with this issue, the initiative aimed at determining: (i) the representativeness of each collection and the territory it covers in terms of both wild species and populations and crop varieties in each collection, as well as the size of each one of the collections; (ii) the situation of accessions conservation in each collection, both *in situ* (genetic, extractive or sustainable development reserves) and *ex situ* (seed conservation chambers, tissue culture, cryogenics and also in the field), as well as the situation of on-farm managed genetic materials, particularly by family and traditional farmers; (iii) the exchange intensity over the last 10 years; (iv) the research activities conducted on each collection and intensity of use; (v) the available infrastructure in each area for sample storage; and (vi) short, medium and long term measures needed for the conservation of each collection.

For genetic resources, Sustainable Use is the only CU category in which plant genetic resources may be kept and used, as opposed to the Full Protection category, in which the use of these resources is banned. Hence, the conservation of plant genetic resources that might be used in the future can only be fully practiced today in extractive reserves, national forests, sustainable development reserves and others falling into the former category.

Another significant advancement has been achieved in recent years through the implementation of many CUs in the Sustainable Use category, particularly extractive reserves. Today Brazil has 56 federal Extractive Reserves, for the most part in the Amazon, where *Bertholettia excelsa* (Brazil nut), *Hevea brasiliensis* (rubber tree), *Euterpe oleracea* and *Euterpe precatoria* (assai), *Theobroma grandiflorum* (cupuassu) and *Attalea speciosa* (babassu) are still the main harvested species, despite the fact that extractive activities play a decreasing role in the household subsistence and income. Their total area extends to over 12 million hectares and the combined area of the 28 State level Extractive Reserves surpasses 2,888,921 ha. However, in the other biomes, there are still communities that carry out extractive activities in relic natural vegetation, which are undergoing accelerated degradation.

A number of plants, which are regionally both important food sources and are affected by extractive activities in the Cerrado, still do not have specific areas for their conservation. These include: pequi (*Caryocar brasiliense*), cagaita (*Eugenia dysenterica*), baru (*Dipteryx alata*), buriti (*Mauritia flexuosa*), macauba (*Acrocomia aculeata*) and mangaba (*Hancornia speciosa*). There are still very few Sustainable Use CUs in other categories that could reconcile use and *in situ* management of plant genetic resources with Sustainable Development Reserves, with only one federal and nine State level units with a total area of about 8,227,032 ha.

In addition, it must be noted that some CUs in the Sustainable Use category do not exactly qualify as protected areas, but rather act as territory zoning for human settlements where natural resources conservation is a secondary goal. This is the case of the Environmental Protection Areas, which have a significant total area chiefly at State level (around 30,711,992 ha). The most common instances of this case that are still included in this category are rural areas around cities from where native vegetation has been virtually eliminated.

Genetic Reserves, which are not included in the SNUC, are CUs whose creation and establishment concept – protecting economically important ecosystems and species – was not disseminated and/or assumed by the institutions responsible for fostering and creating protected areas. Thus, this type of CU has not expanded in recent years, remaining limited to a handful of small, protected areas within the main biomes. Categories classified as extractive reserve, sustainable development reserve and national forest can play the same role that genetic reserves were meant to, so the fact that these protected areas did not prosper is not a problem for the *in situ* management of plant genetic resources.

Since the 1990s, the concept of biodiversity corridors has steered the creation of CUs toward a model based on an increasing number of connections between already existing protected areas, avoiding the formation of islands and all the problems associated with this isolation. Examples of these corridors are chiefly found in the Amazon, were the Amana State Reserve connects the Jau National Park with the Mamiraua Sustainable Development State Reserve. In the Cerrado, the connections between the Serra Geral do Tocantins Ecological Station, the Jalapao State Park and the Nascentes do Parnaiba National Park make up an extended group to which the concept of ecological corridors is also applied.

Furthermore, research efforts pursued in extractive communities increasingly tend to assess the sustainability of the extractive activities. In general, surveys must mainly answer questions about the dynamics of these populations and the optimization of their production systems. Other important considerations have to do with the various socioeconomic links in the productive chains.

Although very timely, some initiatives have been carried out on a larger scale, such as the agrobiodiversity conservation projects developed in agro-extractive management areas in the Amazon and in areas of the Cerrado in northern Minas Gerais State, in southern Ceara State (Araripe National Forest), in Mato Grosso State (Xingu Indigenous Park) and in Tocantins State (Kraho Indigenous Peoples Lands). These initiatives are implemented through the Brazil-Italy Biodiversity Program, carried out by Embrapa and the Chico Mendes Institute, with the participation of non-governmental organizations, social movements, research institutions and universities. In this framework, studies are being conducted on *in situ* and on-farm management of some native species, such as pequi (*Caryocar brasiliense*), mangaba (*Hancornia speciosa*) and coquinho azedo (*Butia capitata*), as well as landrace crop varieties.

Another initiative worth mentioning includes studies aimed at assessing and identifying priority areas and actions for the conservation, the sustainable utilization and the sharing of benefits of Brazilian biodiversity. These studies are coordinated by the Ministry of the Environment and have the participation of several non-governmental organizations, universities and research institutions and are meant to enrich the National Biodiversity Policy. This assessment has identified 900 areas considered as priorities for biodiversity conservation in the country according to four criteria: (i) extreme biological importance; (ii) very high biological importance; (iii) high biological importance; and (iv) insufficiently known, but probably of biological interest. Five hundred and ten areas, or 57% of the total number, have been classified as of extreme biological importance. As a result of this initiative, and based on these data, approximately 57 CUs have been created.

The Ministry of the Environment has coordinated inventories of the conservation status of landrace crop varieties and of some wild crop relatives. Taken by Embrapa and by the National Institute for Amazonian Research (INPA), these inventories have focused specifically on landraces and wild relatives of cotton, peanuts, rice, cucurbits, cassava, maize and pupunha. The activities included in this inventory have been: taxonomic definition of wild relatives, analysis of the geographical distribution and of the conservation status, as well as measures to be taken in order to foster the conservation of these landraces and their wild relatives.

Other priority species are also expected to be included later, including pineapple, barley, beans, passion fruit and peppers, among others. The definition of future strategies for *in situ* management of these plant genetic resources will rely on this basic information.

3.3. ON-FARM MANAGEMENT

On-farm management is a conservation strategy that has only recently been recognized, even though it is an old practice, adopted by all traditional farmers. Over the last decades of the 20th century, scientists working with genetic resources recognized that the absolute majority of the world's genetic resources are still in the hands of farmers. The farmers, particularly those using traditional practices, continue to manage and breed such resources in the same way they have always done, as scientists have come to recognise. All of the above are reasons why the CBD and the International Treaty recognise their importance and seek mechanisms to support them. In recent years, this issue has been increasingly discussed by government and civil society alike. Both now advocate actions aimed at providing support to traditional farmers so as to allow them to maintain their traditional way of managing plants and landraces and varieties, including, in some cases, the recovery of some plant genetic resources that might otherwise have been lost. Nevertheless, this recognition and support takes place in a world context in which the modern market is developing. As a consequence, conflicts repeatedly occur between traditional farmers and capitalized agribusiness, often seen as destroyers of traditional ways. This conflict is exacerbated by most public policies for the rural environment, which still aims to modernise traditional systems, often seen as obsolete. In an attempt to minimize this trend, the Brazilian government created the Ministry of Agricultural Development, and some policies have been designed with this aim in mind by the Ministry of the Environment, whose mandate is to meet many of the demands of the rural world outside capitalized agribusiness. However, one of the big problems facing traditional farmers is that government programs are solely implemented through competitive, fragmented and short duration bidding conditions. In this framework, project funding mechanisms do not take local requirements into consideration and the lack of continuity of these programs remains a limiting factor. It should be stressed that other countries are facing similar situations because on-farm conservation actually requires support mechanisms other than the tools designed to foster rural and conventional agricultural development.

In this context, the number of studies and publications discussing and recognizing the role farmers play in the conservation of landraces and wild crop relatives has dramatically increased in recent years. Many of these studies stress the dynamism of the local management process in the field, where plants are constantly exposed to local environmental factors. This allows these varieties to be selected and adapted to variations (biotic and abiotic factors), thereby making them an important source of genetic resources to be used in the future. Some studies demonstrate that traditional farmers know very well how to select, out of modernization packages offered by extension and R&D institutions, those elements that are more suited to them, which leads to a modernization of the conventional system that is driven by stakeholders. Almost every one of these studies also demonstrates that current traditional farmers stick to traditional agricultural practices, such as the use of landraces, multicropping and animal husbandry, managing genetic resources on-farm and showing that modernization does not always destroy tradition.

However, lack of consistency and difficulty in generating a model for providing support to these farmers, means that the focus and the depth of work along these lines are very uneven. Results are more often subjective than objective, so that the systematic recording of the various programmes and the measurements of their impact are still incipient. In other words, the impact of different initiatives is highly variable: some are very successful in practical terms, while others are rather political and yet others still yield little results in terms of conservation. Therefore, methods for measuring this impact are required, so as to better target future efforts and resources.

Amongst efforts with positive results, those made by *Articulação Nacional de Agroecologia* stand out. This association gathers about 80 NGOs, rural social movements and agroecological networks, bringing together different Brazilian social movements with a view to providing support to family and traditional farmers through actions of recovery, assessment and breeding, as well as seed exchange and production, to name but a few examples. These NGOs work across different areas and use different approaches, from genetic resources conservation to issues pertaining to advocacy and legislation.

Examples of lines of action, fostered both by the government and by social institutions, that have been implemented in Brazil in recent years for the promotion of on-farm conservation include:

3.3.1. Participatory Breeding

Only decentralized participatory breeding will be discussed. Here local communities participate in the process as a whole, receiving only external technical support (governmental and/or non-governmental), which can include the supply of seed samples from the outside. This approach seeks to ensure community food sustainability through the adaptation of plants to the environment and traditions of each one of the involved communities.

Many of these projects are intended to deal with both subsistence and income generation through surplus marketing, as a way to obtain the popular support needed for on-farm of conservation of genetic resources. Unfortunately, the absolute majority of these projects are funded through competitive bidding and are mostly of short duration. When a project is long enough for the completion of one cycle of breeding and the generation of more productive or higher demand genetic resources, it can have a long lasting impact. However, when the duration is insufficient, there is little or very fleeting impact.

3.3.2. Seed Fairs

Seed fairs are events where traditional farmers get together and exchange experiences and seeds. The number, size and scope of these fairs have increased in recent years. However, even though their goal is to recover, exchange and distribute local varieties, creating a potential for the conservation of plant genetic resources within a network, the real impact of the fairs on actual conservation is not yet quantified, and requires further studies and support

3.3.3. Community Seed Banks

In recent years a growing number of initiatives have provided support for the establishment of local seed banks as a means to ensure conservation and perpetuation of local varieties. Farmers of a given locality usually contribute a portion of their seeds, which are kept together in a storage facility, generally managed by themselves and where they can recover seeds for the subsequent crop. This helps protect farmers as far as the conservation of their traditional varieties is concerned and also to reduce risk of possible losses. However, this kind of conservation is usually carried out under very precarious conditions. In most cases, for instance, seeds are exposed to temperatures and humidity not fully adequate for the preservation of their viability for many years. Thus, in case problems occur in a given year, entailing production losses and, as a consequence, absence of restocking, part of these resources can be lost. For initiatives like this to achieve better results in the future, studies on the viability of these banks and more technical support and resources (equipment such as refrigerators, for instance) are needed.

3.3.4. Agrobiodiversity Management Dissemination Centres (*Centros Irradiadores de Manejo da Agrobiodiversidade* – CIMAs)

The Brazilian government created in 2004 an agrobiodiversity program led by the Ministry of the Environment, in connection with social movements, the academic-scientific community and NGOs. This program works with traditional farmers and smallholders involved in agrarian reform and with their families. Besides its basic elements (seeds and landraces, medicinal plants, agriforest systems, agri-extractive and alternative animal management), CIMAs also promote low environmental impact (Permanent Preservation Areas and Legal Reserves) in the areas where selected projects are located.

Results that have already been achieved include: the implementation of 10 CIMAs; the creation of 142 training courses in which 3,503 farmers have been involved; the training of 242 community agents; the introduction of 430 demonstration units; the establishment of 30 community seed banks; the recovery of 123 varieties, especially beans and maize; and the introduction of 138 agriforest systems. New CIMAs are expected to be created in the near future and if widespread and free of bureaucracy, this program will help enormously on-farm conservation of genetic resources.

One example of on-farm conservation in the Xingu Indigenous Park is the way dwellers still plant cassava – *Manihot esculenta.* During the establishment of their plot, a single family in the Yawalapiti village performs a religious ritual called "Casa do Kukurro" (Figure 5). The ritual consists in building two mounds or pits on the edge of the forest. Then, all the cassava varieties they have (about 16) are planted in the same plot, so as to protect and strengthen the energy of all the other surrounding plants. In evolutionary terms, the grouping of varieties makes it easier for them to recombine and generate new varieties that are later on recognized and cultivated. It is a family tradition with an impact on the genetic diversity of this species, which otherwise is at the risk of being lost.

Photo: Fábio Oliveira Freitas

Figure 5: Traditional cassava planting ("Casa do Kukurro)

3.3.5. Recognition and appreciation of traditional populations

Following recent official recognition of several cultural groups, now classified as traditional populations, an increase in demands for land and/or genetic resources conservation is to be expected as a means to strengthen their own culture. It falls upon public institutions to make sure that this process is culturally and environmentally sound. This is important in a number of areas, such as the reconstitution of vegetation or crops in their respective regions that could be totally or partially degraded. Another example would be the promotion of attempts to recover plant genetic resources that each population has historically used and might have been lost with time, based on an inventory of the situation of each one of these populations, focusing on their nutrition.

Among these populations, the case of babassu nut breakers is noteworthy. This is a group composed of an estimated 400 thousand women who earn their living from the extractive management of this palm tree. This group's goal includes both the preservation of this resource and free access to it, as most of the managed palm tree populations are found on privately owned lands. Pressure on federal, but chiefly municipal, legislatures has led to the adoption of 14 municipal bills in the States of Maranhão, Pará and Tocantins, ensuring this group of women the preservation and the use of this resource. However, as proper inspections are seldom carried out, the passing of bills does not always guarantee actual rights.

CHAPTER 4

THE STATE OF *EX SITU* MANAGEMENT

4.1. BACKGROUND

Since the early 1970s, the world has been increasingly concerned about the preservation of, often endangered, genetic resources, needed to meet the demands for plant breeding. This threat stems, among other causes, from the demand for the development and dissemination of modern agriculture. Since the adoption of the First Report on the State of the World's Genetic Resources for Food and Agriculture, new issues have arisen that threaten the conservation of agrobiodiversity and, by extension, Brazilian natural ecosystems, which are sources of valuable genetic resources. One of the most recent threats is the potential expansion of monospecific arboreal crops for pulp production, which are encroaching on subtropical areas, currently dedicated to conventional agriculture or to rangeland management. Another threat is the establishment of new sugarcane plantations for biofuel production, which are encroaching on tropical agricultural and cattle raising areas, pushing the latter activities toward heretofore preserved forest areas. However, the planning authorities are aware of these trends and environmental licensing protocols take the increasing potential threat posed into consideration.

In the 1970s, FAO encouraged the establishment of a global network of Centres for the Conservation of Genetic Resources, with members from the regions with the highest genetic variability. In 1974, the *International Board for Plant Genetic Resources* (IBPGR; or today, *Biodiversity International*), was established by the *Consultative Group for International Agricultural Research* (CGIAR). Also in 1974, EMBRAPA established a research unit whose basic mission was to coordinate appropriate means for genetic resources management in the country. This unit was named the National Centre for Genetic Resources (CENARGEN). In 1984, CENARGEN incorporated into its activities research based on biotechnology for conservation and utilization of genetic resources. Its name was then modified to National Centre for Genetic Resources and Biotechnology Research, but the acronym CENARGEN remained unchanged. More recently, the more synthetic name, Embrapa Genetic Resources and Biotechnology, was adopted.

Before the establishment of CENARGEN, activities related to genetic resources were, with a few exceptions, conducted only in a casual and sporadic way in Brazil. There were frequent gaps in some important research areas and duplications in others throughout the country. Previously, routine germplasm introduction, collection and, more importantly, conservation activities, relied to a great extent on the effort, interest, enthusiasm and connections of individual researchers. However, it should be recognized that some institutions, dedicated to research in certain products, pioneered the establishment and the conservation of germplasm banks. Institutions of particular note in that effort include the São Paulo State Agronomic Institute (Instituto Agronômico do Estado de São Paulo), located in Campinas (IAC), leader of the work on coffee and sugarcane; the Alcohol and Sugar Institute (Instituto do Açúcar e do Álcool - IAA) and the Sugarcane Producers Cooperative (Cooperativa dos Produtores de Cana de Açúcar - COPERSUCAR); the Brazilian Executive Commission for the Cocoa Crop (Comissão Executiva do Plano da Lavoura Cacaueira); the Luiz de Queiroz College of Agriculture (ESALQ/USP), working on maize and vegetables, and Viçosa Federal University (UFV), which traditionally conducted research on beans and soybean. Nevertheless, most of these collections were either incomplete or targeted to the solution of immediate and quite specific problems. The loss of old or even recently introduced materials was a persistent problem. This situation was further complicated by the fact that most food crops used in Brazil are of exotic origin, which makes the country highly dependent on exotic germplasm. Furthermore, the documentation of the collections and/or the information dissemination processes was precarious, which greatly complicated germplasm exchange at both the national and the international levels.

4.2 *EX SITU* CONSERVATION

With the creation of Embrapa Genetic Resources and Biotechnology and the consolidation of the Agricultural Research Cooperative System (Sistema Cooperativo de Pesquisa Agropecuária - SCPA), today named National Agricultural Research System (Sistema Nacional de Pesquisa Agropecuária - SNPA), an environment was put in place that favours the establishment of a national genetic resources network. This was instrumental in organizing and improving the efficiency of the following activities: germplasm collection, exchange and quarantine, characterization, evaluation, documentation, and more importantly, conservation and utilization. SNPA is partially made up of EMBRAPA, with its 41 research units, and similar corporations maintained by most Brazilian states, as well as other federal and state level agricultural research institutions, universities and publicly or privately owned companies directly or indirectly involved in agricultural research. Most initiatives aimed at the conservation of plant, animal and microorganism germplasm available in Brazil have recently been integrated under one umbrella, the Cooperative Platform for Genetic Resources, which includes EMBRAPA and many associated institutions.

Several new initiatives aiming at genetic resources conservation have been launched in Brazil in recent years. Some, however, are not concerned with germplasm distribution or exchange outside their own limits. Although these initiatives can help preserve variability for the future, there is currently no evidence that these resources will eventually become available for general use by the opening of these germplasm collections. Other initiatives and programmes are not equipped with the facilities required for the secure conservation of germplasm and should rather be defined as working collections. Nevertheless, duplicate accessions from these collections can be incorporated, today or in the future, into formal genetic resources conservation structures.

Concrete efforts toward a regional cooperative conservation model of genetic resources have been recently made by the Bahia State Plant Genetic Resources Network, which assembles researchers, university academics and graduate students, but welcomes the participation of all interested parties. The Active Germplasm Banks involved in this network conserve over 80,000 accessions, and effective cooperation has been established between them and Embrapa Genetic Resources and Biotechnology.

Botanical gardens have traditionally managed important plant species, but usually not on a population basis, where they often maintain many species derived from only one or a few representative individuals. However, the Brazilian Botanical Gardens Network has been established and it is now possible to anticipate that it will increasingly partake in efforts aiming at an adequate *ex situ* conservation of relevant segments of the Brazilian plant genetic diversity. Botanical gardens usually greatly prioritize endangered species conservation, which might occasionally match the goal of conserving native wild crop relatives and many other plants that are potentially useful for agriculture.

With the participation of all these different institutions, the National Network currently maintains 383 Active Plant Germplasm Banks (AGBs), of which 140 are within the Embrapa system and 243 are at other SNPA institutions. The distribution by State of Brazilian GABs that work in conjunction with Embrapa Genetic Resources and Biotechnology is depicted in Figure 5. Of these AGBs, 52% conserve only exotic species, while 32% conserve native species alone and the remaining 16% conserve both categories of species. The high proportion of exotic species in these AGBs is indicative of their importance for food and agriculture in Brazil.

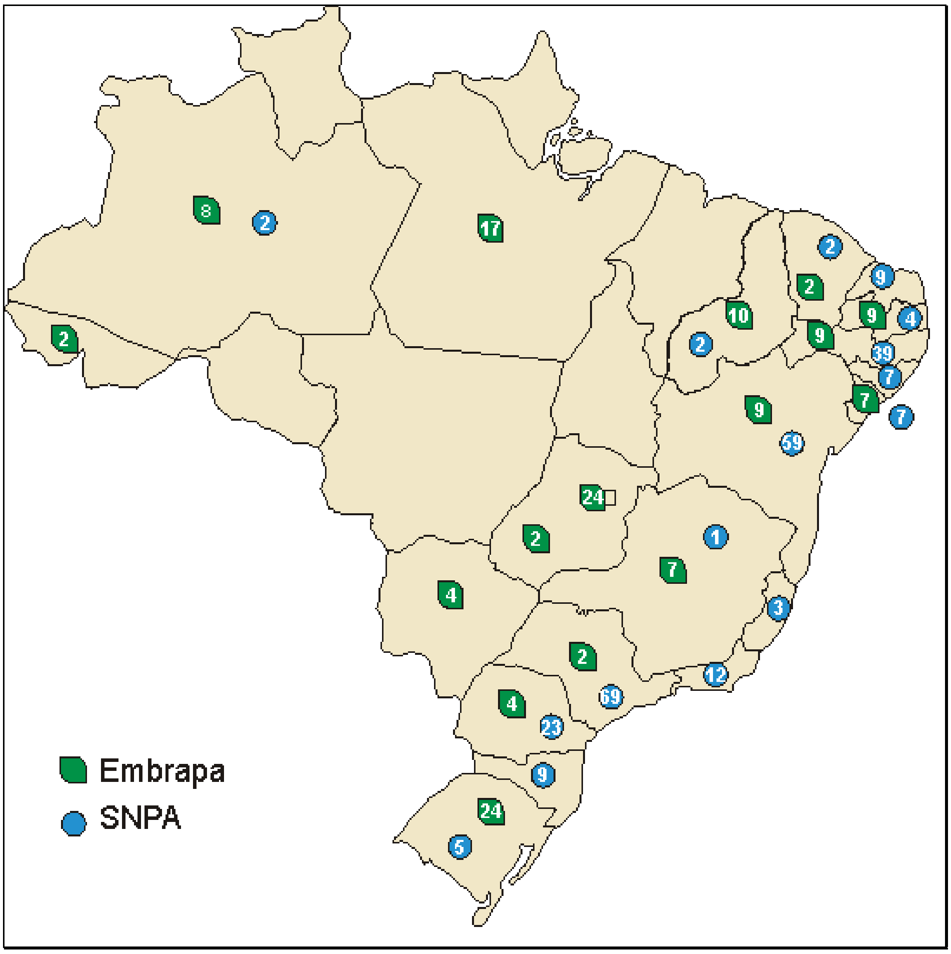

Figure 5: Distribution of Active Germplasm Banks by Brazilian States

It must be noted that high numbers of involved germplasm banks, locations and institutions does not necessarily equate with conservation of a wide range of species or crops. Many germplasm banks share a significant number of duplicate accessions (for instance, beans and cucurbits) and others (for example, those with forage plants) are becoming specialized, thus reducing the number of species their collections include. In addition, this specialization usually results in a significant increase in the number of accessions of the most restricted species they maintain.

The plant germplasm base collection (COLBASE) is maintained at Embrapa Genetic Resources and Biotechnology, while the active collections are held at the respective AGBs. An updated inventory of this system pointed out that there are in Brazil over 170,000 plant germplasm accessions, including duplicates, of which about 107,000 are stored in COLBASE and about 63,000 in other collections (see Table 4).

The native species category also includes traditional local crops and plants usually harvested *in situ* for direct consumption, such as native fruit-bearing plants, which are another important group represented by the Brazilian wild relatives of native and exotic crops. Examples of the latter group are cassava (*Manihot spp*), cashew (*Anacardium spp*), pineapple (*Ananas spp*), passion fruit (*Passiflora* spp), rubber tree (*Hevea spp*), peppers (*Capsicum spp*), sweet potato (*Ipomoea spp*), groundnuts (*Arachis spp*), rice (*Oryza spp*), potato (*Solanum spp* - sect. *Tuberarium*), and barley (*Hordeum spp*). Wild relatives occurring in Brazil might include all known species, in genera such as *Anacardium* and *Hevea*, encompass 85 and 64, respectively, of the *Manihot* and *Arachis* species, corresponding to 80% of the existing species of these genera or include a poor, but not least significant genetic representation, with the four local species of *Oryza*, three of *Solanum* (sect. *Tuberarium*), two of *Hordeum* and one of *Gossypium*.

Native forage species of several genera of grasses or legumes (such as *Centrosema*, *Cratylia*, *Stylosanthes*, *Trifolium*, *Vicia*, *Bromus*, *Paspalum*), native forest trees, medicinal plants (*Dimorphandra*, *Maytenus*), ornamentals (*Heliconia*) and plants of industrial use (*Paulinia*) are constantly added to the collections of the Active Germplasm Banks.

Table 4. Genera and respective plant germplasm accession numbers in Base Collection (COLBASE)

Genus	Number of accessions	%	Genus	Number of accessions	%
Hordeum	29,227	27,8	*Centrosema*	467	0,4
Phaseolus	14,069	13,4	*Brachiaria*	400	0,4
Oryza	9,989	9,5	*Allium*	312	0,3
Glycine	9,177	8,7	*Panicum*	302	0,3
Vigna	5,744	5,5	*Cajanus*	279	0,3
Triticum	5,653	5,4	*Lagenaria*	279	0,3
Zea	4,149	3,9	*Citrullus*	262	0,2
Sorghum	3,615	3,4	*Cucumis*	239	0,2
Gossypium	3,179	3,0	*Abelmoschus*	200	0,2
Amaranthus	2,328	2,2	*Pennisetum*	162	0,2
Helianthus	2,312	2,2	*Vicia*	144	0,1
Sesamum	1,950	1,9	*Luffa*	144	0,1
Cucurbita	1,888	1,8	*Cuphea*	135	0,1
Pisum	1,567	1,5	*Ipomoea*	127	0,1
Lycopersicon	1,439	1,4	*Nicotiana*	114	0,1
Ricinus	778	0,7	*Medicago*	108	0,1
Brassica	761	0,7	*Aegilops*	96	0,1
Arachis	702	0,7	*Desmodium*	87	0,1
Stylosanthes	564	0,5	*Aeschynomene*	75	0,1
Avena	511	0,5	*Capsicum*	473	0,4
Solanum	489	0,5	Other	2,753	2,0
Capsicum	473	0,4	**Total**	**107,249**	**100,0**

Clearly, the largest germplasm collections are those of exotic species, which include products of primary social and economic interest. For this reason, their maintenance and expansion is strategically relevantIt should be stressed that the main food crops which are important to Brazil are dependent on exotic germplasm. Almost 95% of the grain accessions conserved in Brazil, in SNPD collections, are of exotic species. Constant maintenance and enrichment of genetic variability of the species in these collections is a source of permanent concern, especially in the face of potential scenarios of increased restrictions to international exchange. Basically, each Active Germplasm Bank considers that its collection requires taxonomic, geographical and genetic enrichment.

Tables 1A to 10A in the Annex provide a list of species conserved within SNPA (not including COLBASE), the institutions where they are conserved and their respective accession numbers. Table 4A shows that beans, a very important crop for the country, are the product with the highest number of accessions (14,460), followed by soybean (with 13,300 accessions), the main Brazilian export.

In Brazil, *ex situ* management is usually carried out by one of the following methods: (i) keeping seeds in cold chambers, (ii) *in vitro* conservation, and (iii) conservation in the field. Cryopreservation in liquid nitrogen (implemented at a faster pace for animal germplasm) is still at an experimental stage at EMBRAPA and at some associated institutions as far as plant germplasm is concerned. The infrastructure required for widespread use of plant cryopreservation is still below ideal standards, but currently, specific protocols are under development and priority is given to training.

Within the Brazilian system of genetic resources, long-term conservation of plant germplasm has mainly been carried out by the conservation of orthodox seeds (seeds which will survive drying during *ex situ* conservation) in sub-zero temperature chambers (Embrapa Genetic Resources and Biotechnology and Instituto Agronômico de Campinas-IAC). For short and medium term conservation, orthodox seeds can also be stored in cold chambers at above-zero temperatures. Following the first Report on the State of the World's Plant Genetic Resources for Food and Agriculture, the number of Active Germplasm Banks that are equipped with above-zero cold chambers in EMBRAPA and other associated institutions units increased significantly. Nevertheless, regular seed regeneration is still recognized as a bottleneck in many Active Germplasm Banks, especially when multiplication of accessions requires isolation. In addition, core collections have been established for several crops with orthodox seeds (maize, rice, beans). Seed multiplication is also under the responsibility of specific germplasm active banks, but it is at least recognized that these collections indicate possibilities for germplasm utilization, hence adding value to relevant germplasm banks.

For species with recalcitrant seeds, short and medium term *in vitro* conservation, as well as in-the-field conservation based on living plant collections, have already proven promising for conservation. Both techniques are routinely implemented.

In-the-field conservation of perennial plants, carried out by units that have Active Germplasm Banks, not only is expensive and labor intensive, but also requires highly trained personnel. Another problem with this system is plant vulnerability, since in the field, plants are exposed to a number of adverse biotic and abiotic factors. Many of these crops are additionally conserved *in vitro*, and pollen conservation is carried out in a number of fruit tree collections. Lack or instability of funding strongly affect some of the living plant collections, especially those established over larger plots, where maintaining experimental fields free of weeds is a serious challenge in itself.

The national base collection (COLBASE), held by Embrapa Genetic Resources and Biotechnology, has five available chambers that currently have the capacity for storing over 250,000 accessions (558m^3). These cold storage chambers operate at a temperature of -20°C and are designed to conserve seeds for very long periods of time. Germplasm in COLBASE is regularly monitored and germplasm requests are usually answered through specific Active Germplasm Banks for relevant crops. Whenever germplasm must be delivered from COLBASE, arrangements are made in order to ensure its appropriate, concomitant regeneration. The Instituto Agronômico de Campinas (IAC) has two cold storage chambers operating at -10ºC.

Facilities designed for long-term seed conservation at COLBASE have adequate infrastructure for the following activities: reception, preparation, quality control for physiological and phytosanitary conditions, packaging and documentation of stored germplasm (using bar codes). In addition, there are extra greenhouses and screenhouses for multiplication and regeneration of germplasm that cannot be conducted in Active Banks. Some Active Banks multiply their germplasm samples in crop-specific field sites, but some crops, such as maize, are very labor intensive and require extra areas in order to ensure the necessary isolation during multiplication. Appropriate routine planning makes it easier to integrate simultaneous conservation and characterization activities, but in many cases separate fields are required for these two different objectives.

For *in vitro* conservation, two special chambers are used, as well as the *In vitro* Culture Lab (VCL), with one isolation room for preparation of materials. One of these is for temperate species, kept at 10°C and the other chamber, which is designed for tropical species, operates at 19°C. Similar facilities are available for certain crops, mostly for clonally propagated crops, in several EMBRAPA units and associated institutions (IAC, Rio de Janeiro de Janeiro State University/UERJ).

Besides the routine conservation work, research has been carried out on seeds from species that have never before been studied. Such studies, which include anatomy, physiology and pathology, have as their long-term goal the consolidation of the germplasm conservation system using original scientific information. This research aims at (i) classifying the different types of seeds as recalcitrant, orthodox or intermediate, according to their storage requirements; and (ii) establishing appropriate methodologies and routine protocols for their long-term conservation. Similarly, research on cryopreservation has been developed not only for seeds, but also for other types of plant material, especially in the case of indigenous tropical species producing recalcitrant seeds. The Brazilian system for conservation of genetic resources has adopted the international seed quality standards, established by *Biodiversity International* and FAO, introducing adjustments when needed according to different circumstances and to the species being conserved. The International Seed Testing Association/ISTA rules are followed for species with known physiological requirements.

Multiplication and regeneration of germplasm is usually carried out at the Active Banks where the active collections are maintained. Besides the active collections, some units or institutions with germplasm banks can store collections for long-term conservation, notably of perennial species conserved in the field. In this case, collections are used both to develop activities pertaining to genetic resources conservation and for breeding. Although working in the context of agricultural research, the Brazilian System for *ex situ* Management of Genetic Resources contributes significantly to the conservation of plant diversity as a whole, and has the potential for broader action for two main reasons: (i) many native species are of potential interest for agriculture and related activities; and (ii) the System makes physical facilities available where materials from any other plant species can be adequately stored.

For example, in line with the Global Strategy for Plant Conservation, these facilities are ready to help the country reach specific targets established for the *ex situ* management of Brazilian endangered plant species. Germplasm conservation for land rehabilitation and plant community reconstitution, two important subjects in more environmentally oriented initiatives, is often based on the utilization of species that are not traditionally cultivated. As a consequence, participating institutions are seldom equipped to carry out quality management as far as multiplication and conservation of these materials are concerned. Cooperative conservation and multiplication of such germplasm provide a good example of the potential for cooperative and complementary use that the available facilities have.

The conservation of plant germplasm maintained within the Brazilian System is carried out through activities that are also beneficial for the training of undergraduate and graduate students. This has encouraged cooperation with universities and favored the establishment of regional genetic resources networks.

4.3. CHARACTERIZATION AND EVALUATION

Brazil has important germplasm collections of most agricultural products of interest for human consumption, agroindustry and export. These collections are constantly being enriched by newly introduced or collected materials. Nevertheless, the level of exploitation of available variability is still below expectations due to a lag in the characterization and evaluation of accessions before these can be used directly or in plant genetic breeding programs.

In this context, research developed within the SNPA aims at:

- Characterizing and evaluating germplasm, collected or introduced in the country, based on its taxonomic, morphologic, cytogenetic, biochemical and molecular attributes;
- Conducting basic biological research on gene flow and on the determination of reproductive systems;
- Analyzing and estimating the germination viability of pollen grains;
- Studying genetic instability of germplasm by cytogenetic and biochemical methods;

- Identifying markers related to different ploidy levels, modes of reproduction and pollination mechanisms;
- Developing, consolidating and adapting methodologies for the characterization of genetic resources in the following areas: taxonomy, morphology, cytogenetics, biochemistry and molecular biology;
- Fostering and providing human resources training on biological and, especially, genetic characterization.

Within SNPA, characterization and evaluation are considered as two distinct activities, which have multidisciplinary foundations and must be both objective and specific for groups of plants for which the System has a limited number of accessions. Characterization considers simple and rather descriptive aspects, but when experimental, the aspects it looks at tend to be more sophisticated. Evaluation, in turn, is always performed in comparison with known parameters, where in terms of performance, the minimum target to be achieved is the determination of the potential usefulness of the accession.

When well targeted, characterization and evaluation provide additional benefits and enable:

- the identification of duplicate accessions;
- the development of core collections; and
- the identification of modes of reproduction of accessions.

Fundamental stages of characterization and evaluation include:

- the correct botanical identification of each accession;
- the building up of a detailed record of accessions for each species;
- biological characterization, based mainly on qualitative attributes of high heritability (this is carried out through the application of lists of descriptors);
- preliminary evaluation, based mainly on quantitative features and always contrasted with known parameters; and
- in depth evaluation, performed for a smaller number of accessions, which makes it possible to use adequate experimental designs in experiments that have temporal and locational replications.

For biological characterization, the disciplined use of descriptors is the most efficient means to search for the desired information. Nonetheless, limiting factors of a physical, temporal, human and financial nature require objectivity in their use. The application of standardized descriptors differs for groups of germplasm accessions available in Brazil, where for the most privileged; there are international descriptor handbooks and even lists of descriptors adapted to the variability found in Brazil. Here, most descriptors have been applied to a large portion of available accessions. There are groups of accessions for which there are international descriptors available. However, these international descriptors often have little relevance to Brazilian germplasm banks, but in some cases, can be adapted. In some groups, the specific list of descriptors itself must be established (ideally analyzing the discriminatory capacity of proposed descriptors). Other groups, usually including native species related to cultivated species, still require the correct taxonomic identification of most of their accessions and, in some cases, taxonomic revisions may be unavailable. Lastly, there are groups to which the application of any descriptor without knowing the modes of reproduction leads only to the accumulation of data that are hard to interpret.

In the SNPA framework, research is being developed that looks at morphological, cytogenetic, genetic-biochemical and molecular characterization. Morphological characterization and agronomical evaluation have been partially carried out concerning both the number of descriptors and the number of accessions in the Active Germplasm Banks Network.

Biochemical and cytogenetic aspects are studied by a restricted number of SNPA laboratories that have the required infrastructure and, more importantly, trained personnel to carry out these activities. Nevertheless, molecular characterization has become very popular in the last decade and its use is widespread, especially in Active Germplasm Banks that interact with graduate courses in participating universities.

Embrapa Genetic Resources and Biotechnology is equipped with good infrastructure and, moreover, has a specialized research team. This enables the unit not only to perform the characterization of certain materials, but also to act as a disseminator of modern techniques, which it does through training programs and courses targeted at technicians and researchers from universities and other institutions. In accordance with Biodiversity International – formerly named first IBPGR and then IPGRI- policies, Brazil invested in activities related to the introduction of new materials in the country, as well as in germplasm collection and conservation, during the 1970s and the 1980s. Meanwhile, however, characterization and evaluation activities were kept marginalized. This is why only a small portion of the vast collection of materials conserved in Brazil is characterized and assessed evaluated, and information about it remains incomplete.

The large volume of germplasm still requiring characterization and evaluation, as well as the natural slow development of these processes and technical, policy, financial and personnel limitations indicate that this situation will continue for quite some time. Nevertheless, following the first Report on the State of the World's Plant Genetic Resources for Food and Agriculture, modern biochemical and molecular characterization methods have been increasingly used and even developed by Embrapa Genetic Resources and Biotechnology and by most its associated institutions. Such methods have certainly been instrumental to further an important development of plant research in Brazil. This has led to a rapid reduction of the time necessary to complete the characterization of genetic diversity or even to acquire important knowledge on specific genetic systems. This latter points to possibilities for the utilization of specific accessions in breeding programs, including, for the most sophisticated ones, gene mapping and marker assisted selection.

4.4. EMBRAPA GERMPLASM CURATORSHIP SYSTEM

4.4.1.Background

In the late 1970s and the early 1980s, there was felt a need at CENARGEN for a system that would foster integration of its internal activities with those carried out in Active Germplasm Banks and, above all, promote an interaction between active banks. To this end, the Active Germplasm Banks Coordination was created. Initially this was made up of three CENARGEN researchers, whose mission was to bolster integration between different genetic resources activities, carried out by CENARGEN itself or by any other unit or institution. This has now evolved into the current Embrapa Germplasm Curatorship System.

These activities developed gradually, always keeping a global vision of genetic resources for a product or in a group of products. As a pioneering system, it took over one decade for it to consolidate. The system was often discussed and assessed, notably because it was not a formal system, but survived in this form for a number of years, proving increasingly efficient and consistent.

In view of this performance, in 1993, the Executive Board of Embrapa deemed it important and opportune to establish a corporate official system with the specific goal of giving legitimacy to germplasm management activities. And so was created the Germplasm Curatorship System, through Decision no. 028/93 published in BCA no. 29 on June 7, 1993. In 1999, this system was expanded and improved (BCA no. 030/99, August 9, 1999). Its goal is to: "define, systematize and integrate all indispensable activities for germplasm management, conservation and use within the Corporation in the context of the Embrapa program for the Conservation and Use of Genetic Resources".

4.4.2. Organizational Structure of the Germplasm Curatorship System

The Embrapa Germplasm Curatorship System is structured as follows: (a) a System Supervisor directly reporting to the Head of Research and Development at Embrapa

Genetic Resources and Biotechnology; (b) Product or product group Curators and their Assistant Curators, a category in which all are currently from Embrapa Genetic Resources and Biotechnology; (c) Germplasm Bank Curators, from the Embrapa Units that hold germplasm banks; and (d) Product or product group *Ad hoc* Curators, who offer advice to the curators and can be from any private or public institution in the country.

The Supervisor of the Curatorship System is chosen by the Director General of Embrapa Genetic Resources and Biotechnology, and appointed by the President of Embrapa. Product or product group Curators and Assistant Curators are chosen by the Supervisor of the Curatorship System; for their appointment, a Service Order signed by the Director General of Embrapa Genetic Resources and Biotechnology is required. Germplasm Bank Curators are chosen by the Director of the Units holding the respective bank and appointed by the President of Embrapa. As of 2008, there where 38 Product or Product Group Curators, 35 Assistant Curators, and 111 Germplasm Bank Curators, as well as *Ad hoc* Curators, for a total of about 200 people. Due to the very large diversity of important plant, animal and microorganism products in Brazil, and the impossibility of having one Curator for each product at Embrapa Genetic Resources and Biotechnology, the Supervisor of the Curatorship System assembled similar products together into ten groups, which are then divided into subgroups and/or individual products. Each one of the subgroups or products constitutes a curatorship, which is under the responsibility of a Curator and, in some cases, of an Assistant Curator (Table 5).

Table 5. Curatorship System by Product Groups

GROUP	CURATORSHIP
Group 1: Domestic Animals	Large Animals Small Animals Wild Animals Animal DNA
Group 2: Microorganisms	Microorganisms of Interest for Food and Health Microorganisms for Biological Control Microorganisms of Interest for Animal Health Phytopathogenic Microorganisms Soil Microorganisms Microorganisms DNA
Group 3: Sweeteners, Dyes, Stimulants and Condiments	Sweeteners and Stimulants Dyes and Condiments
Group 4: Medicinal, Biocide and Aromatic Plants	Medicinal and Aromatics Biocides
Group 5: Grains	Winter grains Summer Grains Pseudograins
Group 6: Forest, Lacticiferous and Palms	Native Forest Species of the Caatinga Native Forest Species of the Amazon Native Forest Species of the Cerrado and Pantanal Native Forest Species of the Atlantic Forest Exotic Forest Species Laticiferous Species Palms Bamboos
Group 7: Fiber, Oilseeds and Legumes	Fibers Oilseeds Legumes
Group 8: Forages and Green manure plants	Forage Grasses Forage Legumes and Green manure plants Other Forages
Group 9: Fruit-bearing	Conventional Temperate Climate Fruit-bearing Plants Conventional Tropical/Subtropical Fruit-bearing Plants Non-conventional Fruit-bearing plants Fruit–bearing plants DNA
Group 10: Vegetables, Roots and Tubers and Ornamentals	Vegetables Non-conventional Vegetables Ornamentals Roots and Tubers

CHAPTER 5

THE STATE OF USE

5.1. INTRODUCTION

The Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (PGA), adopted during the Fourth International Technical Conference on Plant Genetic Resources (Leipzig, Germany, 1996), stresses that only through the use of PGR can the social and economic benefits from their conservation be understood. However, the use of accessions available in germplasm banks is limited all over the world, including in Brazil, especially considering the diversity available in the country. The main causes for this multicausal phenomenon are: lack of adequate collections documentation and description; lack of information breeders are seeking; limited accession adaptation; insufficient number of breeders, chiefly in developing countries; lack of collection evaluation; limited seed availability due to inadequate regeneration schemes; material exchange between breeders; breeders satisfaction with the genetic variability they find in elite materials; difficulty to identify potentially useful genes; and absence of pre-breeding programs.

Knowledge of potentially useful genes and their incorporation into elite cultivars has been very important to enhance the utilization of genetic resources and broaden the genetic base for breeding programs. In this regard, research involving germplasm prospection, conservation and characterization has become strategically important for Brazil.

For vegetables, many efforts have been made in order to foster efficient and effective use of the variability conserved in GABs. Regarding sweet potato (*Ipomoea batatas*) culture, activities aim at identifying resistance to potyvirus, *Alternaria*, nematodes and soil insects (*Diabrotica*). For onion (*Allium cepa*), activities are focused on bulb quality and bulbification capacity under high temperatures. Concerning cucurbits (*Cucurbita moschata*) and pumpkins (*C. maxima*), efforts are directed toward the identification of morphological features of interest and of resistance to potyvirus and to *Phytophthora* fruit rot, as well as of soluble solids content. For peppers (*Capsicum* spp.), 807 accessions were characterized for diseases resistance, of which 403 of *C. annuum*, 91 of *C. baccatum*, 261 of *C. chinense* and 52 of *C. frutescens* thus widening information available to national breeding programs.

Another important initiative is the Orygens project, based on a wide network of researchers from different public and private institutions in the country; this project has the goal to enhance the use of current knowledge on rice genome for the development of more competitive cultivars. It is focused on the integrated study of the variation of phenotype data -obtained extensively in the field- for some economically important features, as well as on gene mapping information, DNA sequencing and gene function. In this regard, experiments with populations segregating for intraspecific crosses of rice are being conducted in several parts of the country with the aim to build genetic and physical maps for gene location and isolation. Three lines of work have been developed to this end: (1) understanding genetic control; (2) developing improved cultivars based on genomic technology in breeding programs; and (3) using progress made in the genetic knowledge of the rice model species to improve economically important crops, such as maize and sorghum, exploring synteny between these species.

For maize, a relevant example was the *Latin American Maize Project* (Lamp), involving 12 countries. This project had the goal to evaluate the agronomical features of the accessions stored in germplasm banks for future uses. In its first stage, about 15 thousand accessions were evaluated thanks to a joint effort by breeders from the public and private sectors. It made it possible to gain better insight into current germplasm banks situation, number of accessions per bank, quantity and quality of seeds per accession and list of accessions requiring enhancement. In Brazil, about 1,111 accessions –all adapted to high altitudes < 2,000 m– met the requirements established by Lamp (minimum of 1 kg of seeds and germinative power > 75 %).

Among the Brazilian scientific community, recognition and use of plant genetic resources have been growing fast regarding both native and exotic species of current or potential importance for domestic supply as well as for the Brazilian balance of trade. In this sense, several successful examples based on the use of available variability may be mentioned, as it is apparent in some of the case studies included at the end of this chapter. For instance, in the case of the Brazilian soybean, both increases in productivity in traditional growing regions and expansion of the agricultural frontier to incorporate new areas in the Cerrado or the utilization of some areas for crop rotation are undeniable benefits achieved through the creation of new, more productive cultivars adapted to these regions. These results stem from the utilization of germplasm introduced into the country, which provides evidence of how conservation and utilization of genetic resources contribute to Brazilian agriculture. For this genetic progress to continue, both genetic variability and exploitation of cultivars storage reservoirs are required. Rapid increases in soybean adaptation and productivity led breeders to confine germplasm use to most adequate types. As a consequence, until recently one of the main concerns for soybean breeding programs was the narrow genetic base of commercially used cultivars due to the small number of progenitors used for the generation of elite germplasm.

Besides the above mentioned examples of use of genetic resources in Brazil, wider, more effective and efficient use of accessions stored in Brazilian germplasm banks should also be enhanced. Among promising alternatives designed to widen this utilization, pre-breeding programs and core collections have garnered the attention of researchers working directly on genetic resources as well as of breeders.

5.2. PRE-BREEDING PROGRAMS

Intensification of activities related to identification of features and/or genes of interest –present in non-adapted (exotic or semi-exotic) materials or in materials not having undergone any breeding processes– and their incorporation into high production potential (elites) genotypes is a very promising avenue to enhance the use of plant genetic resources. Lack of this kind of connections between PGRs and breeding programs is considered one of the main reasons why germplasm collections use is limited.

One of the important examples of pre-breeding programs in Brazil is maize's. The early 1990s were characterized by an increase of maize leaf diseases. In view of this worrying development, the Maize Research Support Center (Núcleo de Apoio à Pesquisa em Milho - Nap-Milho) at Luiz de Queiroz College of Agriculture –made up of public and private institutions– was established with the mission to carry out a wide evaluation of maize germplasm available in Brazil. In this survey, about 1.3 thousand accessions and 140 populations with some degree of genetic breeding were evaluated in 12 locations representative of this crop in our country. Diseases considered in this project were: northern leaf blight by *Exserohilum turcicum*, southern rust (*Puccinia polysora*), tropical rust (*Physopela zeae*), northern leaf blight *Phaeosphaeria maydis*, maize bushy stunt and virosis (mycoplasm/spiroplasma). New populations with a high percentage of resistance genes to the respective diseases were synthesized from materials identified as promising.

In the case of rice, grown chiefly in the states of Rio Grande do Sul and Santa Catarina, Mato Grosso and Maranhão, wild species have been used in pre-breeding in order to broaden the genetic base and increase the transfer of specific features into elite cultivars. In the two first states, located in the South region, irrigated rice predominates and one of their major problems is low temperature during the growing season. In the states of Mato Grosso and Maranhão, in turn, upland rice predominates; one of the limiting factors to its production is the occurrence of Indian summers. In this context, of the four wild species of the *Oryza* Genus found in Brazil –*O.*

alta (allotetraploid), *O. latifolia* (allotetraploid), *O. grandiglumis* (allotetraploid) and *O. glumaepatula* (diploid)–, *Oryza glumaepatula*, being autogamous, diploid and with the AA genome like *Oryza sativa*, is the one with higher potential for use in cultivated rice genetic breeding. Thus, research on the introgression of genes from this species of cultivated rice is being conducted by Embrapa in order to achieve drought and toxic iron tolerance.

As far as coffee is concerned, pre-breeding programs have been developed for a number of years by IAC, yielding quite significant results for Brazil. Genetic analysis of *Coffea arabica* indicates it has enough variability that can be used for the development of new cultivars. But diploid species of *Coffea* have been exploited in *C. arabica* and *C. canephora* pre-breeding for disease, pests and nematodes resistance using several biotechnology techniques such as tissue culture, genetic transformation and molecular markers. In the context of *Genoma Café*, cooperative project between IAC and the Brazilian Consortium for Coffee Research and Development (Consórcio Brasileiro de Pesquisa e Desenvolvimento do Café) under Embrapa's coordination, about 30 thousand genes of interest have already been identified in the studied germplasm; after functions definition, these genes will be available for use in the development of new cultivars.

In the case of peanuts, pre-breeding efforts are being made for the identification of resistance genes in wild species of the Arachis Section. Evaluations already carried out, using detached leaf assay, made it possible to identify several wild species with higher levels of resistance to late leaf spot (*Cercosporidium personatum*), early leaf spot (*Cercospora arachidicola*) and rust (*Puccinia arachidis*) –which are responsible for significant losses in the Brazilian peanut production– than those in the cultivated species (*Arachis hypogaea*). Twelve accessions of species with "A" genome were selected and are being used as male parents; 6 accessions with "B" genome, as female parents. From "AB" hybrids were obtained six synthetic amphidiploids that were crossed with *Arachis hypogaea*, thus generating 17 F_1 hybrids. Some of these latter hybrids had good F_2 seed production; nevertheless, despite their high disease resistance, some combinations were sterile. Complex crosses have also been carried out trying to take advantage of the high crossability of *A. hypogaea* in the amphidiploid *A. ipaënsis* x *A. duranensis* and the high fungal disease resistance in the other amphidiploids. Backcross populations (BC_1 and BC_2) were generated whose fungal disease resistance is being evaluated under field conditions, together with the F1 hybrids'. Preliminary results point to promising individuals, which are being multiplied for utilization in peanut breeding programs.

5.3. CORE COLLECTIONS

Core collections' number one goal is to represent the genetic diversity of the crop and its wild relatives with minimum duplicates. Actions aimed at establishing core collections in Brazil are still incipient. However, this research line has been prioritized by Embrapa Genetic Resources and Biotechnology, which during one first stage –based on partnerships– established cassava, maize and rice core collections.

5.3.1. Cassava core collection

Being a vegetatively propagating crop, cassava has some particularities that must be stressed; as opposed to those in sexually reproducing species, its alleles cannot be considered as segregating units. The clonal nature of vegetatively propagating crops usually determines that each accession be used as a genotype, not as a source of desirable genes. Although cassava is a vegetatively propagating crop, some farmers in Brazil occasionally allow some plants to reproduce sexually in their fields expecting to obtain new plants with desirable feature combinations. In these cases, seeds germinate and generate adult plants among which farmers choose those that might have new combinations of interest and that are well adapted to local cropping conditions. Once this material is obtained, farmers propagate it vegetatively with other clones they grow. This aspect of cassava biology -combined with the fact that, in many Brazilian regions, cropping is carried out based on a limited use of input and with low environmental impact- has made it possible to generate genetic combinations adapted to different ecogeographical regions.

Thus, the cassava core collection was defined based on two criteria for the accession selection. The first one relates to the need for the core collection to hold clones with known phenotype expression that are considered important for this crop in Brazil. The second is the goal to recover closely linked alleles (gene clusters) or gene combinations that might be responsible for the plant's adaptation to specific environmental situations. Ecogeographical classification was adopted in order to structure the collection's genetic variability, so enabling the implementation of the second selection criterion. The inventory used to establish the core collection included information made available by GABs' curators until July 1998. The collection then included 2,931 accessions maintained in the field (Figure 7). After sampling, the core collection was established with 486 accessions, of which 462 were selected according to the first and 24 according to the second criterion.

5.3.2. Maize core collection

Embrapa's maize germplasm collection, made up of 2,263 accessions (1997 inventory), is stored in GAB-maize, held at Embrapa Maize and Sorghum, in Sete Lagoas, Minas Gerais state. To select this collection's core collection, accessions were classified in four groups according to germplasm origin: a) Indigenous varieties (1,554 accessions – 68.7%) (Table 6); b) improved materials (222 accessions – 9.8%); c) introductions (288 accessions – 12.7%); and d) composite from indigenous varieties (199 accessions – 8.8%). Group **d** was not represented in the core collection because composites are derived from a mix of group **a** indigenous varieties; therefore, its inclusion would have been redundant. The other groups were represented in the following proportions: group a (78%); group b (12%); and group c (10%). This allocation privileges the representation of the indigenous varieties group, which represents Brazilian germplasm. The core collection was limited to 300 accessions, about 13% of the total collection; its size was essentially determined based on practical criteria – it was considered appropriate to curator's management possibilities.

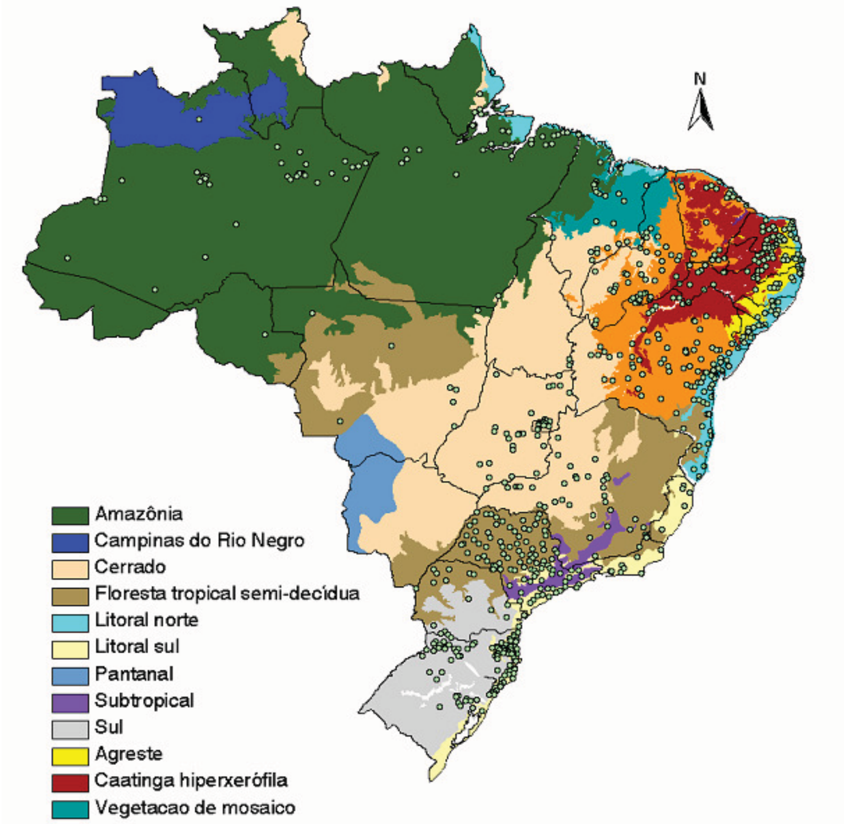

Figure 7: Ecogeographical regions from where cassava was harvested.

Table 6. Distribution of Brazilian Maize indigenous varieties in the core collection (CC) and in the total collection (TC), by type of grain and ecogeographical region of origin of accessions

Ecogeographical Region	Type of grain							
	Popcorn		Dent		Flint		Flour and other	
	CT	CN	CT	CN	CT	CN	CT	CN
South	29	10	279	17	23	9	5	5
Cerrados	26	10	321	19	77	13	50	12
Cerrados – North	12	8	110	14	9	7	6	5
Amazon	35	12	121	14	94	15	19	8
Caatinga	17	8	169	16	38	11	1	1
Agreste – Coastal area	1	1	62	12	14	8	0	0
No classification	4	0	10	0	5	0	7	0

Following the incorporation of 1,090 accessions into GAB-maize, an update of the composition and size of the core collection was proposed in 2002. This material was repatriated from the International Maize and Wheat Improvement Center (Cimmyt) or obtained by harvesting and integrated into the indigenous varieties group of the germplasm collection. So, the core collection was broadened up to 353 accessions, with the indigenous varieties group now represented by 288 genotypes according to the new size of strata in the total collection.

5.3.3. Rice core collection

GAB-rice, held at Embrapa Rice and Beans, in Santo Antônio de Goiás, Goiás state, includes 9,890 accessions. A core collection made up of 550 accessions, or 5.6% of the total collection, was considered acceptable by curators and breeders, as this sized allowed the CC to be adequately managed (morphological and molecular characterization, evaluation in the field, etc.). To select this collection, accessions were classified in three groups: a) traditional varieties (2,402 accessions) harvested over the last 4 decades from small farmers' plots; these latter generally practice subsistence agriculture and grow crops they have maintained for over 30 years; b) improved lineages/cultivars from Brazilian breeding programs (3,448 accessions); and c) lineages/cultivars from other countries' breeding programs introduced into Brazil (4,040 accessions). These three groups represent 56%, 17% and 27% respectively of the core collection.

The traditional varieties stratum accounts for a higher percentage of the collection because it represents rice genetic variability adapted to the various cropping conditions in Brazil. This is why these varieties are a unique genetic resource, very valuable for use as well as for research requiring this variability to be represented. In addition, broadening of rice cultivars genetic base has been proposed as a medium and long term strategy designed to exceed current productivity levels and avoid crop genetic vulnerability. To this end, one of the possibilities was a more intensive use of the traditional varieties diversity available in the framework of this species breeding programs. The core collection tried to implement this recommendation giving more weight to this group of materials in its composition (Table 7).

Table 7. Composition of Embrapa's rice core collection strata by cropping system.

Strata	Cropping system			Total
	Irrigated	Rain-fed	Either*	
Traditional varieties	77	148	83	308
Brazilian lineages and cultivars	37	57	-	94
Introduced lineages and cultivars	73	75	-	148
Total	187	280	83	550

* Accessions cultivated under either rain-fed or irrigated conditions.

The 550 accessions in the rice core collection were evaluated for productivity, cycle, days to flower, amylose content and plant height through experiments conducted in eight environments: Boa Vista (Roraima state), Formoso do Araguaia (Tocantins state), Goiânia (Goiás state), Pelotas and Uruguaiana (Rio Grande do Sul state), Vilhena (Rondônia state), Sinop (Mato Grosso state) and Teresina (Piauí state). In Goiânia the number of panicles and tillers by meter was also evaluated, and the cooking assay was carried out. Molecular characterization is being performed for 242 accessions, using 86 microsatellite markers. The outcome of these characterizations will be used by Embrapa's genetic breeding program for gaining more thorough inside into the collection's diversity structure.

Considerable efforts have been made in order to establish core collections for the largest collections in Embrapa's genetic resources assets - other core collections are to be expected. Nevertheless, the current greatest challenge facing us is the utilization of already established collections. Our capacity to encourage and prioritize the utilization of these collections by breeders, phytotechnologists, biotechnologists, curators and researchers from other areas (evolution, ecology, geoprocessing, etc.) will it make possible to add data and information to them.. Indeed, during this stage, core collections will become an important tool to a broader use of germplasm, leading to the conservation: utilization balance.

5.4. THE USE OF NEW SPECIES

Since the 1990s, the introduction of pseudograins like quinoa (*Chenopodium quinoa*) and amaranth (*Amaranthus caudatus*, *A. hypochondriacos* and *A. cruentus*) has gained importance in Brazil because these have high protein content, quality and no gluten; due to their functional features, they provide nutritional advantages when used human food and animal feed. Pre-breeding activities have been conducted in order to select accessions with agronomical features and take advantage of the variability stemming from natural crossing. Quinoa populations with favorable combinations have differentiated cycles (90 to 140 days), high grain and biomass production, large grains, which meet Brazilian and global demand, no lodging nor dehiscence. In amaranth, populations have been maintained with unarmed inflorescence, high grain and biomass production and no lodging.

5.5. MANAGEMENT AND SUSTAINABLE USE OF AGROBIODIVERSITY COMMUNITY SYSTEMS

Creole or local varieties maintained in production units and communities display high genetic diversity (phenotypical as well as genotypical), being the interface between wild and domesticated types. Agricultural diversity is a product not only of selection in diverse environments, but also of human preferences; so, conservation of this genetic and cultural heritage is essentially dependent on community-driven practices. Thus, agrobiodiversity conservation has been encouraged by the adoption of agroecological principles and processes, which strengthen food security in farms, as well as in indigenous areas and within traditional communities. This effort has specific goals: recovery, conservation and sustainable use of creole varieties of domesticated or semi-domesticated plants; use of medicinal and phytotherapic plants and of agriforestry systems; sustainable management of agri-extractive products from sociobiodiversity; and alternative animal management. This subject is detailed in Chapter 3 above.

Among activities developed in this area, we should stress the exchange of genetic materials and experiences –including innovative practices– among communities, which opens a communication channel. This effort, which includes the implementation of CIMAs, involves the participation of government agencies, academic-scientific and non-governmental communities. Other than its basic elements (seeds and creole varieties, medicinal plants and phytotherapics, agriforestry systems, agri-extractive activities and alternative animal management), CIMAs' proposal also stresses recovery of environmental liability (Permanent Preservation Areas and Legal Reserves) in the areas where selected projects are located. Success achieved in its first stage, targeting conservation and use of agrobiodiversity in community systems, demonstrated this activity's future success and the need for its reach to be broadened. Following the success of this pilot stage, hundreds of initiatives are being implemented in various Brazilian regions through actions organized by family farmers, farmers settled in the framework of the agrarian reform and traditional peoples and communities.

5.6. THE MAPPING OF CREOLE VARIETIES AND CROP WILD RELATIVES

Crop wild relatives are an extremely important part of Brazilian and global heritage as they developed, during their evolutionary process, mechanisms allowing them to survive under extreme adverse conditions such as drought, flood, heat and cold, as well as pest and disease resistance. These are some of the reasons why creole varieties and crop wild relatives are so valuable for human kind. Notwithstanding all these reasons, lack of information on most of these species, many of which endangered, still prevails.

In this context, the Brazilian Ministry of Environment – ME (Ministério do Meio Ambiente – MA) started a pioneering project for the identification and the mapping of creole varieties and wild relatives of some of the main crops grown in Brazil. This is a complex, uniquely important, strategic task, one that demands a wide involvement of several sectors of the Brazilian society in order to achieve: a) the taxonomic definition of crop wild parents; b) the mapping of the geographical distribution of creole varieties and crop wild relatives; c) the assessment of the state of this germplasm *in situ*, *ex situ* and *on farm* conservation; and d) the outline of measures needed to maintain it.

Seven subprojects involving some of the major crops in the country have already been concluded: cotton, peanuts, rice, cucurbits, manioc, maize and peach-palm. Most of these wild relatives might be included in the relevant crop breeding process as a part of the primary gene pool or become a new crop following the domestication process. Subprojects implementation was carried out by Embrapa Research Units and the Amazon National Research Institute (Instituto Nacional de Pesquisa da Amazônia – Inpa). Books containing the main information harvested by the inventory will be published, including maps of the geographical distribution of wild relatives and creole varieties.

Given the importance and positive repercussions of this effort among different sectors of the Brazilian society, it is crucial to ensure its continuity so as to also look at other crops such as pineapple (*Ananas* spp and similar genera), cashew (*Anacardium* spp), barley (*Hordeum* spp), beans [(wild) *Phaseolus vulgaris* and *Macroptilium* spp], passion fruit (*Passiflora* spp) and peppers (*Capsicum* spp). Among food crops, a group that should also be considered is the *Myrtaceae*'s, one of the most important botanic families for human food. Besides food species, the forage species group is worth mentioning; it is the case of *Stylosanthes* Genus, with a wide diversity of species in the country, many of which already being cultivated.

5.7. SPECIES OF CURRENT AND POTENTIAL ECONOMIC VALUE, USED AT LOCAL AND REGIONAL LEVELS

The domestication of native species is a great opportunity to be explored; included here are species already known and marketed by local and regional populations but whose national or international market penetration is low. Nevertheless, this wealth remains underused in Brazil, particularly due to imposed and deeply rooted cultural patterns that privilege exotic products and crops. Nevertheless, the most significant –national and international- markets are eager for new products: this is why Brazil's genetic and biological resources hold great potential to meet this market demand and generate wealth.

Responding to this, the ME coordinated the *Identification of species of the Brazilian flora of current and potential economic value used at local and regional levels: Plants for the Future* project, developed in 2005-2007 with the aim to a) prioritize new commercially underused species of the Brazilian flora, providing possibilities of use by small farmers; b) create new investment opportunities for entrepreneurs in the development of new products; c) identify the degree of use of and gaps in scientific-technological knowledge about species locally and regionally used; d) value biodiversity, clearly demonstrating to society possibilities of use of these important resources; and) enhance food security, broadening previously available options.

Five subprojects, one in each geopolitical region of the country, were contracted in order to achieve these goals. The results of this effort evinced the importance of this initiative that prioritized 775 species from different Brazilian regions: 255 species from the South, 128 from the South East, 131 from the Center West, 162 from the North East and 99 from the North (Table 8). The species included in this list were organized in 12 use groups: food plants, fruit-bearing plants, medicinal plants, aromatic wood, ornamental plants, oil-rich plants, timber, apiculture plants, fiber plants, forage, toxic/biocide and environmental species. For some species there already is a certain degree of prominence in the national scenario like assai (*Euterpe oleracea*) and cupuassu (*Theobroma grandiflorum*). Others, despite their great potential, like feijoa (*Acca sellowiana*), are only known at local and regional levels.

Table 8. Species of current and potential economic value used at local and regional levels identified by the *Plants for the Future* project, groups of use and total number of species prioritized in five Brazilian geopolitical regions.

Region*/ Usage group	**S**	**SE**	**NE**	**CW**	**N**	**Total**
Food plants	17	9	-	-	16	**42**
Fruit-bearing	-	-	12	16	-	**28**
Aromatic	-	-	-	-	9	**9**
Medicinal	30	20	15	16	18	99
Oil-rich	2	-	16	7	6	**31**
Ornamental	21	34	33	42	18	**148**
Fiber	8	18	11	-	16	**53**
Toxic	-	-	-	-	3	**3**
Forages	39	-	22	50	13	**124**
Timber	-	-	40	-	-	**40**
Apiculture	103	-	13	-	-	**116**
Environmental	35	47	-	-	-	**82**
TOTAL	**255**	**128**	**162**	**131**	**99**	**775**

* S = South; SE = South East; NE = North East; CW = Center West; N = North
Source: http://www.mma.gov.br

Progress in knowledge, conservation and enhancement of the use of these native genetic resources is also instrumental to minimize vulnerability of the global food system. In addition, this initiative is decisively contributing to the development of components relating to improved training and strengthened capacities of both researchers and undergraduate / graduate students. Parallel to these five subprojects, five regional seminars were held, one in each region, and presentations made in national and international scientific events. Representatives of governmental and non-governmental, academic-scientific and business sectors attended these regional seminars. All the information gained by this survey is being systematized for publishing, which will provide each one of the regions with a portfolio of native species of current and potential economic value.

This initiative is considered crucial for the implementation of the engagements taken by Brazil as a signatory of FAO International Treaty on Plant Genetic Resources for Food and Agriculture. New actions are being prepared that aim at continuing this work that include specific meetings involving businesses and academic-scientific sectors; this will afford an opportunity to present results already achieved and new possibilities for a wider use of these species, particularly as food, medicinal and ornamental plants and aromatic wood.

5.8. ENHANCING THE USE OF MEDICINAL PLANTS AND PHYTOTHERAPICS

Biodiversity, particularly higher plants', is one of the major sources of feedstock for the production of many phytotherapic drugs. It also forms the basis for household and community remedies (conventional medicine) used in popular and traditional practices. Furthermore, they provide feedstock for the production and the use of phytotherapics, market which skyrocketed over the last decades. Besides this genetic heritage, Brazil holds a rich cultural and ethnic diversity. Thus, in the course of hundreds of years, our country accumulated traditional knowledge and technologies, passed down from generation to generation, among which stands out a wealth of knowledge about management and use of medicinal plants.

Based on genetic wealth and wide cultural diversity, our country can establish its own autonomous development model for the areas of health and use of medicinal and phytotherapic plants. This model shall prioritize sustainable use of biodiversity and genetic resources and be consistent with our ethical principles and international engagements, chiefly the Convention on Biological Diversity, thus fostering socially inclusive wealth generation. Furthermore, this model has as its premisses the respect of safety and effectiveness principles in public health, as well as harmony between socioeconomic development and environmental conservation on the local and the national level alike.

In order to foster management, cultivation, production and commercialization of medicinal plants and phytotherapics, as well as to involve different stakeholders at state and municipal levels, a process aimed at setting up and implementing Medicinal Plants and Phytotherapics Networks is being developed within each biome. This process is advanced in the Caatinga biome, where a number of institutional, governmental and civil society experiences are already taking place in the framework of one joint action involving government, civil society, social movements, farmers and entrepreneurs. These experiences still need to be potentiated and broadened.

5.9. EFFORTS TO ENHANCE THE USE OF PLANT GENETIC RESOURCES

Brazilian researchers are increasingly aware of the importance genetic resources have to their work. A survey conducted among public and private sector maize breeders pointed out that regular utilization of accessions available in germplasm banks is very limited (14% of the interviewees); according to 70% of surveyed researchers, the chief constraint that accounts for this situation is the small amount of information available about those accessions.

Thus, there is a need for further characterization and evaluation work in germplasm banks. Some biotechnology tools can be useful in identifying duplicates, as well as in evaluating the conserved diversity. New efforts toward the establishment of core collections will be done as a way to enhance the use of these genetic resources. Another effort worth prioritizing is feeding the Brazilian System for Genetic Resources Information (Sibrargen) and making it available on the Internet. Such measures are key to identify futures needs in terms of harvesting, characterization and evaluation, and consequently to enhance the use of the Brazilian collections. Furthermore, for efficient and effective conservation and utilization of genetic resources, it is critically important to strengthen and consolidate transdisciplinary and interinstitutional research networks. This will be made possible by the implementation of partnerships aimed at optimizing human and financial resources, which would facilitate and intensify germplasm and knowledge exchange.

5.9.1. Feature/function banks

Despite its several ongoing pre-breeding programs, Brazil has to take further action in order to broaden its genetic variability in a structured way and make it available to genetic breeding programs. To this aim, the establishment of feature and/or function banks is a promising alternative. Recent progress in genomics opened new avenues for detailed research on important biological functions for which it is crucial to have properly characterized organisms available. In fact, in order to understand the relations between structure (genes) and biological function (features), it is essential to have adequately organized PGRs on which to carry out more detailed analysis. And so emerge important new users of plant genetic resources, biotechnologists, who are interested in duly identified biological features and functions on adequate PGRs they can use for more sophisticated analysis.

These new users' interests go beyond the universe of resources related to food and agriculture, as functions and features identified in biodiversity have the potential to be adapted to species of agronomic, social and environmental interest by means of recombinant DNA technology. Thus, in order to meet these new clients' needs, germplasm banks are required to broaden their assets, especially to enable search for functions and features not usually available in traditional assets. For example, growing ecological awareness and consequent pressure for agriculture to become a provider of "environmental services" -such as, inter alia, improved soil quality, carbon fixation to counteract global climate changes, and detoxification of soil and water.- will require prospection of these functions in biodiversity and their mobilization into species of interest.

5.10. THE USE OF GENETIC RESOURCES IN BRAZIL – CASE STUDIES

Case 1. The importance of the introduction of germplasm for soybean (*Glycine max*) improvement.

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Embrapa Soybean, Londrina, state of Paraná

Broad soybean variability for physiological, morphological and agronomical features has made possible its use per se or as a source of genes of economic interest in breeding and cultivar selection programs1 (SINGH; HYMOWITZ, 1989; CARTER et al., 2004). In Brazil, soybean was initially grown in latitudes between 30ºS and 20º south, chiefly in Rio Grande do Sul, Santa Catarina, Paraná and São Paulo states. All germplasm from the Southern United States –about 200 cultivars and lineages– introduced during the 1960s was used directly, thus originating the first cultivars adapted to conditions in the Southern part of the globe, as mentioned by Hill (1961), Bienville (1963), Majos (1963), Bossier (1964), Hardee (1964), Hood (1965), Braag (1966), Davis (1966) and Hale 7 (1967); these cultivars were then utilized in breeding programs for the combination of their features (BONETTI, 1983).

The extension of soybean growing toward our country's low latitudes was hindered by this crop's high sensitivity to photoperiod and short plant height. Soybean is a short-day plant, the start of its flowering being induced by longer nights. In Brazilian tropical regions' summer, this induction took place in the very beginning of the vegetative period, which resulted in short plant

[1] Soybean is an annual species of the *Soja* subgenus; 23 perennial species in the *Glycine* subgenus have been reported as its related wild species, being thus considered as genetic resources for this crop genetic breeding (HYMOWITZ, 2004). Most *G. max* and *G. soja* accessions available globally were harvested in China and Japan and, according to data collected and updated by Bioversity (former International Plant Genetic Resources Institute - Ipgri), over 170 thousand *G. max* accessions are stored by over 160 institutions in approximately 70 countries. China has the world's largest soybean germplasm collection, with about 26 thousand *G. max* and 6.2 thousand *G. soja* accessions. The US Department of Agriculture's (Usda) germplasm collection comes second, with 18,570 *G. max*, 1,116 *G. soja* and 919 perennial *Glycine* species accessions. All perennial species are native of Australia, which has the world's largest collection, with over 2.1 thousand perennial species accessions. Currently, in excess of 3.5 thousand accessions of the 22 *Glycine* perennial species are held in nine global collections (CARTER et al., 2004).

height and low productivity (BONETTI, 1981). It was only after hybridizations between cultivars adapted to higher latitude regions and sources of genes for late flowering in short days –also called ‘genes for long juvenile period’ (chiefly of genotype PI 240664, from the Philippines)- from the American collection that was achieved the objective of obtaining genotypes with late flowering and adequate height in low latitudes (HINSON, 1989; KIIHL; GARCIA, 1989). This effort made it possible to grow soybean anywhere in Brazil (KIIHL; BAYS; ALMEIDA, 1986). Figure 8 displays the evolution of soybean germplasm creation in Brazil from its introduction until 2003; this evolution resulted from systematic introduction and intense use of genetic resources.

With the expansion of the cultivated land area and of soybean monoculture, quite destructive new diseases and pests appeared that led to the development of disease-resistant cultivars. These latter cultivars could only be obtained through IP introductions, which are sources of both genetic resistance stored in this crop Germplasm Active Bank (GAB) and significant broadening of Brazilian cultivars genetic base. Main sources of resistance were used for bacterial diseases (bacterial pustule - Xanthomonas phaseoli pv glycines and bacterial crinkle-leaf - Pseudomonas syringae pv tabaci) and fungal diseases (frogeye leaf spot - Cercospora sojina, soybean mosaic – Soybean Mosaic Virus, brown stem rot - Phialophora gregata f .sp. sojae, stem canker - Diaporthe phaseolorum f.sp. meridionalis, powdery mildew - microsphaera difussa, Phytophthora root and stem rot - Phytophthora sojae, sudden death syndrome Fusarium solani f. sp., rust – Phakopsora pachyrhizi, Soybean cyst nematode - Heterodera glycines, Root-knot nematode – Meloidogyne incognita and Meloidogyne javanica). Other accessions introduced from the United States and also stored in GAB-soybean have been used as sources of resistance to insects (Nezara viridula and Anticarsia gemmatalis).

In the Soybean for Food and Plant Type Program, germplasm introduced from China and Japan has been utilized as a source of special features for the development of adapted cultivars. Furthermore, toward broadening soybean genetic base, it is understood that wild species can become sources of pest-resistance, drought-tolerance, oil content and quality. To this end, biotechnology tools have allowed to achieve early success in obtaining interspecific hybrids G. max X G. tomentella.

Strategically, the whole US soybean germplasm collection started to be introduced in 2006 in order to broaden the Brazilian soybean genetic base and ensure the much needed genetic variability.

Figure 8: Evolution of soybean germplasm creation in Brazil from its introduction up to 2003.

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Case 2. Exchange and utilization of Prunoids genetic resources

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The Prunoid germplasm active bank held at Embrapa Temperate Climate has almost always been under breeders' coordination and monitoring, and accessions have been characterized with interesting attributes are immediately utilized for hybridizations. Maybe this is why germplasm bank and *Prunus* Genetic Breeding Program activities interlink. Thus, it is quite hard to draw the line between what relates to GAB and what is a part of the breeding program. Therefore, the impact of GAB Prunoids and of cultivars created utilizing genetic resources is extremely hard to discuss. About 40% of germplasm in this GAB is continually utilized and over the last 10 years Embrapa started 20 cultivars (RASEIRA; NAKASU, 2002; 2003; RASEIRA *et al*, 2008) and advised that 2 peach, 3 nectarine and 1 plum cultivars, all originating from Florida, should be planted.

Several cultivars have been marketed that are based on germplasm held in GAB (Figure 9). 'Aldrighi', selected by a local farmer, was one of the foundation clones of the peach breeding program. The old Ambrósio Perret cultivar, deemed to bear good sized fruit, was used for hybridizations that originated 'Safira', 'BR6' and 'Magno', these two latter still being grown. 'Cerrito' is a cultivar characterized as having reduced need for cold; it is one of the most frequently used as mother-plant whenever peach pollen comes in from countries with cold winters. This is one of the most efficient genotypes in GAB in transmitting the feature 'reduced need for cold'. Were also identified accessions currently utilized as sources of resistance to: rust – cv. Cristal Taquari; fruit rot – cv. Bolinha; and to bacteriosis – Norman, American cultivar; this latter is not widely used due to its high demand for cold, and accessions 'Gaúcho' and 'Convênio' are preferred.

Figure 9: Cultivars developed based on GAB-Prunoids information and germplasm: Atenas, Cons 952m and Sensação. Photos: Maria do Carmo Bassols Raseira

Most (> 85%) of the 1,008 accessions held in the Prunoids germplasm bank is *Prunus persica*; other accessions in its collection are *Prunus salicina (*second largest number of accessions) and hybrids of *P. salicina; P. domestica*; *P. avium*; *P. amygdalus*; *P.armeniaca*; *P. cerasus*; *P. mume, P. mahaleb; P. nigra; P. kansuensis* and *P. manshurica*.

This germplasm has different origins: Embrapa and IAC genetic breeding programs, other Brazilian states and old cultivars, and introductions from countries such as Bolivia, Spain, United States, Italy, Canary Islands, Mexico and Japan. Characterization, chiefly morphogical and phenological, efforts evinced the vast diversity that is available for use –notably among peach accessions: Flower type and color (white to almost red petals, 5 or multiples of 5 petals, 5 or doubled sepals, or rosaceous bell-shaped flowers); petiole gland types; pulp color (greenish-white, cream-white, light yellow, golden yellow, orange); more or less red cover color on the skin, or without cover color; fruit shape, size and degree of firmness; plant need for cold and heat, flower density, etc. Fruit description is based on 30 morphological physico-chemical features, such as soluble solids content, firmness and, in a handful of accessions, pH level, 5 phenological and production data, and reaction to diseases. Molecular characterization is being carried out based on the most important germplasm in GAB, including foundation clones. In partnership with Texas A&M University –through Dr. David Byrne–, research was started about 2 years ago toward the development of microsatellites to characterize peach germplasm. This work is being developed with the idea of carrying out in the future the systematic characterization of global largest germplasm collections, which would help select a diversified set of germplasm with low chilling requirements (core collection).

But the GAB collection is not only used by Embrapa Temperate Climate's peach and plum genetic breeding program; other research institutions, breeding programs and even other countries benefit from it. For instance, 12% of basic clones (foundation clones) used in the Queretaro (Mexico) non-melting pulp peach breeding program and 20% of those in the Chapingo (Mexico) program are Brazilian. Florida (CA, United States) program utilizes three sources of basic clones to obtain fruit with the above mentioned type of pulp: North Eastern United States, Mexico and Brazil. Furthermore, Oro cv. was obtained by open pollination of the Brazilian cultivar Diamante (Byrne *et al*, 2000).

Exchange, mostly of pollen, is quite intensive between Prunoid breeding programs. The Rutgers University (New Brunswick, United States) program was crucially important in terms of basic clones as the state of Rio Grande do Sul started working with clones. From the Arkansas program, Embrapa received germplasm pollen characterized by greater firmness, largest fruit size and resistance to bacteriosis. The University of California, Davis, is using 'Bolinha' –cultivar create at Embrapa– as the source of resistance to fruit rot, and other Brazilian cultivars as sources of high soluble solids content; pollen from accessions with a lesser susceptibility to *Monilinia fructicola* was sent to North Carolina, US. Information and germplasm have also been exchanged with the Texas A&M University and the University of Florida, as well as with Las Brujas Experimental Station (Uruguay), among other institutions in Brazil and abroad. From Canada, Embrapa Temperate Climate program received pollen from cultivars with better skin cover color and fruit size, and that are supposed to be resistant to bacteriosis. More recently, it received pollen from Spain indigenous varieties which most certainly underwent natural selection along the centuries, thus being extremely valuable from the point of view of both breeding and germplasm conservation.

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Case 3. Passion fruit (*Passiflora* spp.) improvement using wild species

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The utilization of wild germplasm is one of the major demands of passion fruit research carried out in Brazil (FALEIRO *et al*., 2006a); this is due to the importance of the introduction in commercial passion fruit of some characteristics found in several wild passiflora species in the Brazilian flora (JUNQUEIRA *et al*. 2005; 2006). Wild species are being intensively utilized in passion fruit breeding programs in the country; at the same time, these species have been tested as rootstocks with the goal to obtain resistance to soil fungi and to early death, and also as means for diversification of production systems with new functional foods for *in natura* consumption and for use as ornamental and medicinal plants (FALEIRO *et al*., 2005).

Passion fruit genetic variability and utilization

It is estimated that the *Passiflora* Genus includes 465 species, approximately 200 of which originating from Brazil and, in addition to their medicinal and ornamental properties, with a potential for use as food –about 70 species bear edible fruit (SOUZA; MELETTI, 1997). Nevertheless, for the broad genetic variability of wild passion fruit species (FALEIRO *et al*., 2005;. 2006b) (Figure 10) to be utilized in breeding programs, either intraspecific hybridizations or modern biotechnology should be used to obtain somatic hybrids; it is also possible to resort to recombinant DNA technology and genetic engineering.

In Embrapa Cerrados' genetic breeding program, interspecific hybrids of *P. edulis* and *P. setacea*, *P. coccinea* and *P. caerulea*, among others, have been successfully obtained (JUNQUEIRA *et al*., 2005; 2008). At the same time, several authors have been successful in using modern biotechnology to obtain somatic hybrids involving the *Passiflora* cultivated species and some of its wild species such as *P. edulis*, *P. incarnata*, *P. alta*, *P. amethystina*, *P. cincinnata*, *P. gibertii* and *P. coccinea*. Thanks to their tetraploid nature, these somatic hybrids can in principle be used as rootstocks, because they have stronger stems than the resistant wild parent. Likewise, research groups in the Luiz de Queiroz College of Agriculture are working toward the obtainment of transgenic plants which would be resistant to bacteriosis and virosis (VIEIRA *et al*., 2005); and one group in the Viçosa Federal University is working with transgenic plants for resistance to CABMV (ZERBINI et al., 2005).

The great potential of wild species for use

Agronomical evaluations of *Passiflora* wild germplasm have pointed to the potential of *P. actinia*, *P. setacea* and *P. coccinea* for resistance to virosis, of *P. odontophylla*, *P. gibertii*, *P. caerulea*, *P. serrato-digitata*, *P. actinia*, *P. mucronata* and some *P. edulis* and *P. nitida* accessions for resistance to bacteriosis and of *P. serrato-digitata*, *P. gibertii*, *P. coccinea*, *P. actinia*, *P. setacea*, *P. nitida*, *P. caerulea* and some *P. edulis* accessions for resistance to anthracnose.

Were additionally identified self-compatible species such as *P. tenuifila*, *P. elegans*, *P. capsularis*, *P. villosa*, *P. suberosa*, *P. morifolia* and *P. foetida*; these features are important to increase productivity and decrease labor costs entailed by manual pollination, as well as to reduce African bees negative impact. Under central Brazil's conditions, some species, such as *P. setacea* and *P. coccinea*, behave like short-day plant, as they flower and bear fruit during the short-day period of the year, and are harvested in commercial tart passion fruit off-season. If this feature were to be incorporated into commercial passion fruit, it would be possible to eliminate problems related to its seasonality, thus obtaining fruit production all year round in the Center South region of our country. Furthermore, *P. caerulea* and *P. incarnata* tolerance to cold is of great interest.

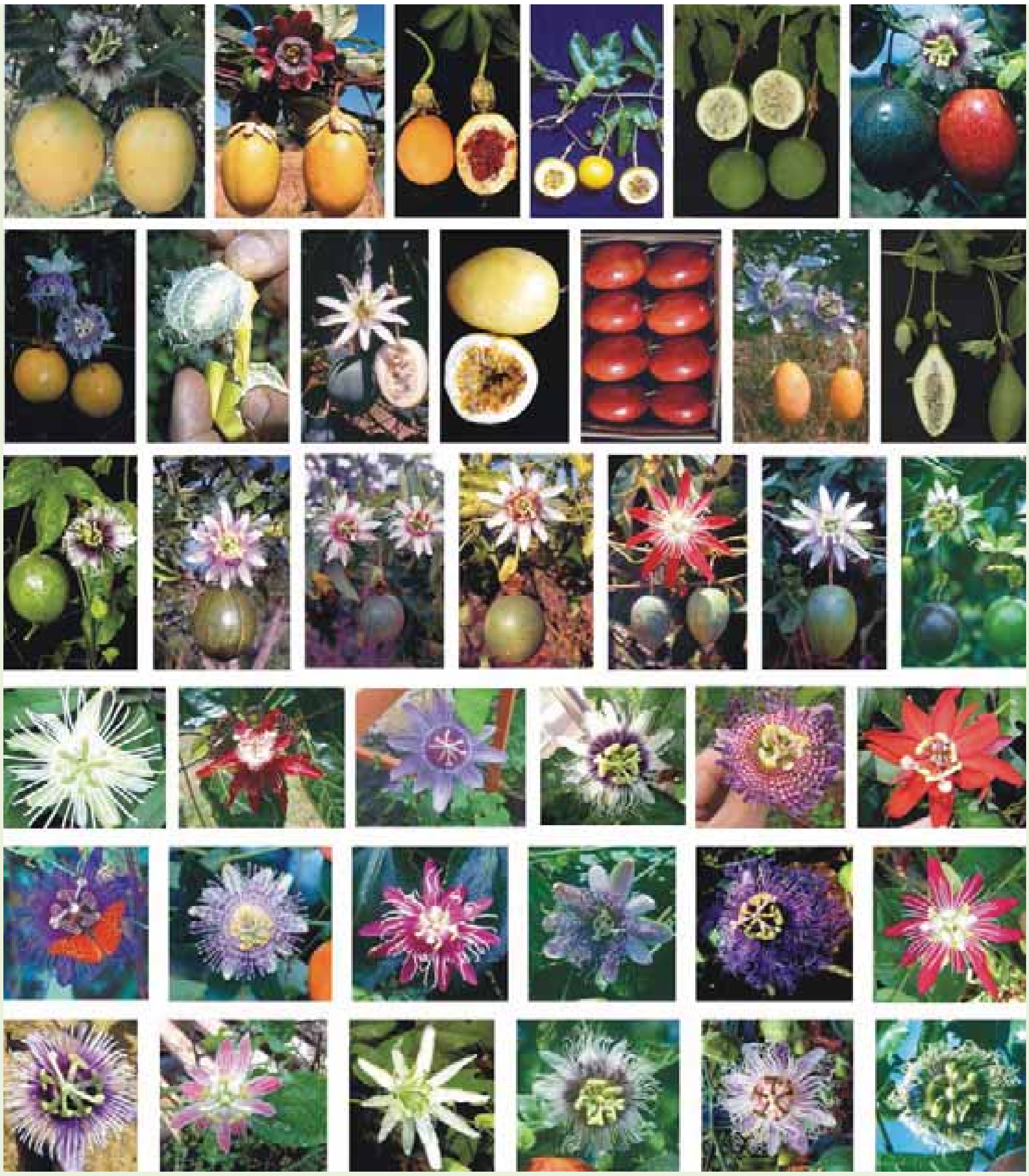

Figure 10: Some examples of *Passiflora* spp. genetic variability. Photo: Embrapa Cerrados

Wild species have also been utilized in order to improve physical, chemical or sensorial characteristics of passion fruit pulp in view of new market options – either as an exotic fruit or as one with enhanced functional properties. *P. caerulea*, as well as *P. edulis* wild accessions, have shown a potential for making the commercial tart passion fruit pulp redder, enhancing its functional properties (Figure 11).

Figure 11: *Passiflora caerulea*, with its reddish pulp color (A) and *Passiflora odontophylla*, showing the short distance between anthers, estigmata and crown, which enables small insects to pollinate the flowers (B). Photo: Embrapa Cerrados

A further feature observed in some wild species, reported by Junqueira et al. (2006a), is a shorter androgynophore, which reduces estigmata length with relation to the crown, thus facilitating pollination by smaller insects. In some wild purple passion fruit accessions and *P. odontophylla*, estigmata touch the crown when the style reaches its maximum curvature (Figure 11), so enabling the flower to be pollinated by bees that are considered important pests because they carry all the pollen without pollinating effectively.

Research outcome - Embrapa Cerrados

Research carried out by Embrapa Cerrados on genetic compatibility, crossability rates, anthesis period, pollen viability period and stigma receptivity have allowed to obtain several fertile interspecific hybrids through artificial crossings; this is promising for the genetic breeding program, and DNA molecular marker-aided retrocrossings have been used to recover commercial features while maintaining resistance genes (FALEIRO et al., 2007). Figure 12 illustrates recurring genome recovery following the base-crossing between *P. edulis* and *P. setacea*. *P. setacea*, *P. coccinea*, *P. caerulea*, *P. glandulosa*, *P. mucronata* and *P.galbana* cross very well with *P. edulis* (commercial tart passion fruit) and with *P. alata* (commercial sweet passion fruit), bearing fruit with fertile seeds. Hybrids involving three or more species have also been obtained with the aim to pyramid different genes for resistance to diseases, as in the case of *P. coccinea* X *P. setacea* X *P. edulis* and *P. setacea* X *P. coccinea* X *P. mucronata* X *P. edulis* hybrids.

Figure 12: RC plants from initial crossing between *P. edulis* and *P. setacea*, illustrating recurrent genome recovery. Photo: Embrapa Cerrados

Among interspecific hybrids that are being obtained, *P. coccinea* X *P. setacea*, launched as the first passion fruit ornamental hybrid in Brazil, BRS Estrela do Cerrado, is particularly worth mentioning. Selection work on RC populations obtained by backcrossing with *P. coccinea* and *P. setacea* allowed to obtain two other passion fruit ornamental hybrids: BRS Rubiflora and BRS Roseflora, respectively (Figure 13).

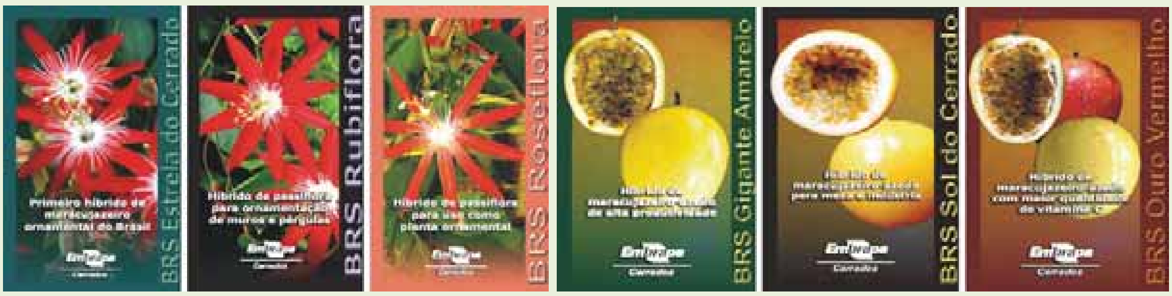

Figure 13: Cover of technical folders with passion fruit ornamental hybrids launched in 2007 (A) and of technical folders on tart passion fruit launched as a cash crop in 2008 (B). Photo: Embrapa Cerrados

Other important technology products include the hybrids BRS Sol do Cerrado, BRS Gigante Amarelo and BRS Ouro Vermelho (Figure 13), which result from the utilization of P. edulis wild accessions at crossings base, which allowed to obtain genetic materials with redder pulp and that are less dependent on artificial pollination. Another very promising hybrid obtained by Embrapa Cerrados breeding program involves *P. caerulea* and *P. edulis* species. From base-crossing, retrocrossing and selection work is being carried out for reddish pulp color. RC plants have shown redder pulp (Figure 14) and good productivity levels.

Also worth mentioning are interspecific hybrids involving *P. nítida*, whose potential is related to its use as rootstocks, which can be obtained through cutting or seed. Junqueira et al. (2006b) observed higher productivity levels in tart passion fruit grafted on *P. nitida*.

Finally, beyond their use for crossing, some wild species have a potential for *in natura* consumption thanks to their properties as functional foods. Along this line of research, the Embrapa Cerrados' breeding program has worked on *P. setacea* and *P. nitida* population selection with the aim to increase fruit size for the fresh fruit market and for the production of feedstock for sweets and ice-cream production.

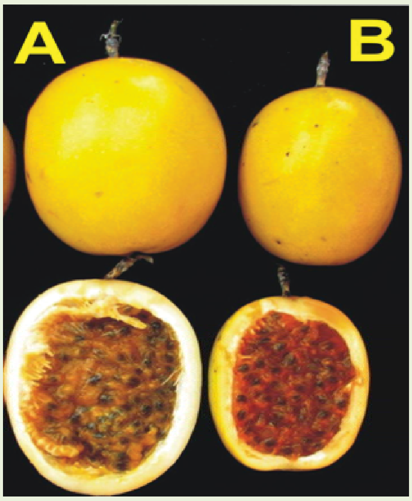

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Figure 14: Fruit of recurrent genitor, *Passiflora edulis* (A) and of RC_2 plant (B) obtained from base crossing between *P caerulea* e *P edulis*.

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Case 4. The use of native genetic resources and conventional knowledge in peach-palm breeding (Bactris gasipaes, Palmae)

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Peach-palm was domesticated by the first settlers of South Eastern Amazon, probably for timber. Later it became important for its oil-rich fruit and, at the height of its domestication, for its amylaceous fruit (Figure 15), perfect for fermentation, celebrating festive occasions. It was a crucial item for the subsistence of peoples from Western Amazon, North Western South America and Southern Central America before the conquest of the continent by the Europeans –according to the ethnicity, as important as maize and/or cassava. It was less important in Central and Eastern Amazon, characterized by different indigenous peoples and genetic resources. After the European conquest, peach-palm gradually lost its importance, as peoples who used it were decimated or acculturated.

In the course of the 20th century, its potential as energy, oil, starch, fiber and beta-carotene-rich food was acclaimed, chiefly because its yield potential in South-American soils is much higher than maize's, which has similar chemico-nutritional composition. In the last quarter of the 20th century, Victor Manuel Patiño (Colombia, died in 2001) and Jorge Mora Urpí (Costa Rica, died in 2008) led a multinational research and development (R&D) effort on peach-palm. In the late 1970s, Brazil joined this effort through a partnership between the Amazon National Research Institute (Inpa) and Embrapa Genetic Resources and Biotechnology. Therefore, today Brazilian and Costa Rican institutions lead the work on this species, which also includes activities in Bolivia, Colombia, Equador, Panama, Peru and Venezuela.

Figure 15: Clusters of small wild peach-palm fruit (*Bactris gasipaes* var. *chichagui*) found near Rio Branco, Acre state, and clusters of cultivated peach-palm (*B. gasipaes* var. *gasipaes*) of the primitive Putumayo race with large and amylaceous fruit, found along the upper Solimões River, Amazonas state.

Between 1983 and 1984, representatives of other stakeholder countries –Costa Rica, Colombia, Ecuador, Peru– started to cooperate in the Brazilian partnership for the prospection of the Amazon Basin, which, funded by the government of the United States of America, changed the history of peach-palm. Analysis of information from this prospection showed that, following the domestication of *Bactris gasipaes*, a complex hierarchy of primitive races (local varieties or landraces) was selected, maintained and managed by indigenous peoples and traditional communities in the Amazon, as well as by other groups of pre-Columbian populations. At the same time, however, all international partners were fascinated by indigenous uses of peach-palm and started to explore how some of these uses could be transformed into niche market items. This fascination with traditional knowledge disturbed the history of peach-palm, as modern demands are very different from indigenous'.

As a fruit of this work, the Pampa Hermosa primitive race, including a high percentage (> 80%) of unarmed plants (stipe, leave sheaths or rachis), was identified in the Yurimaguas region, Loreto, Peru. Besides being unarmed, Pampa Hermosa plants grow rapidly and have a lesser amount of calcium oxalate in their tissues. This set of features is almost the ideal peach-palm ideotype to obtain the heart of palm, gourmet product extracted from the palm tree growth point. Today, this race is cultivated in 80 % or more of Latin-American farms where it is harvested to meet the growing global demand for this gourmet vegetable. In Brazil, Pampa Hermosa accession introductions –as well as identification of other populations with unarmed plants, such as Benjamin Constant, Amazonas, of the primitive Putumayo race-, made the prosperity of that part of the agribusiness sector growing peach-palm for heart of palm production.

This group of materials is being used in breeding programs in Brazil, among which stand out Embrapa's, Agronomical Institute's (IAC – Campinas, São Paulo state) and Inpa's. From its headquarters located in Curitiba, Paraná state, Embrapa Forests coordinates a national network whose members perform progeny assays for the identification of elite germplasm for heart of palm production in Brazilian South East and North regions.

Similarities between peach-palm and maize chemical compositions suggests the former can be used as animal feed, as well as feedstock for the production of meals that could enrich flour or diversify bakery and confectionery. Nevertheless, harvesting and processing costs make peach-palm meal very expensive, especially because it competes with other starches and meals, all less expensive due to their efficient production chains. Peach-palm is an arboreal potato, fruiting in clusters that form 5 or 10m above the ground.

Another indigenous use that greatly interested peach-palm researchers and never found enthusiasts outside the R&D community was fermented beverage. Its most amylaceous fruits are perfect for fermentation, and fermentation process explains why it's called peach palm. The fruit resembles peach (Figure 16); when fermented according to indigenous technology; its aroma is almost identical of a ripe peach's on a tree on a sunny afternoon. Beverage fermented for one day tastes pleasantly of fruit –very different from its taste after cooking– and its color is an attractive shade of orange. If fermented until sugars depletion, its alcohol content reaches 5%; if clarified, it is like an orange-colored beer, with a pleasant taste. Research in Brazil, Colombia and Peru was able to improve indigenous technologies, but no entrepreneur has as yet volunteered to take the product from the bench and take it to the market. Considering *assai* recent success –despite its less attractive flavor, aroma and aspect-, lack of interest in fermented peach-palm is at least curious. But Latin-American institutions are waiting for beverage entrepreneurs to wake up.

When it became clear that traditional uses were not helping broaden peach-palm consumer base, a new, more realistic R&D phase begun for this palmaceous. Manaus (Amazonas state) and Belém (Pará state) consumers are not willing to pay for the amylaceous fruits of the prime of indigenous domestication of the species. They would rather buy red, more or less oil-rich, tasty and not fibrous fruit. This is a typical fruit from the Central and Eastern Amazon, exactly where indigenous peoples considered peach-palm as a good snack, as opposed to the Western Amazonian peoples, for whom it was a staple. Indeed, snack-peach-palm had been sold in the streets of Belém and Manaus for a long time before research even started and had never been considered as an all important product. As the matter of fact, this is largest market for peach-palm. Sold on the streets, it is also prepared at home: boiled in salty water and eaten with coffee, juice or beer, according to the time of the day. Following this new recognition, research on peach-palm for fruit production resumed in the Brazilian Amazon.

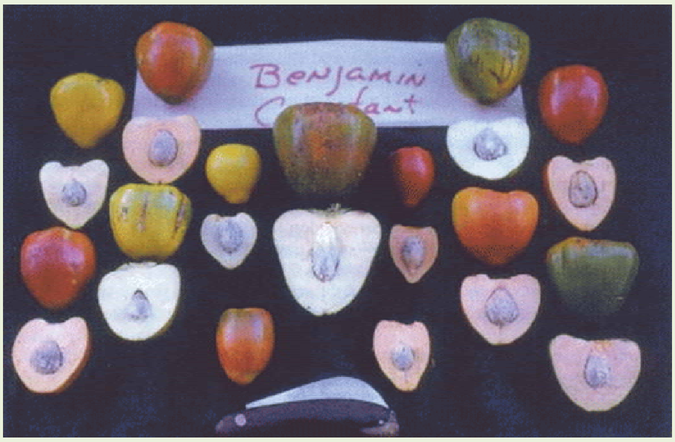

Figure 16: One fraction of cultivated peach-palm fruit morphological variability (*B. gasipaes* var. *gasipaes*); here you see primitive Putumayo race fruits. The larger the fruit, the higher its starch content and the lower its oil content. The deeper its orange color, the higher the fruit β-carotene content.

Embrapa Eastern Amazon started a conventional improvement program exclusively geared to Belém peach-palm street market. New prospection, centered on consumer demand, allowed progeny assays to be developed in order to rapidly generate new cultivars. At the same time, Inpa, now cooperating with the Amazon Federal University, started a participatory breeding program with the goal to meet Manaus peach-palm street market consumers demand. Currently, Coari County, 300 km Western from Manaus, is the number one producer of all the peach-palm marketed in Manaus. Working with researchers, a group of producers has already identified the best matrices and is getting ready to carry out progeny assays in producer's properties; these assays will enable them to sell higher quality fruit, as well as seed to disseminate peach-palm production all over the county. Peach-palm has a long history in the Amazon. Now that institutions are turning their attention to the future, instead of dwelling in the past, no matter how glorious it was, its future is quite promising. Meeting local demand for support to peach-palm family farmers producing within agriforestry systems seems to be a logical way to contribute to the sustainable development of the Amazon.

Recommended literature

Mora Urpí, J.; Weber, J.C.; Clement, C.R. 1997. **Peach palm *Bactris gasipaes* Kunth**; **promoting the conservation and use of underutilized and neglected crops.** 20. Institute of Plant Genetics and Crop Plant Research - IPK, Gatersleben/International Plant Genetic Resources Institute - IPGRI, Rome. 83p. (Italy) http://www.ipgri.cgiar.org/publications/pdf/155.pdf

Case 5. Recovering conventional agriculture genetic resources and improving cucurbits in North Eastern Brazil

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There are several species of cucurbits used in human food and animal feed in different parts of the world. Though not originating from Brazil, cucurbits represent an expressive part of the country's agribusiness, estimated at over R$ 1 billion. Almost half this total comes from watermelon agribusiness [Citrullus lanatus (Thunb) Matsum & Nakai]. Native of Africa and introduced in Brazil in slavery times, watermelon was initially grown in vegetable gardens around slave quarters, later migrating to the North Eastern inland with this formerly wild region settlers; even now it is maintained there by small farmers, that use on-farm produced seed for the following crop, in a cropping system almost agrochemicals-free, especially as far as the so-called defensive agents are concerned.

In this context, it was hypothesized that this germplasm could contain useful genes for the species improvement. This conjecture was raised because this species, introduced from Africa –center of origin for major *Citrullus* species–, is still grown without pesticides in traditional Brazilian North Eastern agriculture. In Brazil, the number of commercial cultivars is quite low –not more than ten; these were developed in the United States and in Japan and, despite their good plant and fruit characteristics, are susceptible to major diseases affecting this crop. Commercial cultivars introduced in Brazil in the1950s were all susceptible to diseases such as: powdery mildew, caused by the *Podosphaera xhantii* fungus; alternaria leaf blight (*Alternaria cucumerina*); to virus such as the papaya ringspot virus W, watermelon strain (PRSV-w); watermelon mosaic virus (WMV), and to the Zucchini yellow mosaic virus (ZYMV), as well as to gummy stem blight, caused by the *Didymella bryoniae* fungus, among many other biotic and abiotic stresses.

It became evident that wealth formerly found in North-Eastern traditional agriculture was endangered owing to, *inter alia*, factors such as rural exodus -exacerbated in years of extreme drought in the region, when seeds sown by farmers yielded no harvest at all- and introduction of cash crops, more attractive due to better fruit aspect, especially flesh color (Figure 17).

Figure 17: Genetic variability in watermelon accessions held at GAB-Cucurbits for the North Eastern region: flesh and rind color, and fruit shape.

Efforts to recover this variability started in the 1990s in several North Eastern states, notably Maranhão and Bahia; they yielded over 1.6 thousand samples, which today constitute GAB-Cucurbits for the North Eastern region. Of these, at least 600 are watermelon samples. This material was harvested from farms where cucurbits seeds were used for the following crop, street markets, roadside points of sales, etc.; at least 600 are watermelon samples.

Main outcomes

Genetic variability found in samples harvested from conventional farms in the North Eastern region was completely ignored by Brazilian scholars. Through characterization and evaluation, however, accessions were identified that have a high potential for use in breeding programs based on valuable assets harvested in the 1990s. The following major features were identified: resistance to powdery mildew (*Sphaerotheca fuliginea*), gummy stem blight (*Dydimela bryoniae*), alternaria leaf blight (*Alternaria cucumerina*) and virosis (*Papaya ringspot virus – watermelon strain* – PRSV-w; *Watermelon mosaic virus* – WMV, *Zucchini yellow mosaic virus* – ZYMV), as well as earliness and size, rind and flesh color, fruit and seed pattern, soluble solids content and seed dormancy. Other than these latter and the occurrence of andromonoecious plants, prolificity (plant bearing many, usually small fruits) was also determined among harvested germplasm, which is a very important feature for watermelon improvement.

This diversity has been studied and is gradually being introduced into commercial cultivars. The first example in this sense is 'Opara', released for cropping in July 2007, which is resistant to powdery mildew from one of the GAB watermelon samples, CPATSA 2. This feature, monogenic and dominant, was incorporated into many Crimson type watermelon lines; these lines originated 'Opara' and will originate many other cultivars with different characteristics.

'BRS Opara' was launched during the Petrolina (Pernambuco state) Agrishow, on July 3-7, 2007; this launch is good news for farmers, but it also stresses the importance of biodiversity conservation for agricultural business sustainability. From a strictly commercial viewpoint, the CPATSA-2 watermelon is a very poor material: small fruit, white flesh, not sweet at all. Nevertheless, instead of being discarded, it was added to over 2,000 other genetic materials (watermelon, cucurbit, melon, West Indian gherkin and loofah) and held in GAB-cucurbits for the Brazilian North East; this GAB was designed by Manoel Abílio de Queiróz, retired Embrapa researcher, professor at the Technology and Social Sciences Department of the Bahia state University (DTCS-UNEB). This is a concrete example of the utilization of conserved genetic treasure for the benefit of the watermelon production chain. Text from <http://www.embrapa.br/imprensa/noticias/2007/julho/1a-semana/noticia.2007-07-02.3162727370/>. Accessed on Oct 20, 2008.

The second major outcome of this recovery and use of cucurbits genetic resources project –maybe the most significant one– is its being carried out through a partnership of Embrapa Semi-Arid and the Technology and Social Sciences Department of the Bahia state University (Uneb), which allows several Master and PhD students to be trained in the various stages of plant genetic resources work. After completing their degree, these students are currently being recruited by different research institutions. The curator of GAB-cucurbits for the Brazilian North East currently is its first student to be fascinated with the genetic variability found in that region, Dr. Rita de Cássia Souza Dias, PhD. Other former students are now working with Embrapa Units (Coastal Tablelands, Genetic Resources and Biotechnology, and Embrapa Rondônia), universities (Feira de Santana state University, Bahia Federal University, Semi-Arid Federal Rural University) and other institutions. New students continue to be fascinated by the work on cucurbit genetic resources: it is an exciting activity, as it deals with gene conservation for the future of agribusiness based on several species we find in our country.

Case 6. Using red rice genetic, cultural and food heritage (*Oryza sativa*)

José Almeida Pereira
Embrapa Mid North

Rice is considered as the main source of energy for the majority of the human kind; it is one of the staples in the Brazilian diet. Consumers' preference for this cereal is usually associated with economic, traditional and cultural aspects, which vary from country to country and even from one part to another within the same country. In Brazil there are some special rice types geared to groups with different dietary habits, but none of these special types is as important as red rice.

Red rice is virtually unknown as a cultivated plant, although it is grown in at least four continents for its characteristics, different from white rice's: taste, texture and probably nutritional value. It is grown in: America (Argentina, Brazil, Nicaragua and Venezuela), Europe (France and Russia), Africa (Madagascar and Mozambique) and Asia (Buthan, China, South Korea, Philippines, India, Indonesia, Japan, Malasya, Nepal, Sri Lanka and Thailand).

In Brazil, red rice is chiefly grown in the North East, where it was introduced by the Portuguese back in the 16th century. Main producers include –in decreasing order of importance– the states of Paraíba, Rio Grande do Norte and Pernambuco. In all these areas, production is related to local populations' dietary habits. Despite its being a highly important target for family agriculture and thousands of consumers alike, this type of rice is undergoing patent genetic erosion due to fierce white rice industry competition and to desertion facing rural areas. The area currently planted with this germplasm is estimated at one third of what it used to be.

Grown chiefly by small farmers as a subsistence crop, red rice is considered an actual part of North Eastern people's genetic, cultural and food heritage. There is a small number of red rice cultivars adapted to Brazilian conditions and currently in use; this probably stems from natural transformations originated by natural crossings and mechanisms such as mutations or gene recombinations, since these cultivars have been selected by the farmers themselves along the last four centuries. Embrapa established in recent years a collection of this rice traditional, local or creole cultivars.

As a product of the morphoagronomic characterization of this collection, some accessions have been identified as being potentially useful for genetic breeding aimed at reducing plant height, hairy glume and leave lodging, as well as at increasing grain yield and percentage of unbroken grains after processing. Another important aspect concerns the utilization of its genetic variability in order to create red rice biofortified cultivars, as some accessions with high essential micronutrient (Iron and Zinc) content were identified.

Based on these data and following the morphoagronomic characterization (Figure 18) of the above mentioned red rice traditional cultivar collection, this latter was duly registered and is held at Embrapa Genetic Resources Biotechnology, Embrapa Rice and Beans and Embrapa Mid North GABs. In a second stage, Embrapa Mid North selected individual plants by progeny assays (Figure 19a) in order to start a genetic breeding program with the goal to develop and commercially release the first red rice cultivars for the cropping conditions prevailing in the North Eastern Semi-Arid region.

Figure 18: Morphoagronomic characterization of red rice traditional cultivars at Embrapa Mid North in 2004.

Since natural populations of autogamous plants usually encompass a mix of homozygotic genotypes, after two years it was possible to obtain pure red rice lineages adapted to local conditions. In a third stage, Embrapa Mid North in partnership with Embrapa Rice and Beans has started a pioneering initiative in Brazil, a red rice artificial hybridization effort using as parents some of the selected traditional cultivars. Several lineages (early and advanced generations) with agronomic, cooking and nutritional characteristics of interest have been obtained (Figures 19b and 19c). Commercial release in Brazil of the first improved cultivars is expected within the next 2 or 3 years.

This initiative is highly important for both conservation and use of rice genetic variability, consonant with the strategy advocated by FAO Global Plan of Action for Food Security.

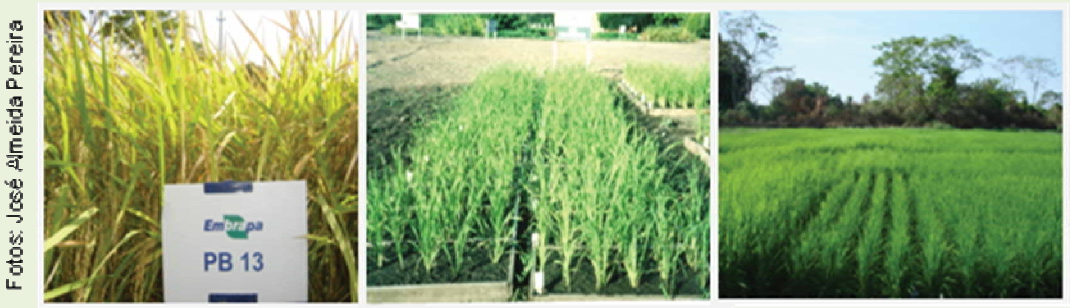


Figure 19: **Using red rice genetic variability for high grain yield: PB 13, cultivar obtained at Embrapa Mid North by individual selection of plants with progeny assay – 2005 (A); lines F_1 (B) and lineages F7 (C) obtained at Embrapa Mid North by artificial hybridization in 2005 and 2007, respectively**

Case 7. Preservation and use of Manihot wild species

Alfredo Augusto Cunha Alves
Embrapa Cassava and Tropical Fruits

The *Manihot* Genus includes about 98 documented species of which only *M. esculenta* is cultivated, and it is considered as one of the most important staples in tropical human diet. Embrapa's breeding program is working exclusively with genetic diversity of this cultivated species. Despite its rusticity, cassava undergoes great losses due to biotic and abiotic factors; wild species, which contain resistance genes to main stresses affecting this crop, are very seldom studied and many of them are endangered.

Brazil, considered the main center of origin of cassava, holds the broader global genetic diversity of *Manihot* Genus, disseminated all over the country. One of the main objectives of Embrapa Cassava and Tropical Fruit has been the establishment and broadening of one collection of this valuable germplasm so as to make the utilization of wild species useful genes possible. Over the last 4 years, one collection was established with accessions obtained from different sources, including harvesting carried out in the semi-arid (Caatinga) and Cerrado (Federal District and environs) regions. Currently, this collection holds about 920 accessions (with at least 18 species of wild germplasm), displays broad vegetative polymorphism and has a potential for utilization in cassava genetic breeding programs (Figure 20). One sexual seed bank is also being preserved that holds approximately 60 thousand seeds (open pollination).

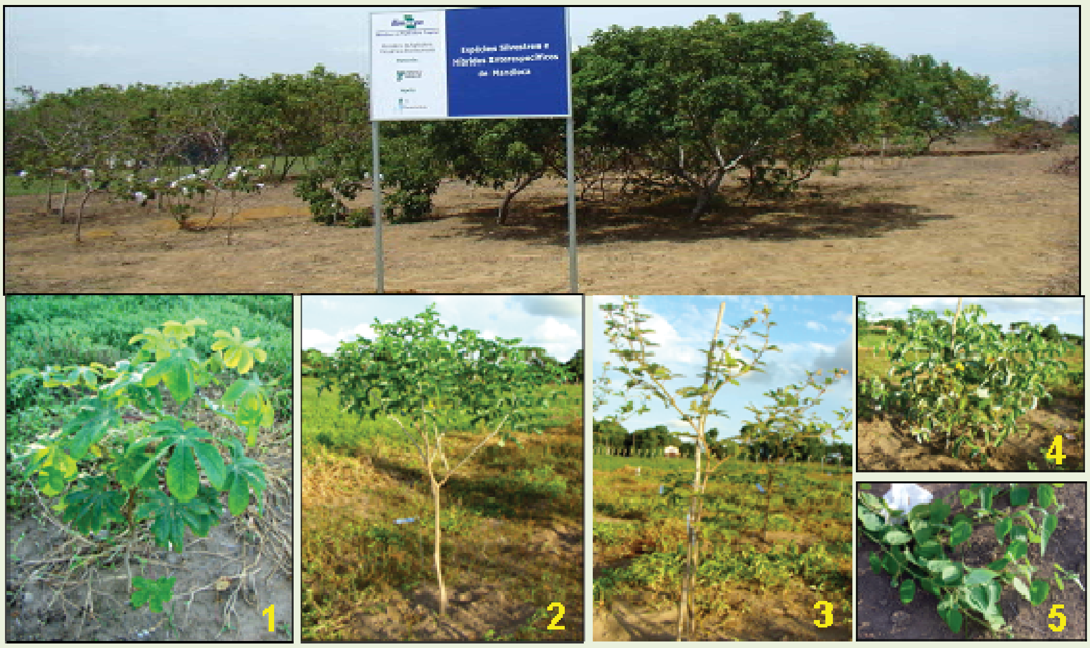


Figure 20: Cassava wild species collection at Embrapa Cassava and Tropical Fruit, Cruz das Almas, Bahia state, with 920 accessions from 18 species. Detail: some species' genetic variability: 1) M. glaziovii; 2) M. dichotoma; 3) M. tomentosa; 4) M. irwinii; and 5) M. anomala.

Research being carried out on this wild germplasm encompasses the following projects: 1) evaluation of wild species and interspecific hybrids for drought, pest and disease resistance; 2) crossing compatibility between wild species and *M. esculenta*; and 3) cytogenetic analysis, production and pollen grain viability. The drought resistance project is supported by CGIAR –through its "Challenge Generation" program– and will benefit developing countries in which cassava forms the base of food security.

Case 8. The use of the Brazilian genetic diversity in cassava enhancement

Wania Maria Gonçalves Fukuda
Embrapa Cassava and Tropical Fruit

In Brazil, Cassava has a wide genetic diversity chiefly represented by landraces. Brazil is as considered as the possible center of origin and diversification of cassava cultivated species. About 4,132 cassava accessions have already been catalogued in our country; they are stored in collections and germplasm banks disseminated over the whole national territory.

Brazilian diversity constitutes a wide genetic base for cassava breeding programs in all tropical areas in the world, as it includes resistance genes to main pests and diseases affecting this crop; furthermore, these genes allow the adaptation to different edapho-climatic conditions. Indeed, genetic variability had already been identified for almost all features, including morphogical, agronomic, as well as nutritional quality and technological features. Variations for physiological features are more seldom studied, but there is evidence indicating high variability as a consequence of temperature, photosynthesis and sensitivity of stomata to relative humidity of air. Although Brazil's cassava genetic resources are not very much exploited relative to its size, its use is extremely successful in our country.

Root carotene, iron and zinc content

Vitamin A deficiency prevails in some areas of the Brazilian North East where cassava is widely grown and is the main staple food for the population; so, this crop is an excellent means to overcome nutritional deficits in this region. It was recently confirmed that, other than carbohydrate, cassava has diversity for root carotene, iron and zinc content; moreover, there is a high correlation between yellow root color and carotenoids content. The about 1.8 thousand cassava accessions in the cassava germplasm active bank (GAB-Cassava), located in Cruz das Almas, Bahia state, were evaluated in order to identify what accessions in this crop's roots are richest in carotenoids. Cassava plants with higher and lower root hydrogen cyanide (HCN) content were used as parents for the development of new hybrids with higher root carotenoid content (Figure 21).

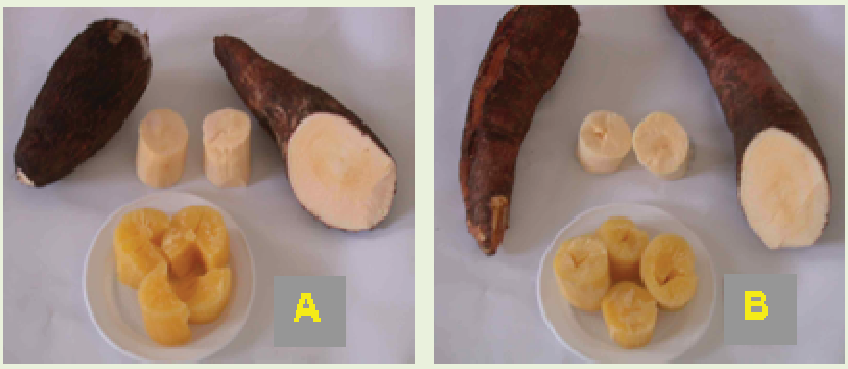


Figure 21: BRS Dourada (A) and BRS Gema de Ovo (B), commercial cassava cultivars from selections made at GAB-Cassava for carotenoids content and low root HCN.

So, hybrids were developed from crossing carried out in the framework of the cassava breeding program conducted at Embrapa Cassava and Tropical Fruit; gains in root total carotenoids in these hybrids were 209.4% compared with parents, with a maximum of 12µg/grams of root total carotenoids (fresh weight), as well as low HCN root content and good quality for fresh consumption (Table 9 and Figure 22).

Table 9. **Total carotenoid content (µg/g^{-1}) (fresh weight) in populations developed by Embrapa Cassava and Tropical Fruit (families 2003 and 2004)**

Germplasm	**Family 2003 (228 genotypes)**			**Family 2004 (136 genotypes)**		
	Carotenoid content			**Carotenoid content**		
	Mean	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
Progenitors	2,84	2,84	1,50	3,37	2,14	4,01
Hybrids	4,49	4,49	0.87	6,21	2,76	12,41
Gain	58,1%	-42%	**146%**	84,2%	28,9%	**209,4**

This material, adapted to poor Brazilian North Eastern regions where Vitamin A deficiency is a concern, certainly is one of the important contributions of native cassava germplasm to Brazil.

Figure 22: Cassava hybrids generated from germplasm selected at GA-Cassava in order to heighten cassava root carotenoid content.

Other than for Vitamin A, GAB-Cassava germplasm has been explored for iron and zinc root content, resulting in important contributions toward reduction of poor populations' nutritional deficiencies (iron, zinc) (Table 10); this germplasm has been intensively used in cassava breeding programs.

Table 10. Iron and zinc content (mg,kg^{-1}) in landraces roots held in GAB-Cassava and in hybrids of 2003,2004 and 2005 populations, generated by Embrapa Cassava and Tropical Fruit

Germplasm	**Iron content (mg kg^{-1})**				**Zinc content (mg kg^{-1})**			
	No. of genotypes	**Mean**	**Minimum**	**Maximum**	**No. of genotypes**	**Mean**	**Minimum**	**Maximum**
Landraces	72	9,2	0,0	56,5	72	4,14	0,0	26,2
2003 populations	179	8,2	0,0	511	179	5,20	0,0	34.1
2004 populations	136	13,1	1,0	77,5	136	12,50	0,5	87,1
2005 populations	40	23,80	20,54	30,65	40	7,94	1,97	34,38

Drought resistance

Current research with the goal to identify sources of drought resistance is also worth mentioning. About a thousand accessions were initially evaluated in four ecosystems in the North Eastern Semi-Arid region; genotypes were identified that are tolerant to drought periods of up to 8 months while maintaining good root and aerial part production; this latter is extremely important to feed animals during long drought periods (Figure 23).

From genotypes with these features, Embrapa Cassava and Tropical Fruit breeding program developed several hybrids that associated drought resistance to other features such as resistance to bacteriosis and Phytophthora root rot, good yield and root starch content. Among these genotypes stand out BRS Formosa (Figure 24a) –resistant to drought and bacteriosis, with high levels of acceptance by farmers– and BRS Kiriris (Figure 24b) –resistant to drought and Phytophthora root rot– cultivars. Other than these, several cultivars have been created from sources of drought resistance identified in GAB-Cassava.

Figure 23: **Drought-resistant cassava germplasm selected at GAB-Cassava.**

Unusual starch and hydrogen cyanide content

The exploitation of GAB-Cassava in order to identify unusual starches will certainly lead to an increase in this crop added value due to its high quality for industrial utilization. Furthermore, edible cassava exports to Japan and some European countries will be encouraged by the conventional plant breeding currently being carried out with GAB-Cassava germplasm, which has already achieved a decrease in hydrogen cyanide root content to 12ppm.

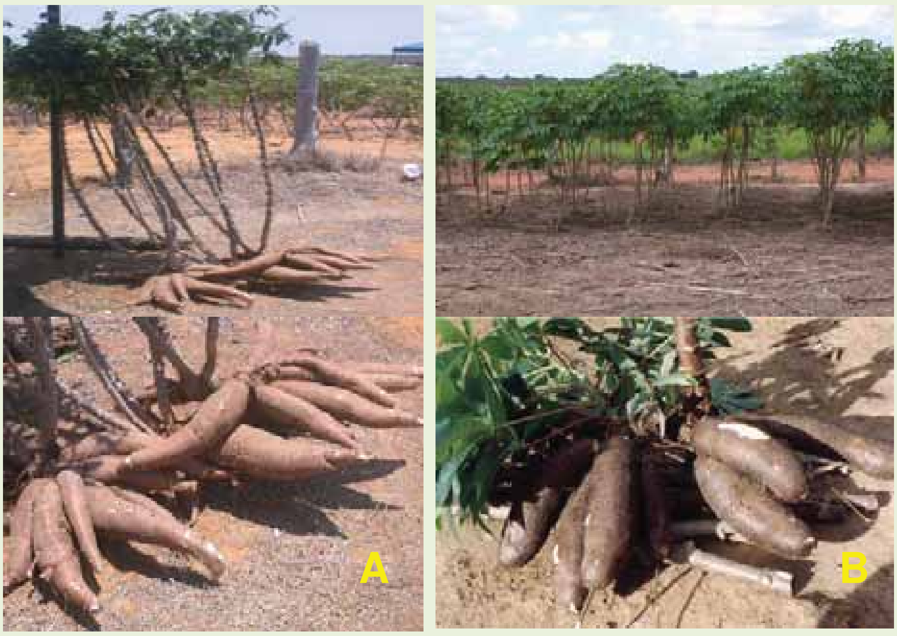


Figure 24: BRS Formosa (A) and BRS Kiriris (B), drought-resistant cassava hybrids obtained from clones selected at GAB-Cassava

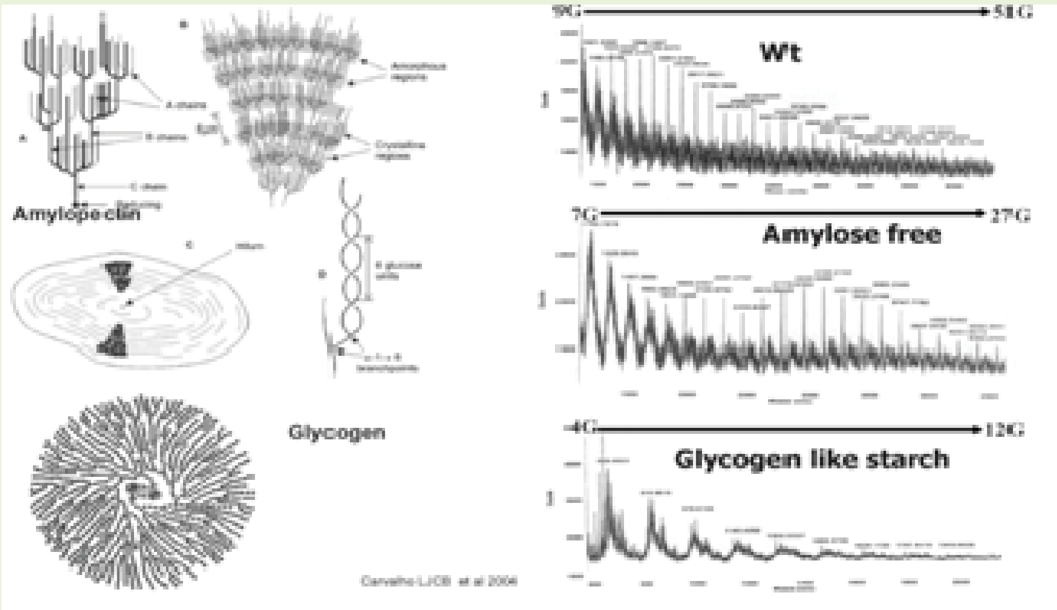
Case 9. Utilization of spontaneous mutations in Manihot esculenta for the improvement of cassava roots nutritional quality

Luiz Castelo Carvalho Branco
Embrapa Genetic Resources and Biotechnology

Local races are primitive forms of modern cultivars used by farmers; they represent the first step toward cassava domestication. Genetic analysis of natural populations of local races found in the center of origin and domestication of cassava, in the Amazon, has led to the discovery of spontaneous mutations in metabolic pathways for the conversion of saccharose into starches and the synthesis/accumulation of carotenoids. Variability in natural processes is also being studied; it requires high numbers of functional proteins and can help heighten cassava storage roots protein content. In an evolutionary approach, spontaneous mutants are used in studies of gene functions that determine these features and in cassava breeding programs, thus allowing the creation of cultivars with specific niche market applications.

Spontaneous mutations in starch synthesis

Starch produced in the roots of cassava commercially used in Brazil has distinctive functional features such as gel clarity, excellent expansion capacity, natural flavor and very high texture quality. All these characteristics are determined by starch type and proportion of amylose relative to amylopectin. Research conduct at Embrapa Genetic Resources and Biotechnology successfully identified germplasm with different spontaneous mutations, which lead to plant high free sugar content combined with variations in starches, including amylose free starches (CAS36.4), glycogen-type starches (CAS36.1), starch containing short chain and dense branching amylopectin (CAS36.3) (Figure 25). These biochemical phenotypes originate from BEI (glycogen-type starch) and GBSS (amylose free starch) genes mutations.



Source: Luiz Castelo Carvalho Branco

Figure 25: Sweet cassava, mutation identified on M. esculenta amylopectin structure.

Spontaneous mutations in carotenoids synthesis and accumulation

Pigmentation of cassava roots found in Brazil varies from white to deep pink, including gradients of yellow (Figure 26). The spectrum of carotenoids separation in HPLC indicates that this color stems from variations in root carotenoids amount and type. This variability originates from two types of spontaneous mutations identified in germplasm harvested in the country. Red cassava (Mirasol), which only accumulates lycopene, underwent one mutation on the gene encoding the lycopene β-cyclase enzyme. In the yellow cassava class, deep yellow cassava (MC008), with only β-carotene in its root, underwent regulatory mutation on the gene encoding β-hydroxyls, responsible for xanthophylls formation. Generally, about 54 to 77% of carotenoids present in pigmented cassava roots are found in the form of β-carotene.

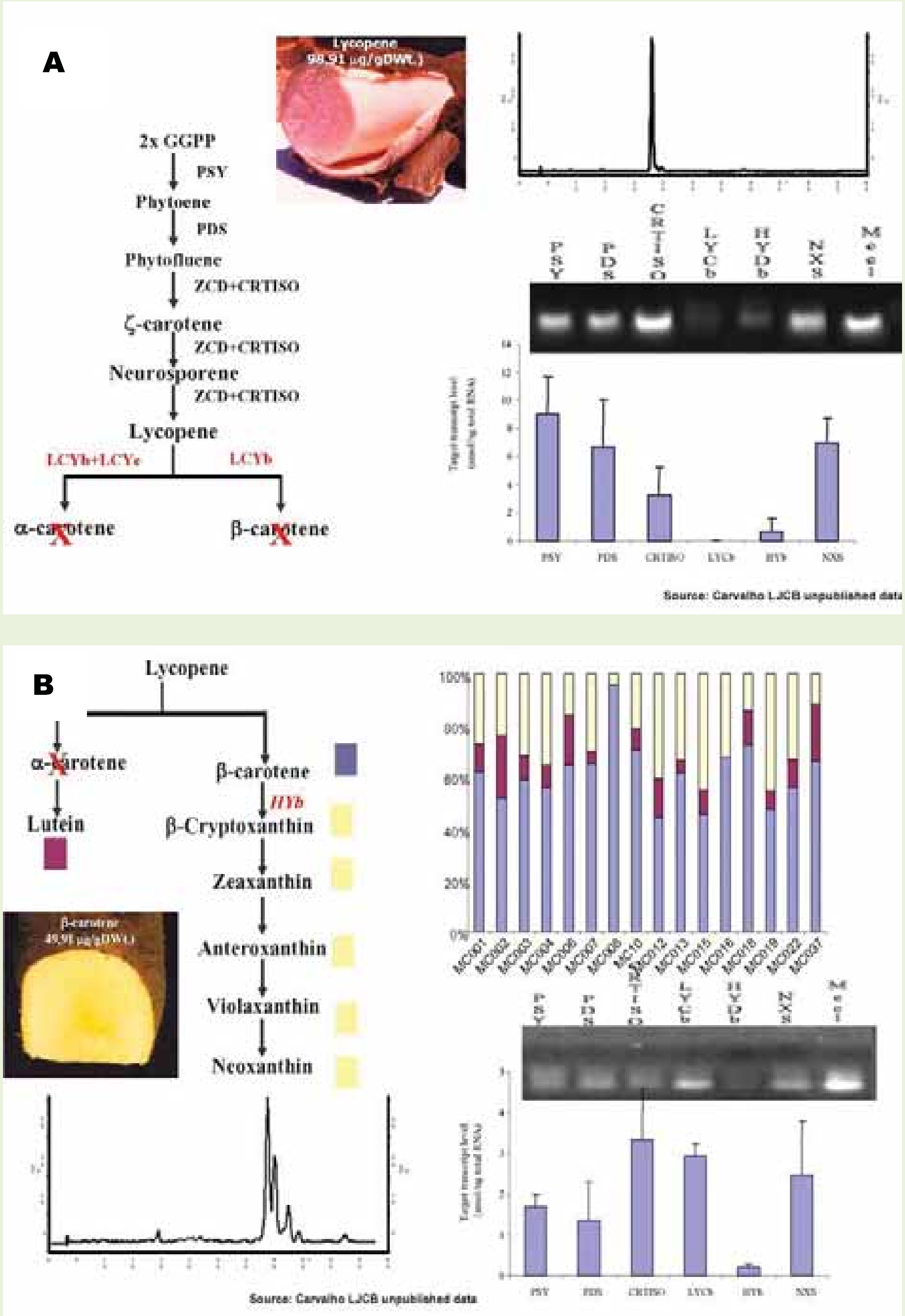


Figure 26: Variation in carotenoid amount and type in M. esculenta roots due to spontaneous mutations identified in germplasm harvested in Brazil: Pink (A) and yellow (B) mutations.

Natural variability of pigmented cassava protein content

For carotenoids to accumulate, they must be stabilized in cassava roots, which is ensured by sequestration proteins in the chromoplast. This mechanism entails variations of 40%-60% in the pigmented root protein content compared to white cassava (Figure 27).

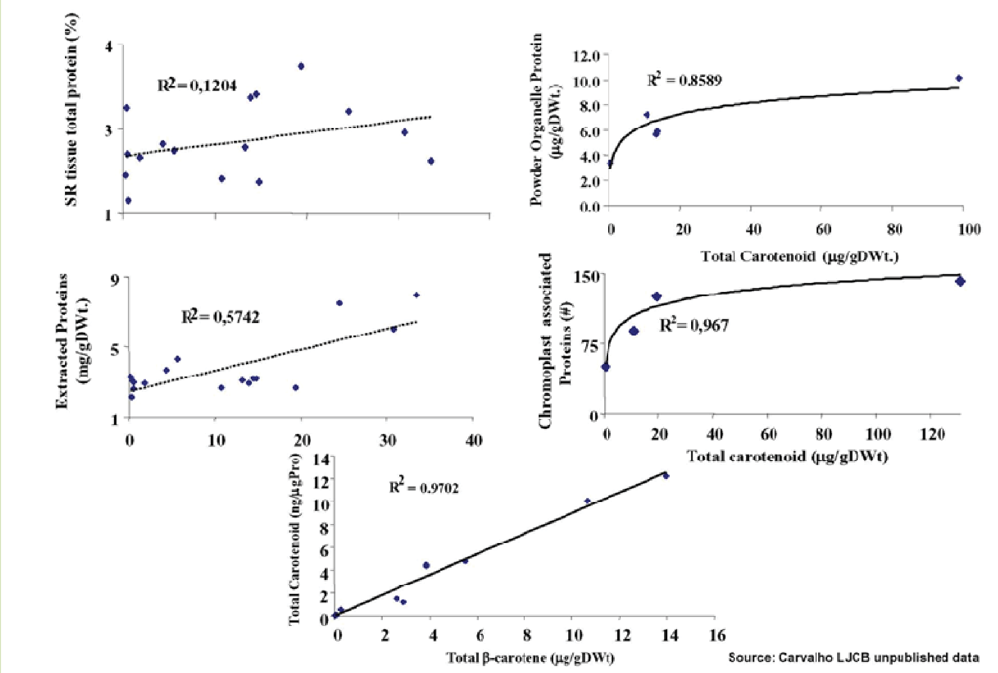


Figure 27: Correlation between protein and carotenoid contents in *M.esculenta* root germplasm harvested in Brazil.

These proteins were identified as belonging to the class of small heat chock chaperone proteins (Figure 28); variability found in germplasm has been studied and utilized to enhance cultivated cassava roots protein content.

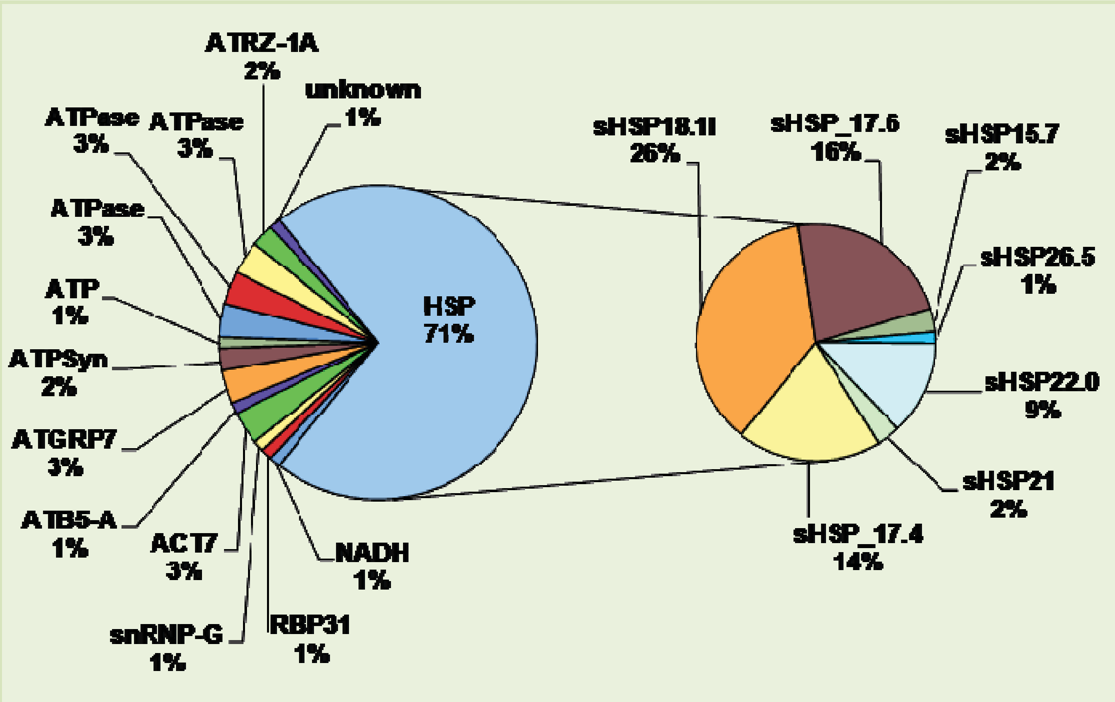


Figure 28: Small heat chock chaperone proteins in pigmented roots of M. esculenta germplasm collected in Brazil

Case 10. The use of native Southern Brazilian fruit tree genetic resources

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Embrapa Temperate Climate

The native Southern Brazilian fruit tree species germplasm active bank (GAB-Natives South), at Embrapa Temperate Climate, holds 12 native and two introduced species. They are: guabiroba (Campomanesia xanthocarpa); Surinam Cherry (Eugenia uniflora); Strawberry Guava (Psidium catleyanum); feijoa (Acca sellowiana); ingá (Inga uruguensis); guabiju (Myrcianthes pungens); araticum (Rollinia sylvatica); Jelly Palm (Butia capitata.); camass (Eugenia pyriformis); cherry of the Rio Grande (Eugenia involucraat.); jabuticaba (Plinia cauliflora); were recently added to the collection Rubus sp. accessions. Exotic species are Para Guava (Psidium acutangulum) and Japanese raisin tree (Hovenia dulcis). Parallel to field evaluations and laboratory determinations, new processing methods have been tested with a view to better use of these fruit trees. Furthermore, an evaluation of their value as functional food is ongoing based on a joint initiative with the College of Pharmacy (Rio Grande do Sul Federal University). Essential oils have already been identified and phenolic compounds, anthocyans and antioxidant power determination is currently being conducted.

Initial studies carried out at GAB-Natives South concerned Strawberry Guava, involving research on reproduction mode, chromosome number, characterization (shape, skin color, flavor, mean weight, soluble solids content, wall thickness, pulp firmness and fruit general aspect; size; seed number and size) and best accessions selection. Most interesting germplasm is also evaluated for yield; two clones have been selected and propagated: Ya-cy – of yellow skin fruit (Figure 29a) and Irapuã – of deep-red skin fruit (Figure 29b).

Following the work on Surinam Cherry (Figure 29c) involving research on reproduction mode, pollinating agents, fruit features and utilization, we currently have in excess of 175 morpho-phenologically and agronomically characterized selections of this species. Furthermore, due its anti-inflammatory properties, a partnership with American researchers was recently established in order to test this species' effects on cancer. Genotype characterization and selection was started for camass and cherry of the Rio Grande; at the same time, jelly palm collections are being developed for future pre-selection work.

Figure 29: Strawberry Guava –yellow (A) and deep-red (B) skin- and Surinam Cherry (C) held in the native Brazilian South Region fruit tree species germplasm active bank. Photos: Caroline Marques Castro

Finally, research conducted at GAB-Natives South interested both primary sector and industry. For instance, over 30 thousand strawberry guava plants were made available over the years, and micro and small industries in the area intend to process Surinam Cherry, Strawberry Guava and feijoa, among others. The establishment of orchards with these native species will benefit local fruit growers, as this ensures them complementary income –some of the latter, such as Strawberry Guava and some types of Surinam Cherry, fruit after peach and plum harvest. At the same time, it will benefit industry and consumers, who will have new product options, which eventually contributes to species conservation.

Case 11. Introgression of Oryza glumaepatula genes of economic interest into elite lineages of Oryza sativa enhancement program

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Embrapa Rice and Beans and Embrapa Genetic Resources and Biotechnology

Rice (Oryza sativa) holds a prominent place in the daily diet of over half of the human population, especially in the Brazilian diet. The Brazilian population is projected to reach 237 million people by 2025. This means that, just to meet domestic demand, rice production will have to be about 61% above the current 10 million tons yearly harvested in Brazil. Brazilian rice production can be increased through genetic breeding, enhanced use of modern inputs, better crop management or expansion of the cropping area.

Genetic breeding seems to be the best alternative for increasing the Brazilian rice yield and production. Genomic tools and less conventional breeding methods (recurrent selection, advanced backcross) have enabled the exploitation of rice genetic variability found in traditional varieties and Oryza wild species, which until recently was limited to a few successful initiatives. Progress achieved in molecular genetics research indicates that rice traditional varieties and wild species have a high potential for genetic breeding.

Asian wild rice populations have continually been destroyed in their different habitats, which have often entailed total loss of genes of economical importance by genetic erosion. Moreover, it is obvious that these populations might undergo introgression of genes from the cultivated species due to steady encroachment of agricultural frontier on regions formerly little exploited for this purpose. In Brazil, the nine expeditions to harvest wild rice species carried out as yet (see below) observed that most wild rice populations are still preserved due to their isolation and to the absence of nearby commercial cropping. Wild rice species native of Brazil constitute an invaluable germplasm and require special attention, as their biology is virtually unknown. These species undoubtfully are gene reservoirs of agronomical importance for this crop genetic enhancement.

Harvesting, characterization and conservation of rice wild and conventional germplasm should be associated with an efficient program for the utilization of these materials. The great majority of accessions in Germplasm Banks contribute limited genes to modern rice varieties, especially for complex features such as yield and grain quality (Tanksley & McCouch, 1997).

Brazilian rice wild species harvesting

The nine Brazilian expeditions to harvest wild rice species concerned the following biomes: 1) The Amazon Amazonas state, harvesting from Negro (1992) and Solimões (1993) Rivers basin, Tocantins state, from wetland areas (2001, 2002 and 2006); 2) Pantanal: Mato Grosso and Mato Grosso do Sul states (1974 and 2002); 3) The Cerrado: Goiás (two expeditions in 2001) and Roraima (2005) states.

In the 1992 and 1993 Amazon expeditions, 85 accessions were harvested, of which 49 O. glumaepatula, 33 O. grandiglumis and 4 O. alta (Figure 30).

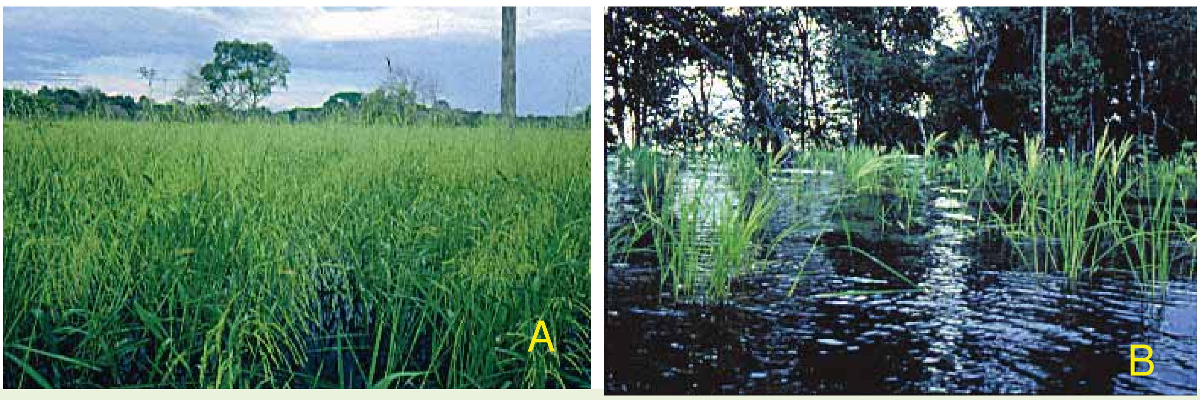

Figure 30: Oryza grandiglumis population, Negro River, 1992 (A) and O. glumaepatula population, Solimões River, 1993 (B).

During the 1994 Pantanal Mato-grossense expedition, 15 accessions were harvested, eight O. glumaepatula and seven O. latifolia (Figure 31).

Figure 31: O. glumaepatula and O. latifolia populations at Tamengo Bay, Paraguaia River, by Corumbá city (A) and O. glumaepatula, also Paraguaia River (B), Mato Grosso do Sul state, 1994.

The two 2001 expeditions to Goiás state and one to Tocantins state harvested 34 samples, of which 26 O. glumaepatula and eight O. alta (Figure 32). In the savannas where most harvesting activities were conducted, just O. glumaepatula was found, and in some sites only; it was ascertained that this species is in a serious danger of extinction owing to expansion of agricultural and livestock areas in the Goiás state savannas. Fast forest clearance, the use of these areas for cash cropping and construction of dams for water storage are all factors leading to a rapid degradation of this environment.

Figure 32: O. glumaepatula population in wetland areas (savanna) (A), typical for the Goiás state Cerrado, and details of one O. glumaepatula (B) population found in Goiás state wetland areas (savanna). 2001.

The Pantanal Mato-grossense expedition, 2002, harvested 17 samples of wild rice populations, of which seven O. grandiglumis, three O. glumaepatula and seven O. latifolia. Of these, tetraploids were harvested from the Cáceres and Poconé areas, which confirms the hypothesis that this is where the contact zone between O. grandiglumis and O. latifolia (Oliveira, 1994) species is located.

The wild rice mapping and harvesting expedition to Roraima state was undertaken in 2005 and harvested 21 samples of the O. glumaepatula (Figure 33) species populations. Most samples were harvested from wetlands areas within the Cerrado Biome (known in this region as Lavrado).

Figure 33: Oryza glumaepatula population in wetlands of the Cerrado Biome in Roraima state, 2005.

The mapping and harvesting expedition to Tocantins state, April 2006, harvested 27 samples, of which 17 O. glumaepatula and 17 O. alta. In this expedition, a large O. alta population was found isolated and bearing no signs of any man-induced changes in their habitat. Owing to reproductive barriers, in situ management of tetraploid wild species (O. grandiglumis, O. alta and O. latifolia) is relatively easier, as in natural conditions these do not cross with cultivated rice (O. sativa), which is diploid. The establishment of preservation areas is enough to provide these populations with a haven where they can remain undisturbed.

Characterization and use of wild species in rice breeding

In order to surpass current rice yield, it is mandatory to broaden the genetic base of populations used in plant breeding programs. One possibility would be the use of rice wild species occurring in Brazil, such as O. glumaepatula, and of traditional varieties in breeding programs (Ando & Rangel, 1994; Rangel et al., 1996). The use of wild species in rice enhancement programs is hampered by incompatibility in crossings with O. sativa, which usually generate sterile hybrids, as well as progeny, with a series of undesirable features. For this reason, rice breeding programs do not prioritize it -even avoiding broad crossing-, as new gene introgression usually entails loss of good features already fixated during selection. This entails narrowing of the populations' genetic base and a limited use of other species or genera genetic variability.

Despite their proven value and potential, rice traditional varieties and chiefly wild species are still considered by breeders as a last resort, seldom used. This is so because in the course of the introgression of one gene from a wild species of economic interest into the cultivated elite lineage, other genes are also inevitably transferred that are not of agronomic interest. This usually happens owing to genetic link drag, i.e., to the presence of deleterious genes linked with the locus of interest in the same chromosome arm. The use of molecular techniques for genomic analysis, associated with classic breeding methods, can greatly facilitate the utilization of this germplasm in the development of rice cultivars which are superior to those currently being used (Ferreira and Grattapaglia, 1995).

Molecular research showed that O. glumaepatula is genetically related to O. sativa, which significantly facilitates gene introgression from the wild into the cultivated species (Buso, 1998; Buso et al., 2001). Using samples of O. glumaepatula populations harvested in Brazil, Embrapa is conducting a pre-breeding program with the goal to incorporate genes from this species into O. sativa elite lineage; this process is monitored based on molecular markers and genetic maps. This way, carrier lineages have been created and utilized to broaden the genetic base of irrigated rice populations and to develop hybrids. To this purpose, one O. sativa elite lineage was crossed with one O. glumaepatula accession, also with AA genome but belonging to a totally different gene set from the cultivated rice (Cavalheiro et al., 1996). Using molecular markers (microsatellites), were selected those of the obtained F1's which have wild species genes; following this selection, they underwent retrocrossings for 'BG 90-

2'. Chromosomes genetic maps and an extended phenotypical analysis for yield components were used to locate the genomic chromosomal regions controlling quantitative features (QTLs) of interest – chiefly those related to the genetic control of yield (Brondani et al., 2002). Examination of genetic maps and, as a consequence, knowledge of the allele composition of segregating families allowed the selection of improved families, with wild species genes. In order for these families potential to be observed, they have been included in yield assays and continue to be selected in breeding programs based on classic methods. Several of these families are among most promising lineages in the enhancement program, displaying high yielding potentials; some of them stand out for grain quality, as well as unbroken, total and translucent grain yield. Combination of alternative genetic enhancement techniques and classic methods has allowed an immediate utilization of wild species in these programs routine (Ferreira & Rangel, 2005).

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CHAPTER 6

THE STATE OF NATIONAL PROGRAMMES, TRAINING AND LEGISLATION

6.1. NATIONAL PROGRAMS

6.1.1. National Genetic Resources Networks established by Embrapa

In 1980, Embrapa (Brazilian Agricultural Research Corporation) created the National Genetic Resources Research Program (Programa Nacional de Pesquisas em Recursos Genéticos – PNPRG) and made Embrapa Genetic Resources and Biotechnology its national Coordinating Unit. This Program grouped all research projects on plant and animal genetic resources conducted by Embrapa research centers and other institutions within the National System of Agricultural Research. Through PNPRG, the first Active Germplasm Bank network was established, with projects carrying out germplasm introduction, exchange, collection, evaluation, characterization, conservation, documentation and information activities. While it was active, PNPRG was characterized by efforts made by the curatorship team of Embrapa Genetic Resources and Biotechnology in order to establish Active Germplasm Banks at Embrapa Research Centers, and mainly to raise awareness of the importance of conservation and use of genetic resources. During this period, a great number of researchers were trained in the area of genetic resources and an adequate infrastructure for germplasm conservation was established in the Units.

In 1994, Embrapa implemented a new research and development system, the Embrapa Planning System (Sistema Embrapa de Planejamento - SEP), based on 16 large National Research Programs. Reasserting the extreme importance it attached to Brazil’s genetic resources, Embrapa chose the conservation and use of genetic resources as one of its 16 priority National Research Programs. The goal of this program was stated as follows: “enrichment and conservation of exotic and native genetic resources of current and potential importance to the country, promoting and enhancing through characterization and evaluation the utilization of these resources in breeding programs with a view to developing a sustainable agriculture”. The two foundations of this program were Embrapa Genetic Resources and Biotechnology, and the Active Germplasm Banks Network, whose short, medium and long-term management and conservation efforts throughout the country were complementary and integrated.

This program’s specific goals were to: (a) enrich available genetic variability of species of current and potential socioeconomic importance through collection, introduction and exchange efforts; (b) ensure short, medium and long term *in situ* and *ex situ* conservation of genetic resources of species of current or potential interest for Brazilian agriculture; (c) characterize and evaluate germplasm, and disseminate this knowledge among breeding programs; (d) define quarantine standards and procedures for a safe technical and scientific exchange of plant, animal and microorganism genetic resources, and establish biosafety standards for the exchange of genetically modified organisms; (e) maintain an efficient information system on the characteristics of the genetic resources available for research, aiming to promote the country’s agricultural development; and (f) disseminate information on genetic resources with a view to raising national awareness of the importance of conservation and utilization of genetic resources in the context of biodiversity. This program became operational in Research & Development projects submitted by SNPA institutions that proposed solutions for problems related to the program’s goal. This program was active until 2002, when a new Embrapa Planning System was implemented.

In 2002, the Embrapa Management System (Sistema Embrapa de Gestão – SEG) was created. It aims to implement, within the Corporation, a competitive research system organized around Macroprograms with defined subjects, which are prioritized by R&D

sectors at Embrapa's headquarters. Following the implementation of the new research management system, the National Program was discontinued. Thus, after competing with other network projects, which concerned other issues, the Genetic Resources Program was approved and became a large network-based project named the National Genetic Resources Network (Rede Nacional de Recursos Genéticos – RENARGEN). Thus, the previous program was restructured in the form of a network in order to allow current and future national demand for genetic resources to be thoroughly taken into account. This goal is achieved by concentrating research on enrichment, conservation, characterization and dissemination of indigenous and exotic germplasm in the context of Brazilian food security and the need to improve the bargaining power of Brazil in international exchange negotiations, in line with the National Biodiversity Policy, then in its implementation phase.

A significant part of the RENARGEN efforts concern products with a strong impact on agribusiness and on family agriculture. As it evolves, this work provides growing opportunities for training and capacity building owing either to activities involving technological innovation or to the quality of the participating teams. This multidisciplinary network involves a large number of specialities and institutions. It is divided into Component Projects led by different Embrapa units and targeted to very relevant issues and challenges. In 2008, the network includes 11 Component Projects, with a total of 125 Action Plans and 827 activities. There are 32 Embrapa Research Centers, several universities and a number of public research institutions involved in this network, with a total of 635 researchers.

In 2009, the National Genetic Resources Network structure will undergo further modification and will be named National Genetic Resources Platform, made up of four network-based projects:

- Plant Genetic Resources Network
- Animal Genetic Resources Network
- Microbial Genetic Resources Network
- Integration of Genetic Resources Networks.

The first three networks will be made up of Component Projects aimed at conservation *per se*, whereas the fourth network will be made up of participating transverse projects, common to the first three Networks. The National Genetic Resources Platform will then include 30 Component Projects distributed as follows: Plant Network (14 Component Projects), Animal Network (six Component Projects), Microbial Network (six Component Projects) and the Integration Network (four Component Projects). The goal of the latter is to interlink the other three networks by means of integrated management, which will be carried out through three participating transverse projects (Curatorship System, Exchange and Documentation of Genetic Resources); these latter projects extend across the 26 Component Projects.

6.1.2. Multi-annual programs developed by the Ministry of the Environment

Pursuant to the mandate given to the Biodiversity and Forests Bureau and to the Biodiversity Conservation Department, the following areas fall within the Genetic Resources Bureau purview: (a) conservation, evaluation and enhancement of knowledge and sustainable use of agrobiodiversity components; (b) promotion of the sustainable use of native species of current or potential economic importance, especially those with food and nutritional value; (c) conservation of landraces and wild relatives of crops; (d) protection and recovery of endangered fauna, flora and microorganism species; (e) prevention of introduction, eradication and control, of invasive exotic species that jeopardize ecosystems, habitats or species; (f) promotion of biosafety concerning genetically modified organisms (GMOs); and (g) provision of elements enabling the National Technical Commission on Biosafety (Commisão Técnica Nacional de Biossegurança - CTNBio) to design policies and standards for GMO biosafety. Actions developed in the framework of the Genetic Resources Bureau (Gerência de Recursos Genéticos - GRG) are included in two government Multi-annual Programs: (i) Conservation, Management and Sustainable Use of

Agrobiodiversity; and (ii) Conservation and Sustainable Use of Biodiversity and Genetic Resources.

6.1.2.1. Conservation, Management and Sustainable Use of Agrobiodiversity

This program includes the following efforts developed by the GRG: (a) Identification of and research on animal and plant species of economic importance, and (b) Implementation of community-based systems for the management and sustainable use of agrobiodiversity. The following activities, directly carried out by the GRG, are involved in these efforts: (i) *In situ, ex situ* and *on farm* management of plant genetic resources in Brazil; (ii) Mapping of landraces and of the wild relatives of crops; (iii) Research on species of current and potential economic value, of both local and regional use, designated as – *Plants for the Future*; (iv) Conservation and sustainable use of agrobiodiversity in community-based systems and (v) Promotion of the use of medicinal plants.

6.1.2.2. Conservation and Sustainable Use of Biodiversity and Genetic Resources

This program includes the following efforts, directly or indirectly developed by the GRG: (a) Conservation of endangered fauna species and migratory species; (b) Monitoring and control of invasive exotic species; and (c) Development of actions toward GMO biosafety. The following activities, directly carried out by the GRG, are involved in these efforts: (i) Review of listings and recovery of endangered fauna, flora and microorganisms species; (ii) Prevention, control and eradication of invasive exotic fauna, flora and microorganism species; and (iii) GMO biosafety.

6.2. EDUCATION SYSTEM

6.2.1. Agricultural Sciences Undergraduate Programs

Higher education in areas related to agricultural sciences has a long history in Brazil. Agronomy courses were the first ones to be created in the country. The Eliseu Maciel Faculty of Agronomy was founded in 1892 in Pelotas (Rio Grande do Sul state), and is the oldest in Brazil. Initially under the auspices of the Ministry of Agriculture, colleges of agriculture were later placed under the Ministry of Education. The vast majority of agricultural colleges are controlled by federal or state government. Recently, some agricultural schools have been established by private universities. In 2006, a total of 143,798 students were enrolled in agronomy and biological sciences undergraduate programs. Table 11 displays the total number of undergraduate programs in agricultural sciences and related areas).

Table 11. Number of agricultural sciences-related academic programs – higher education (2006)

COURSE	NUMBER OF ACADEMIC PROGRAMS
Agronomy	163
Biological Sciences	247
Forestry	39
Agricultural Engineering	23
Environmental Engineering	84
T O T A L	556

Source: MEC/ INEP

6.2.2. Agricultural Sciences Graduate Programs

Brazil has a large number of agricultural sciences graduate programs. This was made possible directly by investments made between the 1970s and 1980s, when large numbers of researchers were sent abroad for training at the graduate level, especially in the United States and in Europe. On the return of these specialized researchers, it was possible to start several graduate academic programs in Brazil; likewise, a number of research groups were set up at the National Centers for Agricultural Research, which were established following the establishment of the Brazilian Agricultural Research Corporation (Embrapa) in 1973. As a consequence, capacity building of research in Brazil is closely linked with extensive graduate programs. These latter programs follow the American pattern, i.e., composed of master's and Ph.D. degrees programs of two and four years duration, respectively. At the end of 2006, there were 3,540 professors teaching in Agronomy, Forestry, Agricultural Engineering, Botany and Genetics graduate programs. As for the students, there were 4,960 enrolled in master's degrees programs and 4,045 in Ph.D. programs. The number of Agricultural Sciences-related graduate courses is displayed on Table 9 below. Some of these include only a master's degree program; others, only a Ph.D. program, but most have both.

Table 12. Graduate Programs in different areas of importance to plant genetic resources, by level (M.Sc. / Ph.D.)

AREA	M.Sc.	Ph.D.	M.Sc. and Ph.D.	Total
Agronomy	42	0	74	118
Botany	4	0	16	20
Agricultural Engineering	5	0	8	13
Genetics	3	2	18	25
Forestry	5	1	8	14
T O T A L	**59**	**3**	**124**	**190**

Source: Capes/MEC – year base: 2006

In addition to the graduate programs listed on Table 12, Colleges of Biological Sciences offer 205 graduate programs, many of which include several areas of importance to plant genetic resources, such as Agronomy, Genetics and Botany.

6.2.2.1. Plant Genetic Resources Graduate Programs

Although genetic resources are prominent in research, notably following Embrapa's pioneering work in the 1970´s, educational efforts in this area have lagged behind and been slow to start. The first graduate program in the area of plant genetic resources was offered by the Santa Catarina state Federal University (UFSC), in Florianopolis, with an academic master's degree program initiated in 1997 and a Ph.D. program started in 2003.

Both the Feira de Santana State University (UEFS, Feira de Santana – Bahia state) and the Recôncavo Baiano Federal University (UFRB, Cruz das Almas, Bahia state) -the latter in partnership with Embrapa Cassava and Tropical Fruits, approved in 2007 the establishment of their respective master's degree programs in plant genetic resources. The Feira de Santana program includes three research lines: genetics and plant breeding; germplasm collection, characterization and conservation; biodiversity, bioprospection and native and exotic plant sustainable management. The UFRB/Embrapa program includes two research lines: plant genetic resources conservation and management; breeding and biotechnology. Both offer a course on plant genetic resources.

Each one of the above mentioned programs admit about ten students a year and several dissertations are ongoing. Further details can be found on these university websites (www.uefs.br and www.ufrb.br).

In addition, a plant genetic resources course is taught as a part of the Irrigated Horticulture master's program at the Bahia State University (UNEB, www.ppghi.uneb.br), which has a research line on breeding of genetic resources and horticultural species. Finally, the same course is also offered as a part of both the master's and the Ph.D. programs in Phytotechnology at the Semi-Arid Rural Federal University (UFERSA) in Mossoró, Rio Grande do Norte state.

The above-mentioned academic programs are mainly directed at plant genetic resources research. Furthermore, a number of studies on the same issue have been conducted in the framework of graduate programs in agronomy, including the master's programs in plant production at the South Western Bahia University (UESB) and in plant breeding at the Pernambuco Rural Federal University (UFRPE).

All of the above indicates that graduate programs in the Northeast of Brazil are paying growing attention to plant genetic resources, where several students are writing dissertations and theses on various aspects of the genetic resources of different plant species of interest for this Brazilian region, especially the semi-arid region.

Also worthy of mention are the Campinas Agronomical Institute (IAC), which has a master's program in tropical agriculture, where, within its framework, it is possible to write dissertations on genetic resources. This is also the case at the Amazon National Research Institute (Instituto Nacional de Pesquisa da Amazônia – INPA), where a course is taught on the conservation and use of genetic resources. The Viçosa Federal University, in Minas Gerais state, develops a number of studies on horticulture and plant genetic resources; moreover, its graduate (master's and Ph.D.) programs in phytotechnology include a course on the management of plant genetic resources. Finally, that same course is offered at the Norte Fluminense State University (UENF), both in the undergraduate and the graduate programs in plant breeding. UNEF programs also have a research line on plant genetic resources.

6.2.3. Agricultural Research conducted in Universities

In Brazil, research is basically carried out in public universities, at both federal and state levels, which generate approximately 90% of the country's scientific research. With a few exceptions, private universities have little to add to this scenario. University research is usually funded from non-budgetary funds provided from external sources. Investment is required on basic infrastructures such as libraries, computers, laboratory facilities and human resources. This investment is funded by CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior), within the Ministry of Education. However, the most important source of financing for university research is the Ministry of Science and Technology (MCT), whose funds are distributed through two agencies: The National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq) and The Research and Projects Funding Agency (Financiadora de Estudos e Projetos - FINEP). Other important funding sources for research in Brazil are state level research support foundations; these are especially created to fund and provide support to research, thus allowing the national scientific base to broaden, both in qualitative and in quantitative terms.

6.3. PLANT GENETIC RESOURCES RESEARCH & DEVELOPMENT ACTIVITIES IN BRAZIL

In Brazil, research and development efforts have been essentially public. In rural areas, Science and Technology have developed mainly in public faculties and research centers, first and foremost in federal institutions; private sector institutions, as well as those related to agricultural services play a minor, low profile role. Some research areas related to agriculture are defined as strategic, such as technological development, production and industrial policy, which are areas have been directly funded by the Ministry of Agriculture and Food Supply. The Ministry of Science and Technology essentially contributes a vast graduate studies system and funding to research institutions for plant genetic resources research and development.

6.3.1. Brazilian Agricultural Research Corporation - EMBRAPA

The Brazilian Agricultural Research Corporation (Embrapa), placed under the umbrella of the Ministry of Agriculture and Food Supply, was established on April 26th, 1973. Its mission was restated in the 5th Strategic Development Plan (Plano de Desenvolvimento Estratégico - PDE), adopted in 2008. It reads: **"To provide research, development and innovative solutions for the sustainable development of agriculture and agroindustry for the benefit of Brazilian society."** Embrapa exists as 39 research units and three service units, and is present in almost all Brazilian states, in all the Brazilian biomes.

In order to enhance Brazilian leadership in tropical agriculture, Embrapa has invested chiefly on capacity building. It currently has 8,623 employees, of which 2,294 are researchers - 66% with Ph.D., and 25% with M.Sc. degrees. In 2007, Embrapa's budget was around U$ 740 million, including payroll. In the same year, its total budget (including capital) was 24.8% higher than the 2006 budget.

In April 2008, Embrapa received a share of the Growth Acceleration Plan (Plano de Aceleração do Crescimento - PAC), launched by the federal Government. In order to enhance Embrapa's performance, PAC is expected to invest R$ 200 million in 2008, and R$ 300 million for 2009/10. These funds will be invested in ten large projects: (i) Sustainable Amazon agriculture; (ii) Food security and safe food; (iii) Utilization of natural resources and sustainable agricultural production; (iv) Family agriculture competitiveness and sustainability; (v) Increasing the extent of knowledge; (vi) Agroenergy; (vii) Governance and institutional innovation; (viii) Revitalization and modernization of intellectual capacity and infrastructure; (ix) Recovering the operational capacity of state level agricultural research organizations; and (x) Satellite monitoring of PAC construction sites and their impacts.

The National System of Agricultural Research (Sistema Nacional de Pesquisa Agropecuária - SNPA) is under Embrapa's coordination. SNPA is made up of public, federal and state level institutions, universities, private companies and foundations that conduct cooperative research in different geographic areas and different scientific fields. Technologies generated by SNPA have transformed Brazilian agriculture.

Embrapa has three types of Agricultural Research Center: Product Centers, Eco-regional Centers and Thematic Centers. Product Centers are strategically located in different parts of the country where the target species are economically important. Embrapa has National Research Centers for the most important crops including: Rice and Beans in Goiânia, Goiás; Soybean in Londrina, Paraná; Maize and Sorghum in Sete Lagoas, Minas Gerais; Horticultural Crops in Brasília, Distrito Federal; Wheat in Passo Fundo, Rio Grande do Sul; Cotton in Campina Grande, Paraíba; Grapes and Wine in Bento Gonçalves, Rio Grande do Sul; Forests in Colombo, Paraná; Cassava and Tropical Fruits in Cruz das Almas, Bahia. Centers devoted to research on different environments (eco-regional research centers) and which work on plant genetic resources are found in the following regions: Mid North region in Teresina, Piauí; Pantanal in Corumbá, Mato Grosso do Sul; Coastal Tablelands in Aracajú, Sergipe; Cerrado in Brasília, Federal District; Semi-Arid in Petrolina, Pernambuco; South in Bagé, Rio Grande do Sul; Southeast in São Carlos, São Paulo, West in Dourados, Mato Grosso do Sul; Eastern Amazon in Belém, Pará; Western Amazon in Manaus, Amazonas. Three of the eco-regional centers are known as Agriforestry Research Centers and are located in Boa Vista, Roraima; Rio Branco, Acre, and Porto Velho, Rondônia. The distribution of Embrapa Research Centers is shown in Figure 30.

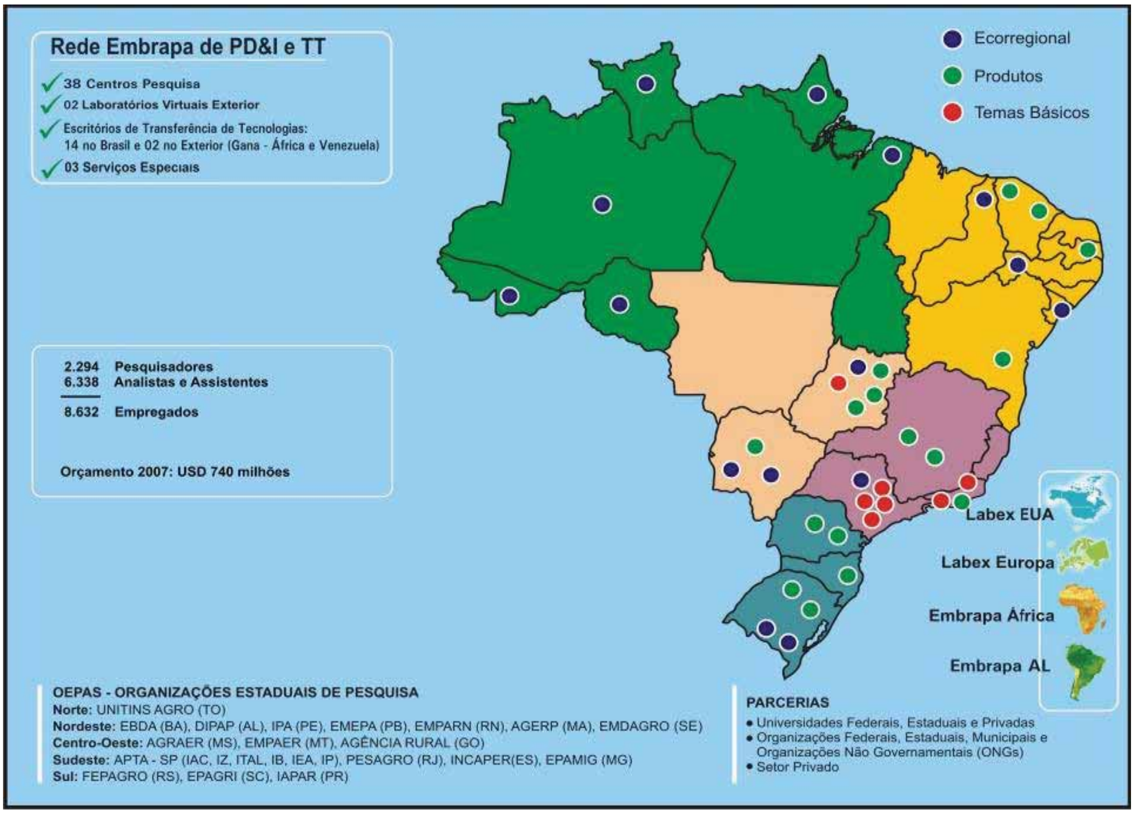

Figure 30: Distribution of SNPA Research Units

The National Center for Genetic Resources and Biotechnology Research - Embrapa Genetic Resources and Biotechnology, located in Brasília, Federal District, is one of the thematic research centers. The center plays an important role in the conservation of plant, animal and microorganism genetic resources. Embrapa Genetic Resources and Biotechnology coordinates genetic resources conservation activities through a system called National Genetic Resources Network (RENARGEN), which will be replaced in early 2009 by a broader structure named the National Genetic Resources Platform.

6.3.1.1. National Center for Genetic Resources and Biotechnology Research

The National Center for Genetic Resources and Biotechnology Research (Embrapa Genetic Resources and Biotechnology) was established in 1974 in the context of an increasing global scientific awareness about the importance of genetic resources. This awareness was consolidated following the first United Nations Conference on the Environment and Development, held in Stockholm, Sweden, in 1972. Twenty years later, the Earth Summit held in Rio de Janeiro (***United Nations*** Conference on Environment and Development) showed the potential impact of genetic resources and biotechnological research on the economic and ecological sustainability of agro-ecosystems. This growing awareness entailed increased responsibility for Embrapa Genetic Resources and Biotechnology.

The role of Embrapa Genetic Resources and Biotechnology is the conservation and characterization of genetic resources (plant, animal and microorganism), as well as at the development of biotechnologies. This Research Centre has contributed significantly to the development of a sustainable and environmentally balanced agriculture in Brazil. Other than the above-mentioned activities, the centre also conducts research on integrated pest management and develops specific agricultural defense efforts.

Embrapa Genetic Resources and Biotechnology (Cenargen) carries out research in four major areas: Genetic Resources, Biotechnology, Biological Control and Biosafety. To fulfill its mission, it relies on its 289 employees, of whom 130 are researchers; 80 are research support staff, and 79 are management staff. Among the researchers, 92 hold a Ph.D. degree from a Brazilian or an overseas university, 36 have a master’s degree, and two hold a Bachelor’s degree. Besides having a training program that offers different courses throughout the year, Cenargen provides support to undergraduate and graduate programs in Brazilian universities. Cenargen researchers supervise over 80 students, including interns, thanks to the support provided by research funding institutions.

One of Embrapa Genetic Resources and Biotechnology’s major missions is the long-term conservation of germplasm. This activity is carried out through a Seed Germplasm Base Collection (COLBASE) established in 1976 to ensure decades-long survival of seeds of species of socioeconomic interest, thus securing seed supply sources for food and agriculture. COLBASE management complies with international operational standards and has cold chambers (-20ºC) with current storage capacity for 240 thousand accessions. Enrichment of the genetic variability of the species stored at COLBASE is carried out through collection, introduction, exchange and use of genetic materials sent by Active Banks. Laboratory tests are performed in order to evaluate physiological and sanitary quality of accessions. COLBASE currently stores 107,000 accessions of 745 species. Details on genera and numbers of stored accessions are shown in Tables 1A to 10A of the Annex to this National Report.

6.3.2. National System of Agricultural Research

The SNPA is basically made up of federal and state level public institutions which conduct cooperative research in different geographic regions and fields of scientific knowledge. It is under Embrapa’s coordination, and its state level member institutions are: PESAGRO – Empresa de Pesquisa Agropecuária do Estado do Rio de Janeiro; EPAMIG – Empresa de Pesquisa Agropecuária do Estado de Minas Gerais; APTA – Agência Paulista de Tecnologia Agropecuária; IAPAR – Instituto de Agronomia do Estado do Paraná; FEPAGRO – Fundação de Pesquisa Agropecuária do Estado do Rio Grande do Sul; INCAPER – Instituto de Pesquisa, Assistência Técnica e Extensão Rural do Estado do Espírito Santo; AGÊNCIA RURAL – Agência para o Desenvolvimento Rural do Estado de

Goiás; EPAGRI – Empresa de Pesquisa Agropecuária e Extensão Rural do Estado de Santa Catarina; AGRAER - Agência de Desenvolvimento Agrário e Extensão Rural do Estado de Mato Grosso do Sul; UNITINS AGRO – Organização Estadual de Pesquisa Agropecuária do Estado de Tocantins; AGÉNCIA RURAL - Agência Goiana de Desenvolvimento Rural e Fundiário do Estado de Goiás; EMPAER – Empresa Mato-Grossense de Pesquisa Agropecuária e Extensão Rural; EMEPA – Empresa de Pesquisa Agropecuária do Estado da Paraíba; EBDA – Empresa Baiana de Desenvolvimento Agropecuário; EMDAGRO – Empresa de Desenvolvimento Agropecuário do Estado de Sergipe; AGERP - Agência de Pesquisa Agropecuária e Extensão Rural do Estado do ***Maranhão*****;** DIPAP – Divisão de Pesquisa Agropecuária do Estado de Alagoas; EMPARN – Empresa de Pesquisa Agropecuária do Estado do Rio Grande do Norte; and IPA – Empresa de Pesquisa Agropecuária do Estado de Pernambuco. Figure XX displays the distribution of Embrapa's Research Centers and of state level research corporations.

6.4. INFORMATION SYSTEMS AND INFORMATION SERVICES

6.4.1. Brazilian System for Information and Genetic Resources – (Sibrargen)

Information and telecommunications technology made great strides between 1996 and 2008. This allowed positive and substantial action to be taken in documentation and computerization of genetic resources, facilitating swift and simple remote access to centralized databases. Computers and software for the documentation of genetic resources have been continually updated in order to keep up with growing demands from system users. The communication line, which in 1996 operated at 2 MBPS, has recently started operating at 100 MBPS-a 50x increase in transmission speed.

Keeping up with facilities made available by the evolution of information and telecommunications technology, the Genetic Resources Information System (Sistema de Informação de Recursos Genéticos – SIRG) was replaced in the early 2000s with the current Brazilian System for Genetic Resources Information – Sibrargen. SIRG was designed to run on PCs with Coleta, Registro, Colbase, Colativa, Dicatab and Avalia applications. Each one of these applications ran on a separate computer, which hampered information-sharing and caused data redundancy and information inconsistency. Since computers were not interlinked in a network, information was not available for remote access and could only be obtained from one computer and by one person at a time. SIRG was developed using Basic programming language, with databases in indexed files.

Sibrargen was designed to establish and maintain a centralized data bank which runs in a decentralized way over the internet, managed by information generating teams. Databases are thematic and interlinked, centralized in a single data bank, which stores and makes available information generated in the framework of several activities related to genetic resources: exchange, collection, conservation (*ex-situ,* with plants in the field, in seed banks and *in-vitro*), germplasm characterization and evaluation. Different Sibrargen modules can be seen on Figure 31.

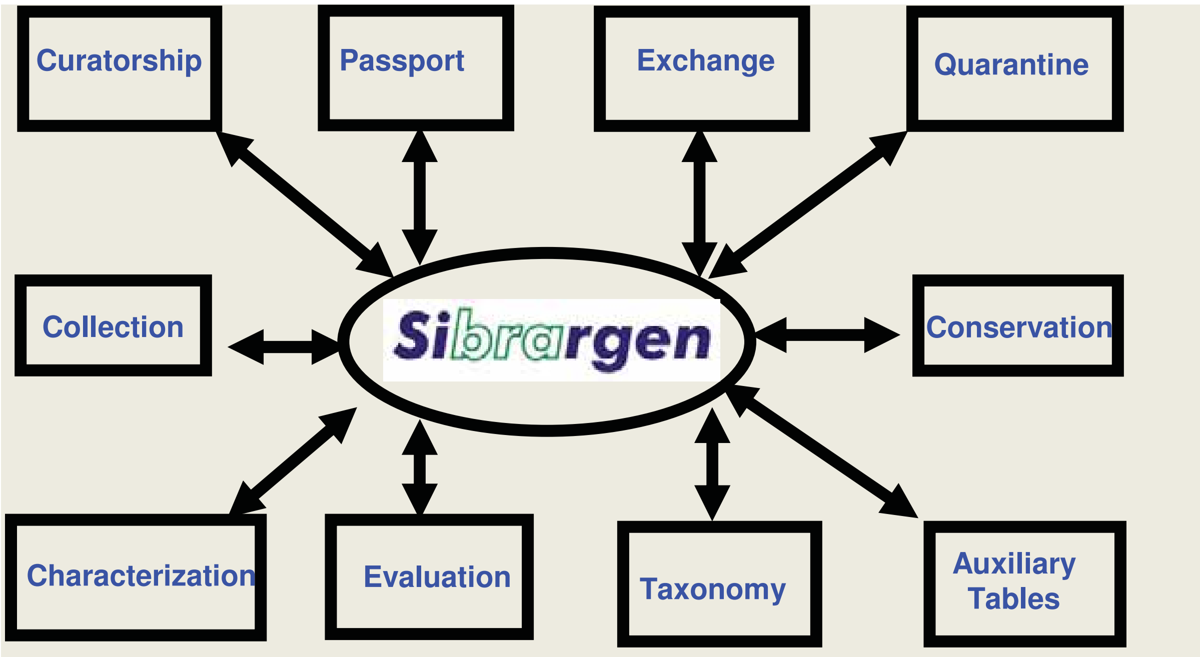

Figure 31: **Brazilian System for Genetic Resources Information – Sibrargen - Modules**

Sibrargen development was based on Oracle tools (database management system, Forms and Reports). The Sibrargen homepage was designed with web tools (HTML and JSP) using Embrapa's network infrastructure. In its first phase, the system was implemented within Embrapa. However, other Brazilian institutions are also expected to use it, notably those within the SNPA.

Technology available in recent years has allowed:

- information standardization, organization, clustering and availability in an integrated way, avoiding redundancy;
- access based on selection criteria from different thematic areas;
- remote and immediate user access to available Sibrargen information; and
- database maintenance by teams working in different locations.

In 2007, Brazil was chosen by FAO to join the group of countries that would test the integration of national information systems on genetic resources through the Multilateral System – FAO's MLS, currently under development. This was done in order to meet the demand for germplasm exchange based on MultiCrop Passport Data (MCPD-FAO) in the framework of the International Treaty on Plant Genetic Resources for Food and Agriculture. Sibrargen is currently making available passport data for cassava accessions (*Manihot esculenta* Crantz) where, through Embrapa, Brazil will make this data available from 2009 on the exchange system, which required system and data adjustments in order to comply with the standards.

Because Sibrargen has been active for over seven years, the Embrapa Executive Board decided in 2008 that it should undergo technical evaluation in order to adapt to future requirements. Modifications have been suggested in order to both enhance user satisfaction and, as far as information technology is concerned, improve the system performance by incorporating updated Web technologies.

Another important aspect being considered in the framework of the system update is the possible integration of the Sibrargen Plant Module into Global GRIN (Germplasm Resources Information Network), which is currently being developed by the United States Department of Agriculture in cooperation with Biodiversity International and the Global Crop Diversity Trust.

Parallel to evaluation and adaptation of the Sibrargen plant genetic resources module, animal and microorganism modules are being developed. The animal genetic resources module will be GRIN-Animal version two, currently being developed through a partnership between Brazil, the United States and Canada; the institutions involved in this work are Embrapa, ARS and AAFC, respectively. The microorganism genetic resources module is being developed by Embrapa itself using open source software to develop a Web application as its operating environment.

6.4.2. Electronic Information Methods

There are many Brazilian websites containing information related to plant genetic resources. Several government agencies, universities, scientific societies, as well as agricultural information institutions, have specific web pages, as displayed in Table 13.

The Integrated Information System on Science and Technology Funding (Sistema Integrado de Informação sobre Financiamento de Ciência e Tecnologia - Prossiga), under the Ministry of Science and Technology, holds information about research activities conducted in Brazil, which is updated by funding agencies. Its prime audience is made up of scientists, professors and managers. Prossiga is a cooperative system that integrates the major federal and state level agencies funding science and technology research: CNPq, FINEP, CAPES, FAPERGS, FAPESP, FAPEMIG, FAPERJ, FACEPE and FUNCAP. These forward monthly data to Prossiga, thus ensuring that the information is current. This system allows searching by agency, funding type, institution name, researcher name, subject, subject area, city, state, etc. Another important source of information is the National Catalogue of Series Publications Collections (Catálogo Nacional de Coleções de Publicações Seriadas – NCC), coordinated by the Brazilian Institute for Science and Technology Information (Instituto Brasileiro de Informação em Ciências e Tecnologia – IBICT), where IBICT is a cooperative system of information sources from Brazilian institutions. This Catalogue gives access to technical journals and compiles information from hundreds of major Brazilian library catalogues in its publicly accessible National Catalogue. NCC aims to optimize resource availability for libraries and documentation services; to this end, it participates in a network and improves services to final users. NCC makes information available that can be used for: (i) the dissemination, identification and location of science and technology journals, both national and international, available in Brazil; (ii) designing a coordinated acquisition policy, and (iii) interlibrary loans, through a common system for bibliographic references and standardized title entry. NCC is open to the participation of libraries holding important automated collections of science and technology series publications.

Table 13. Some Web sites containing Information on Plant Genetic Resources

TYPE	**Website**
Government	www.agricultura.gov.br; www.embrapa.br; www.mct.gov.br; www.cenargen.embrapa.br; www.mma.gov.br; www.cnpq.br; www.finep.gov.br; ipe.ibict.br/fomento; www.fapesp.br; www.ebda.ba.gov.br; www.sdr.ce.gov.br; www.emater.df.gov.br; www.emater.mg.gov.br; www.emater.pr.gov.br; www.empaer.pantanal.br; www.epagri.rct-sc.br; www.cati.sp.gov.br; www.prodase.com.br/emdagro; www.agenciarural.go.gov.br; www.seagri.ba.gov.br; www.sdr.ce.gov.br; www.pr.gov.br/seab; www.fisepe.pe.gov.br/sprra; www.ibama.gov.br; www.agricultura.sp.gov.br

Universities and Institutes	www.mec.gov.br; www.unb.br; www.usp.br; www.unesp.br; www.ufmg.br; www.ufg.br; www.ufv.br; www.ufrgs.br; www.unifap.br; www.fua.br; www.ufpa.br; www.ufg.br; www.ufmt.br; www.ufms.br; www.ufal.br; www.ufba.br; www.ufc.br; www.ufla.br; www.ufmg.br; www.ufu.br; www.ufrj.br; www.uff.br; www.ufrrj.br; www.ufpr.br; www.ufsm.br; www.ufsc.br; www.unicamp.br; www.uece.br; www.uem.br; www.uerj.br; www.uel.br; www.esalq.usp.br
Periodicals and Journals	www.globorural.globo.com; www.rbspa.ufba.br; www.scielo.br/scielo; http://www.periodicos.capes.gov.br
Others	www.wwf.org.br; www.brasilnature.org.br; www.finatec.org.br; www.cna-rural.com.br; www.faeg.com.br; www.famasul.com.br; www.faemg.org.br; www.faep.com.br; www.senar.com.br; www.fundacaoabc.com.br; www.sidronet.com.br/fundacaoms; www.fundecitrus.com.br; www.abmr.com.br; www.apacame.org.br

The Common Bibliographic Program (Programa Bibliográfico Comum - COMUT) was established in 1980 by the Ministry of Education through CAPES and is currently organized by IBICT, SESU (MEC) and FINEP (MCT). COMUT aims at providing the country with efficient access to information and gives the academic and research communities access to documents in all subjects by providing hard copies of papers published in journals, thesis and Congress Proceedings. In compliance with Copyright legislation, these hard copies are for academic use only. This structure operates through a network of libraries, called base libraries, which have the adequate bibliography, human resources and technology to meet user demand. CAPES has also created its Journal Portal, giving access to full text materials of over 12,365 international, national and foreign journals, as well as to 126 databases, containing abstracts of documents in all areas of knowledge. It also includes a selection of important academic information sources, with free internet access. Through this CAPES service, professors, researchers, students and employees from 191 higher education and research institutions across Brazil have immediate access to current global scientific publications. This portal can be freely accessed by all users in the participating institutions. It is accessed from any terminal with an internet connection in the institutions, or from authorized terminals. All undergraduate, graduate, and research programs in the country can achieve improved quality, productivity and competitiveness by using this continuously evolving portal.

6.4.3 Printed information

6.4.3.1. Scientific Information

Brazil has some series publications on areas of knowledge specifically related to Agricultural Sciences or related subjects. The major series publications, listed below in alphabetical order and by subject, apply a reference system and have very strict editorial boards.

Agricultural Sciences in General: Brazilian Archives of Biology and Technology; Ciência Rural; Pesquisa Agropecuária Brasileira - PAB.

Biological Sciences in General**:** Bragantia; Brazilian Archives of Biology and Technology; Brazilian Journal of Biology; Brazilian Journal of Medical and Biological Research; História, Ciências, Saúde: Manguinhos; Interciência; Revista Brasileira de Biologia.

Genetics: Brazilian Journal of Genetics.

6.4.3.2. Official Statistical Information

The Brazilian Geography and Statistics Institute (Instituto Brasileiro de Geografia e Estatística – IBGE) is the major Brazilian organization in charge of the dissemination of updated information on surface area, demography, price indexes, industry, trade, weather forecasts, agriculture, animal production, plant production, agriforestry, access, population, family budget and national budget. This information is available in the database known as SIDRA (Sistema IBGE de Recuperação Automática - IBGE Automated Recovery System), which can be accessed at www.sidra.ibge.gov.br.

6.5. AGREEMENTS AND CONVENTIONS APPLICABLE TO GENETIC RESOURCES

Commitments and legal obligations aim at promoting the conservation of biodiversity, the sustainable use of its elements, fair and equitable sharing of benefits originating from the utilization of genetic resources, as well as respect, preservation, maintenance and protection of traditional knowledge from different sources. The most significant actions to this end derive from the Convention on Biological Diversity (CBD). Over the last decade, Brazil has taken both unilateral and multilateral measures at the international, national and regional levels to protect, promote and preserve traditional knowledge.

One of the most positive factors for the conservation and sustainable use of biodiversity, as well as for the protection of traditional knowledge, is the fact that Brazil signed and ratified the CBD. As a signatory to the CBD and one of the countries with the richest biodiversities in the world, Brazil has adapted its public policies in order to ensure the sustainable use and the conservation of biological resources; this has been done chiefly through the National Biodiversity Policy.

Another important measure taken by Brazil–together with China, Colombia, Costa Rica, Ecuador, India, Indonesia, Kenya, Mexico, Peru, South Africa and Venezuela, was the creation of the group called Like-minded Megadiverse Countries (LMMC), recorded in the Cancun Declaration. Later on, other countries, such as Bolivia, Malaysia and the Democratic Republic of Congo, joined the group. Over 70% of the global biodiversity is found in the territories of these 15 countries. The LMMC was established as a special mechanism for mutual consultation and cooperation and aims at promoting common interests and priorities regarding the preservation and the sustainable use of biodiversity among its member countries. Brazil is chairing LMMC for the first time in 2009-2010, which should advance coordination between member countries in the defense of sensitive areas during the preparatory meetings for CDB’s COP 10. During these two years, the group will play an active role in discussing the International Regimen on Access and Benefit-sharing, involving the sustainable use of biodiversity and associated traditional knowledge (see also Chapter 8).

Brazil has a rich social diversity that includes over 200 indigenous tribes and a large number of local communities (*quilombolas, calungas, caiçaras*, rubber tappers and others); these hold vast amounts of traditional knowledge about the conservation and sustainable use of local biodiversity. This is why Brazil pays continuous attention to the legal protection of knowledge on and the use of local diversity. This is notably the case with associated economic potential, which involves the development of biotechnology products for use both in agriculture and medicine. In view of these factors, access to biodiversity and traditional knowledge is permitted, but only for scientific research, bio-prospection and technological development, complying with current legislation (see Chapter 8).

6.6. PRIVATE AGRICULTURAL ORGANIZATIONS

6.6.1. National Agricultural Confederation

The National Agricultural Confederation (CNA), enjoys wide recognition among rural dwellers. The CNA participates actively in discussions and decision-making concerning

Brazilian agriculture. Its technical department provides support to rural producers, chiefly in the following areas: agrarian policy, agricultural policy, taxes, rural pension fund, legislation affecting rural workers, as well as domestic and international market conditions. The Brazilian union structure is industrial, pyramid-shaped, and composed of approximately 2,000 trade unions, some of which have branches in farms. Unions are organized on a state basis and are further united in a National structure called the *Federação*. As this system's leader, the CNA is recognized as the only legally constituted institution organizing agricultural workers (Brazil has industrial unionism). This design ensures high penetration of the system, which includes in excess of one million members who freely join unions all over Brazil. The *Federação*, at the state level, and the CNA strive to strengthen rural unions. Unions provide direct support to producers, looking for integrated solutions to local problems.

CHAPTER 7

THE STATE OF REGIONAL & INTERNATIONAL COLLABORATION: STRATEGIC DIRECTIONS – TO IMPROVE REGIONAL AND INTERNATIONAL COLLABORATION

7.1. INTRODUCTION

The genetic breeding process is closely linked with the breadth of the available genetic base, which in turn is influenced by the available useful resources available, in the form of collected and characterized materials, held in germplasm banks, which are important inputs for the development of new cultivars. For any plant genetic breeding program to be successful it is crucial to access these materials containing variability, be it by harvesting or by introduction and exchange.

International exchange of genetic resources was practiced by Brazil in the course of the 20th century without great formalities, based on reciprocity treatment, process which benefited research and development public institutions, universities, seed producing private companies, among others. This easier access to genetic resources was one of the main reasons for constant launch of new cultivars, which played an outstanding role in the evolution of the Brazilian agri-food and agroindustrial sectors.

However, in a complex international environment, influenced by strategic interests in biological resources, by progress in technological avenues that rely heavily on genetic variability, and by the consolidation of a legal framework for the protection of knowledge, relations between countries as well as between organizations in each country are bound to change as far as access to genetic variability-bearing organisms is concerned. Especially, the provisions of the Convention on Biological Diversity (CDB), which has led to the adoption of national legislations that assert sovereignty over biological resources, have had negative impacts on the flow of these resources worldwide (see Chapter 8).

Although it is one of the richest countries in biological diversities worldwide, Brazil depends heavily on genetic resources from other regions for agricultural production and food. Brazilian agriculture, quite diversified thanks to our country's ecological complexity, would never progress if it were not for systematic and growing imports of genetic resources; mainly those associated to Brazilians staple diet components such as rice, wheat, maize, sugar-cane and potato, among many others. Likewise, Brazilian agricultural competitiveness on coffee, orange, soybean, meat, etc., on international markets is also dependent on an uninterrupted flow of imported germplasm. This dependence will persist, because Brazilian research on food security and agroindustrial competitiveness will always requires genetic material with ecological adaptation characteristics, such as resistance to prevalent pests and diseases, and adaptation to adverse environmental conditions

7.2. THE INTRODUCTION OF GERMPLASM IN BRAZIL

The introduction of plant germplasm in Brazil is a dynamic process based on which more productive, pest-resistant varieties adapted to our edaphoclimatic conditions are obtained. Embrapa Genetic Resources and Biotechnology coordinates the Brazilian participation in a wide international germplasm exchange and cooperation system which benefits all its units, as well as institutions dependent on access to exotic genetic resources. Germplasm import applications are submitted by the Germplasm Exchange unit in that Embrapa unit, located in Brasília, DF. This latter takes the appropriate steps with the Plant Health Department

(Departamento de Sanidade Vegetal - DSV), under the Ministry of Agriculture, Livestock and Food Supply (Ministério da Agricultura, Pecuária e Abastecimento - MAPA). Other research institutions should forward their germplasm import applications directly to the Federal Agriculture Office (Delegacia Federal de Agricultura - DFA) for the relevant state, which, in turn, will forward them to DSV. This latter department asks Embrapa Genetic Resources and Biotechnology's technical opinion before issuing the "Import Permit". Procedures taking place after germplasm arrives in Brazil come within DFA's competence, whereas quarantine is ensured by Embrapa Genetic Resources and Biotechnology or by another quarantine agency accredited by the MAPA.

Embrapa Genetic Resources and Biotechnology has carried out exchange and quarantine of germplasm imported for research since 1976. Until December 2004, a total of 477,651 germplasm accessions had been exchanged, of which 354,049 imports, 51,932 exports and 71,670 domestic exchanges. Products more intensively exchanged during this period were maize, wheat, rice, vegetables, soybean and beans. International institutions having sent more germplasm to Brazil include: the International Maize and Wheat Improvement Center (CIMMYT), at both its headquarters in Mexico and its Uruguay and Colombia units; the International Center for Tropical Agriculture (Centro Internacional para Agricultura Tropical - CIAT), in Colombia; the Department of Agriculture of the United States (USDA), the Potato International Center (Centro Internacional de la Patata - CIP), in Peru, the International Rice Research Institute IRRI, in the Philippines and the Commonwealth Scientific and Industrial Research Organization (CSIRO), in Australia. In Brazil, the institutions having received larger amounts of germplasm from abroad are: Embrapa (different units), Instituto Agronômico do Paraná (IAPAR), Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina S.A. (EPAGRI), Universidade Estadual Paulista (UNESP) and Escola Superior de Agricultura "Luis de Queiroz" (ESALQ).

Under Embrapa Genetic Resources and Biotechnology's coordination for 30 years, plant germplasm cooperation and exchange activities have been increasingly safe, thanks to the incorporation of new concepts and methodologies in keeping up with the evolution of methods and processes. There are measurable benefits to the addition of almost 500,000 new accessions to our country's genetic heritage with a minimum risk of inadvertently introducing harmful organisms into Brazilian agroecosystems.

7.2.1. Biological Security in Genetic Resources Cooperation and Introduction

Biosecurity is the term FAO has adopted when searching for tools and activities to raise awareness among the international community about the "management of all risks associated with agriculture and food production, including fisheries and forestry." Risks include the evaluation of living modified organisms (LMO), invasive species, the introduction plant and animal pests, the erosion of biodiversity entailed by loss of genetic and biological resources, disease dissemination, weed plant infestation, biological weapons, etc. This FAO terminology is used for designing public policies for plant and animal health and for genetically modified organisms (biosecurity). Moreover, it is also related to the development of scientific methods, ethical considerations, reliability and vigilance for the protection of society.

As far as international coordination strengthening is concerned, Brazil feels the need for a better interaction with its neighbors, with a view to reducing perils, risks and damage to agriculture, livestock and the environment by the means of the mitigation or even a ban on the introduction of alien invasive species (AIS), fungi, bacteria, viruses, insects, plants and animals.

For the Amazon, examples include the banana black leaf streak (black sigatoka) (*Mycosphaerella fijiensis*), that entered the country from Venezuela or Colombia, the fruit fly, *Bactrocera carambolae* (Diptera, Tephretidae), that entered from the French Guiana, the citrus black fly, *Aleurocanthus woglumi* (Hemiptera, Aleyrodidae) that may have entered from Colombia or other neighboring countries where this pest is reported to occur. Other examples for Brazil include boll weevil, *Anthonomus grandis* (Coleoptera, Curculionidae) and the white fly, *Bemisia spp*. (Hemiptera, Aleyrodidae). Many threats currently face cocoa growing in Brazil, which will be endangered if Moniliophthora pod rot, a disease caused by the *Moniliophthora roreri* fungus, actually enters the country, because the latter is much more devastating than the cocoa swollen shoots disease. Unfortunately, Moniliophthora pod rot is already found in Peru, near the Brazilian border (Acre state). Also feared is the arrival of the Asian beetle, terrible pest for forest species.

For the Amazon specific case, and considering the great need for strengthened harmonization among countries, a specific suggestion has been made in some debate fora: the establishment of a Regional Committee on Sanitary and Phytosanitary Measures, designed to develop activities similar to those the South Cone Plant Protection Committee (Comitê de Sanidade Vegetal dos Países do Cone Sul - COSAVE) carries out for the MERCOSUR countries. The same kind of efforts is required in the Amazon, where the intervention of the Ministry of Foreign Affairs (Ministério das Relações Exteriores - MRE), the MAPA and other ministries, as well as of the Amazon Cooperation International Treaty on Plant Genetic Resources for Food and Agriculture Organization, which has its secretariat in Brasilia (DF), is much needed. This way, sanitary barriers would be reinforced, so enabling inspection activities and quarantine services to achieve better performances.

Key in underpinning this international coordination is the GISP – Global Program for Invasive Species, developed in 1996 and established in 1997 to deal with the problem of invasive species and provide support to the implementation of Article 8(h) of the Convention of Biodiversity. GISP is operated by a consortium among the Scientific Committee on Problems of the Environment (SCOPE), CAB International (CABI) and the International Union for Conservation of Nature (IUCN), in partnership with the UN Environment Program (UNEP). GISP is also a member of the DIVERSITAS international program of biodiversity science, which develops environmental efforts worldwide. GISP joined with Embrapa to host a meeting at the Embrapa headquarters in Brasília-DF with the Ministry of Environment (MMA), MRE and MAPA in October 17-19, 2001 on alien invasive species. Participants included experts from Argentina, Bolivia, Brazil, Chile, Colombia, Equador, the French Guiana, Paraguay, Peru, Suriname, Uruguay and Venezuela. The meeting resulted in the following declaration:

a) Invasive alien species, which include pests, diseases and weeds, besides causing enormous economic damage, mainly to agriculture, constitute one of the main threats to biodiversity and to natural ecosystems, in addition to risks to human health.
b) Increasing globalization, with increases in international transport, trade and tourism, and the initiation of climate changes due to the greenhouse effect and changes in land use, enhance the opportunities for the introduction and spread of invasive alien species in the region.
c) South America harbors half of the tropical forests and more than a third of the biodiversity of the world, an immense and valuable natural asset, in large part shared by 13 countries, many of which are megadiverse; biodiversity is the basis for sustainability of environmental services, forestry and fisheries, agriculture and the new industry of biotechnology. About 50% of Brazil's Gross National Product, for example, is derived from the direct use of biodiversity and its genetic resources.The loss caused by invasive alien species in South America's agricultural production exceeds several billion dollars annually. As an example, in Argentina the Mediterranean fruit fly costs US$ 10 million dollars per year in control programs, plus 15-20% of production in direct loss annually, equivalent to US$ 90 million dollars per year, and incalculable indirect economic and social impact with the reduced production and loss of export markets.
f) As they share the same continent, only separated by political boundaries, the South American countries share the same destiny in the event of introduction of invasive

alien species – it is essential, therefore, to promote greater cooperation among the countries of the region to keep off of combat a common enemy.

g) The importance of full implementation in the region of Decision V/8 of the 5th Conference of the Parties to the Convention on Biological Diversity is recognized, which established guiding principles for the prevention and control of invasive alien species that threaten ecosystems, habitats or species.
h) There is a need to promote greater exchange of information, starting with the elaboration of national assessments on this problem, research, capacity building, institutional strengthening, public awareness, coordination of actions and harmonization of legislation.
i) Without prejudice to other themes identified in national assessments, the introduction of invasive alien species in the different hydrographic basins of the region and transboundary ecosystems deserves urgent attention.
j) Better coordination and cooperation is needed between the national agricultural, forestry, fishery and environmental sectors in the treatment of this issue, including the establishment of national committees on invasive alien species, and involving other sectors related to the issue such as health, tourism, transport and commerce, as well as the private sector.
k) It is essential, therefore, to promote greater cooperation among the countries of the region to keep off or combat a common enemy, as well as to cooperate, led by FAO, CBD and GISP, with the other countries of the Americas and with the global effort to solve a common problem.
l) It is recognized, however, the lack of public awareness about the importance of this issue, which facilitates the accidental introduction of invasive alien species.
m) The effective prevention and control of invasive alien species in South America will need adequate financial and technical support.

7.3. PROGRAMS AND ACTIONS OF THE MINISTRY OF FOREIGN AFFAIRS

International cooperation is an essential tool to foster a country's development and to build technical and commercial capacity of companies, universities and research institutes, combining the search for the well-being of national populations and the need for competitiveness in the new global economy. Furthermore, international cooperation, either directly between institutions from different countries or with the mediation of an international organization, which might provide financial and administrative support to actions, is a safe and effective tool to increase contact and strengthen politico-economic ties between the involved countries. In Brazil, the Ministry of Foreign Affairs is responsible for the coordination of foreign policy-making in the matters concerning science and technology, defending the country's positions in negotiations and implementation of bilateral and multilateral cooperation programs.

The Brazilian Cooperation Agency (Agência Brasileira de Cooperação – ABC) is the MRE's operative arm and plays a decisive role in this process. This agency is in charge of the coordination and supervision of technical cooperation programs in which Brazil is involved. Programs and projects are negotiated and implemented based on agreements signed by Brazil with partner-countries and international organizations. In order to fulfill its mission, the Brazilian Cooperation Agency steers its work pursuant to Brazilian foreign policy, within the competence of the MRE, and to national development priorities, defined by governmental plans and programs for different sectors. Technical cooperation programs and projects are developed along two major lines: horizontal cooperation and cooperation from abroad. Horizontal cooperation is the technical cooperation implemented between Brazil and other developing countries. Cooperation from abroad encompasses bilateral and multilateral technical cooperation services received.

There are basically three cooperation modes. According to the knowledge flow they can be classified as: (i) received cooperation services, meeting an internal need or demand; (ii) provided cooperation, meeting external needs and demands, and (iii) mutual cooperation, consisting in knowledge and product exchange, benefiting both parties. As far as its political outreach is concerned, cooperation is bilateral -between two countries' governments and institutions- or multilateral -when involving international organizations or several countries.

7.3.1. Received Bilateral or Multilateral Technical Cooperation

Brazil is a party to several bilateral or multilateral conventions and agreements. The Received Multilateral Technical Cooperation (Cooperação Técnica Recebida Multilateral - CTRM) agreements include: the agreement signed in 1959 with the IADB - Inter-American Development Bank; the agreement signed in 1984 with the IICA – Inter-American Institute for Cooperation on Agriculture; the agreement signed in 1992 with the European Economic Community; and the agreement signed in 1964 with the OAS – Organization of the American States. As far as Received Bilateral Technical Cooperation (RBTC) is concerned, Brazil has signed Agreements with the following countries: Canada,,France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, the United Kingdom, and the United States.

7.3.2. Technical Cooperation between Developing Countries/TCDC

Our country also has also signed technical cooperation agreements with other nations from different continents, as follows: a) Africa: Algeria, Angola, Benin, Cameroon, Cape Verde, Egypt, Gabon, Ghana, Guinea-Bissau, Ivory Coast, Mali, Morocco, Mozambique, Namibia, Nigeria, Kenya, São Tomé and Príncipe, Senegal, South Africa (under negotiation), Togo, Zaire and Zimbabwe; b) Latin America and the Caribbean: Argentina, Bolivia, Chile, Costa Rica, Colombia, Cuba, the Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay and Venezuela; c) Asia and Eastern Europe: China, Iraq, Israel, Kuwait, Lebanon, Palestine, Russia (under negotiation) Saudi Arabia, and Thailand.

7.3.3. Collaboration within the Southern Cone Common Market

The Southern Cone Common Market (MERCOSUR) was originally constituted by Brazil, Argentina, Uruguay and Paraguay, with Chile as a partner in plant health. The first step leading to its creation was the Program on Integration and Economic Cooperation signed by Brazil and Argentina in 1986. In 1991, the Asuncion International Treaty established December 31, 1994, as the date when the clauses governing relations between theses countries would entry into force. MERCOSUR major goals are: free circulation of products, services and means of production between member countries; suppression of customs duties and other hindrances to the circulation of economic factors; creation of a Common External Tariff (CET) to be applied to non member countries; coordination of member countries' common positions in regional and international economic forums; policy coordination: industrial, agricultural, fiscal, monetary, currency exchange, customs regarding foreign trade, transportation and communications; policy coordination aiming at ensuring reasonable competitive conditions between member countries; legislation harmonization in all above mentioned policy areas to facilitate economic integration of member countries; achieving economic stability and overcoming its member countries' typical underdevelopment. This "unification" affects germplasm exchange, as it has both a positive sense of free circulation benefiting all member countries and a negative aspect of lowering quarantine security, since non-tariff barriers tend, as all other barriers, to be more flexible.

7.4. COLLABORATION WITH CGIAR INTERNATIONAL CENTERS

The International Agricultural Research Centers under the Consultative Group on International Agricultural Research (CGIAR) are responsible, *inter alia*, for germplasm conservation and research on species selected according to their destination, with the major goal of minimizing hunger and poverty in tropical developing countries. Maintenance and distribution of germplasm collections to partners in the programs worldwide is the main role of these Centers Genetic Resources Units, considering that germplasm exchange is a very important activity for crop genetic breeding, in order to meet the always growing need for food in developing countries.

Within this group of institutions, CIAT, CIP, CIMMYT, IRRI, the International Institute of Tropical Agriculture (IITA), the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) coordinate the so-called "International Assays" of species under their competence. These assays are targeted to the breeding of those species, along different lines, and are organized to obtain two or more generations per year, with sowing season alternating in the two hemispheres. Assays are conducted in several countries simultaneously, and the outcomes of breeding actions are evaluated on a large scale, so achieving important progress and significant reduction of the time needed to obtain results.

But there is one major concern about this: materials the International Centers are working with originate from all over the world and are evenly distributed worldwide, so becoming potential means for the dissemination of quarantine pests. In view of this, each Center harbors Seed Health Units where relevant materials are examined. These procedures, however, even when carefully carried out, do not ensure that materials to be distributed are healthy; so, recipient countries are encouraged to quarantine materials coming from abroad. In Brazil, even though a large number of institutions participate in several assays, these materials are introduced through Embrapa Genetic Resources and Biotechnology, which has established a special scheme for phytosanitary analysis allowing our country to carry out these assays with a minimum risk of introducing new pests.

7.5. INTERNATIONAL TECHNICO-SCIENTIFIC COOPERATION PROGRAMS

Brazil is a member of the Inter-American Institute for Cooperation on Agriculture (IICA), whose purpose is to encourage and support agricultural development and the well-being of rural populations in its member countries. Therefore, Brazil participates in several programs, including PROCISUR, TROPIGEN and PROCITRÓPICOS.

PROCISUR is the Cooperative Program for the Agro-alimentary and Agroindustrial Technological Development of the Southern Cone Countries. It was created in 1980 with the goal to help building the regional system and contribute to innovation in its framework for the generation of knowledge and technologies, in a joint effort of national agricultural research institutions. The parties to this Program are Argentina, Bolivia, Brazil, Chile, Paraguay, Uruguay and the IICA. In 2000, a commitment was signed for the improvement of this program in order to incorporate into it the technological environment generated by globalization, economic opening and regional integration. On the medium term, work has been planned for 2001-2004.

PROCITROPICS is the Cooperative Program on Research and Technology Transfer for the South American Tropics. This program fosters the integration of research efforts made by agricultural institutions in Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, Venezuela and the IICA. Its goals are: the establishment of strategic alliances, identification, the development and monitoring of opportunities, and cooperation in strategic and priority actions for member countries. Furthermore, this program aims at developing the use of institutional information and resources, as well as at managing this information.

The Amazon Cooperation Treaty was signed in 1978 by Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela with the goal to foster joint actions aiming at the harmonious development of the Amazon. ACTO was created in 1995 in order to strengthen and implement its objectives. In 2002, the ACTO Permanent Secretariat was established, with its headquarters in Brasilia. This institution has worked on the common commitment to the preservation of the environment and the rational use of the Amazon natural resources.

The South American Program to Support Cooperation in Science and Technology – PROSUL was established in 2002. This program was set up by the Ministry of Science and Technology (Ministério da Ciência e Tecnologia- MCT), operated by CNPq and enacted by MCT Decree no. 872, December 20, 2001. This program is exclusively managed by the Brazilian Government, through the PROSUL Managing Committee, made up of representatives of the MCT and of the Brazilian science and technology community. It has the goal to provide support to cooperation activities in science, technology and innovation between Brazilian and South American groups toward the region's scientific and technological development for an improved quality of life.

In 1984, the Ibero-American Program of Science and Technology for Development (CYTED) was created. This is a multilateral cooperation program whose current theme areas are: agri-food, health, industrial development promotion, sustainable development, global change and ecosystems, communication and information technologies and science and society. Party countries are: Argentina, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Chile, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Portugal, Spain, Uruguay and Venezuela. CNPq (National Council of Scientific Research and Development) signed this agreement on behalf of Brazil.

The Atlantic Forest Program was created in the framework of the Brazil-Germany Cooperation Agreement with the following goals: inducing the generation and consolidation of a scientific and technological base allowing the inclusion of the environmental dimension into the Brazilian sustainable development process, ensuring capacity building of high-end research in Brazil, entering the international competitive scenario and fostering cooperation in bilateral projects. In Brazil, this program is carried out by CNPq; during its first phase (2001-2005) 7 projects were provided support whose outcomes led to extension of the program.

In December 2003, the establishment of the Theme Cooperation Program in Science and Technology – PROAFRICA was proposed. This was later instituted in Brazil by the Ministry of Science and Technology (MCT Decree 363, July 22, 2004) and is operated by CNPq. This program has the goal to enhance the scientific-technological capacity of African countries by funding movement of scientists and researchers working in selected projects. Initial priority cooperation actions concern Brazilian and Portuguese speaking African groups.

Based on Bilateral Agreements between Brazil and India, and Brazil and South Africa, the Trilateral Program for Scientific and Technological Cooperation (India, Brazil and South Africa - IBSA) was created by the MCT Decree 481, July 14, .2005. IBSA has the goal to provide support to cooperation activities in science and technology that, in turn, contribute, in a sustained way, to the scientific and technological development of the three countries. Themes to this end will be selected that contribute to improving citizens' quality of life. Theme areas include, most importantly, actions/projects related to HIV/AIDS, tuberculosis, malaria, biotechnology in health and agriculture, nanosciences and nanotechnology, as well as oceanographic sciences.

7.5.1. Brazil–Italy biodiversity program

An example of international program of technico-scientific cooperation is the Brazil–Italy Biodiversity Program. This is a bilateral cooperation initiative that aims at contributing to the

Brazilian government's efforts to enhance food security and poverty alleviation in poor regions through actions toward the conservation and sustainable use of agricultural and wild biodiversity for the benefit of the relevant biodiversity holders.

At the same time, this program is a joint effort of the two countries toward the implementation of the following priority points of the Convention on Biological Diversity (CBD): Cooperation (art. 5), *in situ* management (art. 8 j), sustainable use of components of biodiversity (art. 10a-c,and), incentives (art. 11), and research and training (art. 12), technical and scientific cooperation (art. 18.2,4-5); as well as the following priority points of the Global Plan of Action (GPA) adopted in Leipzig (International Technical Conference on Plant Genetic Resources) in 1996: *in situ* conservation (points 1, 2, 4), *ex situ* conservation (points 5, 7, 8); germplasm utilization (points 9, 12, 13, 14); institutional strengthening and capacity building (points 15, 16, 19).

This program's specific goal is to develop actions in four priority geographical areas toward the conservation and sustainable use of biodiversity, with the support of specific national actions, in the areas of applied research, training and development. This should be done with full participation of beneficiary communities and exclusively in their favor in order to achieve the following goals:

a. At the local level, the adequate and sustainable use of local biodiversity, promotion of local biodiversity-rich products and of the impact of these resources on income and quality of life of beneficiary groups through the appropriate use of technological and economic -market or other- incentives, and through research, training and awareness-raising;
b. At the national level, awareness-raising about the value of biodiversity for food security and rural poverty alleviation, as well as about the need for its sustainable preservation and use. This goal will be pursued by the means of an integrated set of transversal actions of analysis, communication, discussions and awareness-raising of the groups involved: researchers, decision-makers, public authorities, social, political and commercial stakeholders.

The program foresees the development of four projects in the field and one national level project of transversal actions. The four local level projects are listed in alphabetical order based on the initial of their best-known geographical location; the project of transversal actions was considered as resulting from these latter. The local level projects are:

1. Project 1 (Araripe): Sustainable Utilization of Biodiversity by Communities in the Araripe Ecoregion.
2. Project 2 (Cazumbá-Iracema): Cazumbá-Iracema Extractive Reserve: a model of conservation and sustainable use of biodiversity by traditional communities in the Amazon.
3. Project 3 (Krahô-Xingú): Ethno-biology and Conservation of Agrobiodiversity for the Promotion of Food Security and Sustainable Development of Communities in the Xingu Indigenous Park and Krahô Indigenous Territory (Tocantins).
4. Project 4 (Montes Claros): Sustainable management of agro-biodiversity in Cerrado and Caatinga environments.
5. Project 5 (Transversal): Cross-sectorial actions for the four local projects.

The four local projects (1 a 4) are being carried out by the two Brazilian implementing agencies, EMBRAPA and IBAMA, the former being responsible for the two projects targeted chiefly to agricultural biodiversity (Projects 3 and 4), and the latter by those concerning natural biodiversity (Projects 1 and 2). Both agencies, however, will participate in all four projects with various levels of intensity and interaction.

Non-Governmental Organizations participate chiefly in the three projects demanding more operational effort (1-2-4). These NGOs were identified and got involved during the participative design phase (with the exception of Project 2). These NGOs, which will actively participate in projects' actions, are meant to establish the link with local, rural and traditional communities, as well as to interlink them. Project 5 is implemented from Brasilia by the two Brazilian agencies, EMBRAPA and IBAMA, with the collaboration of Italian organizations specialized in research and training.

Following the three year period of work on the priority areas targeted by local actions in three biomes (Amazon, Cerrado and Caatinga), within six states (Acre, Goiás, Minas Gerais, Pernambuco, Piauí and Ceará), it is expected that:

- Beneficiary communities have completed the process of introduction of conservation and sustainable use of the strategic components of agricultural and/or natural biodiversity, with the goal to enhance their food, sanitary and income conditions, recovering such practices from their own traditions or borrowing them from other communities;
- Socio-technical intermediaries of field research actions have potentiated, in terms of theoretical knowledge and interactive experiences, as well as horizontal and vertical interactions, their ability to act as bridges between local, national and international scientific/technological communities, on the one hand, and beneficiary communities, on the other;
- Units and groups having carried out the integrated field work -namely EMBRAPA, IBAMA and the other participants involved (federal, state and regional universities, other local research and develop institutions)- have developed forms of participative work with local communities and the relevant socio-technical intermediaries, and initiated an exchange process involving formal and informal, advanced and traditional knowledge; and have also learned to value the social and solidarity dimension of their work.
- The Italian groups involved in cooperative research and development are aware of the great potential mutual benefit of technico-scientific cooperation with Brazilian partners to achieve goals shared by both countries that concern sustainable development based on each nation's natural and human resources, and open to exchange with the outside world;
- Political environments and policy-makers at the local and federal levels have favorably welcome the messages and proposals called forth due to the program outcomes, and that these latter represent a reference model for the design and/or modification of general, sectorial and local public policies.

7.6. EMBRAPA'S INTERNATIONAL COOPERATION

The diversity of agricultural research conducted by the various research centers within the Brazilian Agricultural Research Corporation –Embrapa- can be measured from the diversity of international technical cooperation agreements signed by the Corporation. Heretofore 275 agreements have been signed with 56 countries and 155 international research institutions, involving chiefly research in partnership. With the goal to enhance opportunities for international cooperation in agricultural research, as well as to keep up with scientific progress, trends and activities of interest for the agribusiness of some partner countries, Embrapa has implemented two virtual laboratories (Labex), the first one in the United States, in collaboration with the Agricultural Research Service (http://www.embrapa.br/a_embrapa/labex/labex-usa) and the second one in Europe (http://www.agropolis.fr/international/labex.html), in partnership with Agropolis, in Montpellier. Furthermore, two business offices have been established, one for Africa (located in Ghana) and the other one for Latin America (in Venezuela).

7.6.1. Cooperation in Plant Genetic Resources

The availability of the plant genetic resources needed for plant breeding activities is of paramount importance to the development and sustainability of the Brazilian agriculture.

The introduction of genetic material has flowed continuously in order to confer sustainability to the Brazilian agriculture, whose foundations are chiefly made up of products not originating from Brazil. Over the last years, in excess of 16,500 germplasm accessions have been introduced, mainly wheat (CIMMYT), soybean (United States, originally from from China and South Korea), cotton (United States), maize (repatriated by CIMMYT); chickpea (Germany), lentils (Germany), *Salix spp*. (England and Germany), *Oryza nivara,* nim, sunflower (Canada), castor bean (United States), ramie, Phaseolus (CIAT and Gembloux - Belgium), wild Glycine (Australia), sweet pea (Germany), sesame (United States) canola/colza (Canada), banana (Asia), citrus (United States and Europe), mango (Asia and United States), pomaceous (Canada, United States and Europe), prunoids (Mexico, United States and Europe), grape (México), among others.

Genetic resources of exotic forest species have been enriched with the importation from Australia of a collection of myrtaceous species made up of 107 accessions of *Angophora, Corymbia, Eucalyptus* and *Melaleuca* genera. *Eucalyptus* and *Corymbia* genera have also been introduced, with the following species: *E. grandis, E. saligna, E. viminalis, E. cloeziana, E. deanei, E. camaldulensis, E. pilularis, E. resinifera, E. pellita, E. tereticornis* and *Corymbia maculata*. A wide variety of arboreal species of conifers or exotic leafy species have also been introduced, in the form of seed, cutting or pollen. These included: *Abies grandis, Acer platanoides, Aesculus hippocastrum, Betula platyphylla, Carpinus betulus, Cedrus atlantica glauca, Cedrus deodar, Clematis viticella, Fagus sylvatica, Gingko biloba, Laurus nobilis, Mucuna deeringiana, Nyssa sylvatica, Liriodendron tulipeira, Pseudotsuga menziessii, Quercus coccinea, Sequoia sempervirens, Sequoiadendron gigantum, Araucaria cunninghamii,* clones de *Pinus taeda; Cryptomeria japonica, Fagus sylvatica,* Alamo Grisalho (*Populus tremula* x *Populus alba*), Khaya anthothec, among others.

The United States currently has the largest germplasm bank worldwide: the National Center for Genetic Resources Preservation, in Fort Collins (CO). Its conservation chambers hold about 500,000 germplasm accessions which the institution is almost completely free to exchange. Embrapa, through its Virtual Laboratory Abroad Program (Laboratório Virtual da Embrapa no Exterior - LABEX), funded by the World Bank and the Inter-American Development Bank, decided to launch, beginning in 2005, a wide collaboration with the Agricultural Research Service (ARS) in genetic resources. An Embrapa researcher works at the Laboratory in Fort Collins and, at the same time, promotes cooperation activities between Embrapa Units, ARS and American education and research institutions. Since the beginning of this collaboration, Brazil has received over 40,000 germplasm accessions originating from the NCGRP (soybean, rice, maize, sorghum, wheat). Furthermore, many bean, peach, plum, citrus, forage species, peppers, vegetables and medicinal plants accessions will be exchanged in 2009 and 2010, and Brazil will reciprocate and send Brazilian materials to ARS banks.

The Embrapa-ARS collaboration also makes it possible to carry out several research projects, such as long term conservation of species, cryopreservation conditions for sensitive species, studies on the conservation of recalcitrant species, etc. At the same time, a vast training program based on short duration internships (of up to six months) and postdoctoral programs allows Embrapa researchers to be up-to-date and trained in several American universities. The kind of cooperation described above will continue for an additional three to four year period, during which a number of other activities will be carried out, thus consolidating the collaboration between Brazil and the United States in genetic resources.

7.6.2. Embrapa Cooperation - Latin America and the Caribbean

Several priority areas have been defined for Embrapa's actions in Latin America and the Caribbean. Cooperation proposals are under evaluation and some actions/projects are already being implemented. Defined priorities include: the strengthening and structuring of agricultural research institutions; the transfer of feasible, economically attractive agricultural technology responding to the different agri-ecological regional environments in order to decrease food risk; the application of tools and technologies of geoprocessing, agro-climatic zoning, and others, develop by Embrapa; soil conservationist management; the provision of agricultural technologies in partnership with the Brazilian agribusiness abroad; partnerships in the establishment and maintenance of demonstration fields and validation tests in several countries; agroindustrial products and processes: cashew, tropical fruit growing, cassava, rain-fed rice, horticulture, maize, cotton, palm oil kernel, soybean, cattle raising, goat raising and sheep raising.

Cooperation with Argentina aims at the transfer of crops and techniques for potato breeding (beginning in 2008) and at the introduction and evaluation of the expression of the sunflower Hahb 10 transcriptional factor in soybean cultivars (under negotiation). With Bolivia, cooperation has the goal to support institutional and managerial development, beef and milk cattle raising, and vitiviniculture development in the Tarija region (under negotiation). Cooperation with Chile aims at the development of potato cultivars, for which the documents have already been signed. Capacity building in the management of tropical fruit agroindustrial production and processing in the Ecuadorian coastal area is already being implemented. Capacity building in integrated production, stressing the management of pests and diseases affecting tropical, Amazonian and Andean fruit species, as well as the development of agroproduction processes for biofuels are under negotiation. Work with Haiti is already ongoing and concern cashew processing and studies on vegetables.

Also ongoing are: training in tropical fruit production management, chiefly regarding mango, in Honduras; diversification and enhancement of tropical fruit growing in Jamaica; technology transfers regarding production and processing systems for cashew in Panama, Suriname and Guyana. Other actions involving fruit growing are ongoing, such as the agronomical management and processing of dwarf, giant and hybrid coconut in El Salvador. Cooperation projects with Venezuela are under negotiation and involve the production of seedlings and ecological coffee processing, and the development of alternative technologies for small scale citrus production and for cassava production. Capacity building and technology transfer projects are being implemented together with Paraguay. Regarding cattle breeding and reproduction for family farmers, these projects are at an early stage in this country. Capacity building in cattle genetic breeding and reproduction will be undertaken in Panama following the signature of technological cooperation projects.

El Salvador is demanding the transfer of technology for the production of ethanol, and Paraguay and Costa Rica, for the study of techniques for the production of biofuel raw materials. Technologies for the production and utilization of soybean have been targeted by cooperation; projects are being implemented in this area with Guyana and Cuba. The enhancement of vegetable production techniques in Costa Rican protected environments is already being implemented in cooperation with Embrapa, whereas other projects relating to temperate climate fruit, animal production and other technologies are under negotiation with Costa Rica, Guatemala, Nicaragua, Colombia and Cuba.

7.6.3. Embrapa Cooperation - Africa

Embrapa established a Business Office in Ghana following the decision by the Brazilian government to help strengthening African countries' technical-scientific capacity. Brazil has bilateral cooperation agreements with African countries in agriculture. (Table 14).

Furthermore, there are trilateral agreements already implemented or under negotiation. The institutions involved in trilateral agreements include: FIDA, JICA, AFDB (African Development Bank), ITTO/Ghana, IBSA Fund (India, Brazil and South Africa), consultants from the Bill Gates Foundation, FAO and FARA (Forum for Agricultural Research in Africa), as well as AGRA (Alliance for a Green Revolution in Africa), which has recently signed agreements with FAO, FIDA and FMA that aimed at fostering food production in Africa.

Discussions are ongoing toward Embrapa Agroenergy's involvement in projects still to be defined in the region that would be supported by the ECOWAS Bank.

7.7. COOPERATIVE EDUCATIONAL PROGRAMS

The Ministry of Education is highly active in the area of international cooperation, not only in the technical and financial sectors, but also toward the enhancement of education and capacity building human resources training aiming to strengthen the nation's capacity. In this regard, it participates in a number of international meetings and events, as well as in the United Nations global conferences, presenting the important progress achieved by Brazil in education.

Country	Type de Cooperation Offered/Situation
Angola	[1]Support to restructuring of the National System for Agrarian Research
Cape Verde	[1]Support to INIDA institutional strengthening [1]Support to Goat-sheep raising development [1]Support to the development of horticulture
Congo/Brazzaville	[2]Capacity building and technology transfer toward the modernization of the sugar-alcohol sector [2]Capacity building and technology transfer for African palm tree cultivation
Gabon	Sustainable development of cassava cropping
Ghana	Development of foundations for the establishment of agro-energy [1]Laboratory procedures in biotechnology and cassava genetic resources management [3]Development of forest tree cultures [3]Technology transfer in cashew production and processing systems
Guiné-Bissau	[3]Technology transfer and capacity building for food security and agribusiness development
Mozambique	[1]Project: support to development and strengthening of the Agricultural Research Sector/IIAM [1]Support to the development of horticulture and fruit growing [3]Construction of cisterns, underground dams, rainwater *in situ* harvesting and productive gardens in Gaza, Tete and Inhambane rural communities [3]Brazil-France project for training Mozambican technicians in conservation agriculture
Nigeria	[3]Tropical fruit and vegetable production and processing [3]Agroindustrial cassava production and processing
Kenya	[2]Bases for the establishment of bioenergy production [2]Introduction of agricultural technologies grain crop breeding [2]Development of cattle production capacity
Senegal	[3]Capacity building in beef and milk cattle production systems [3]Capacity building in the management of agroindustrial production and processing of rice and vegetables [2]Support to the national biofuels program
Sierra Leona	[2]Adding value to small farmers' agricultural products
Tanzania	[2]Cashew nut post-harvesting technologies improvement [2]Introduction of agricultural technologies for cassava and tropical fruits [2]Capacity building of Tanzania toward the implementation of conservation agriculture de conservation in soybean production systems [2]Introduction of vegetable post-harvesting technologies 2Development of cattle production capacity
Zambia	[2]Establishment of the agro-energy policy and its regulation [2]Capacity building of Zambia in the use of biotechnology as a tool for identifying and testing seed 2 Development of cattle production capacity [2]Promoting soil enrichment by the means of conservation agricultural practices

Table 14. Embrapa's Bilateral Cooperation in Africa

1 - Ongoing, 2 – Under discussion, 3 – Under review (Coordination ABC/MRE)

The Ministry of Education works in close coordination with the Ministry of Foreign Affairs in negotiating bilateral and multilateral education agreements, as these are the legal tools governing relations between countries in the framework of the international cooperation that enables Brazil to implement its foreign educational policy. At the bilateral level, this Ministry carries out productive cooperation with several countries, including the United States, Canada, Argentina, England, France, Spain and Germany. At the multilateral level, is closest relations are with international organizations, such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Organization of American States (OAS), the Organization of Ibero-american States for Education, Science and Culture (OEI), the Inter-American Development Bank (IADB) and the World Bank (BIRD), among others.

The Brazilian Ministry of Education is also active in international fora aiming at the integration of the educational area. Such is the case of the Meeting of Ministers of Education of the MERCOSUR member countries, the Conference of the Ministers of Education of the Portuguese Speaking Community, the Meeting of Ministers of Education of the Inter-American Council for Integral Development (of the OAS), the Ibero-american Conference on Education and the Summit of the Americas.

The National Council of Scientific Research and Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq), a research funding agency under the Ministry of Science and Technology, develops international programs that include bilateral and multilateral research projects. Both bilateral and multilateral cooperation agreements provide support to research, development and innovation projects in preferential areas, agreed upon by foreign funding institutions, with the goal to encompass a high number of missions by project and to encourage the participation of research groups. Both are intended to provide elements enriching the exchange of experiences between high level Brazilian and foreign researchers by the means of joint research projects and scientific events.

The importance of the Graduate Students Agreement Program (Programa de Estudantes-Convênio de Pós-Graduação - PEC-PG) cannot be overstated. This program, aiming at capacity building, allows foreign citizens from developing countries to pursue graduate studies in Brazilian higher education institutions. This cooperation activity applies only to countries having signed the Agreement on Cultural and Educational Cooperation with Brazil. PEC-PG provides scholarships for foreign citizens enrolled in master's or Ph.D. academic programs in Brazilian institutions accredited by the Coordination for the Improvement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES). These scholarships include, additionally, tuition exemption and the ticket back home following dissertation or thesis defense.

CHAPTER 8
ACCESS TO PLANT GENETIC RESOURCES AND SHARING OF BENEFITS ARISING OUT OF THEIR USE, AND FARMERS' RIGHTS

8.1. INTRODUCTION

In 1995, when the first National Report National was prepared, Brazil had just joined the World Trade Organization (WTO) and ratified the Convention on Biodiversity. Therefore, most of the legislation more closely related to access to and movement of genetic resources was still under discussion. Some of the older laws, such as those concerning plant health or environment, have been included into the legal framework built in the country since then. Today Brazil has a number of control mechanisms. Therefore, any intended utilization of genetic material, native and exotic alike, must comply with laws and delegated legislation in force.

So the use of plant genetic resources, understood as import, export, research and development, is especially regulated by the phytosanitary, environmental, access and benefit-sharing, as well as intellectual property, legislations.

8.2. ENVIRONMENTAL LEGISLATION

Today Brazil has a modern environmental legislation; several regulating standards having been enacted in recent years. Brazilian environmental legal framework for the use of plant genetic resources is made up of laws and delegated legislation including, importantly:

- Law no. 4,771/65 and Decree no. 5,975/06 (Forestry Code);
- Law no. 6,938/85 and Decree no. 99,274/90 (National Environmental Policy);
- Law no. 9,605/98 (Environmental Crime Law);
- Decree no. 6,514/08 (Infractions and administrative sanctions - Environment);
- Law no. 9,985/00 (National System of Nature Conservation Units).
- Decree no. 4,703/03 (National Biodiversity Policy);
- Decree no. 4,703/03 (National Biodiversity Committee);
- Law no. 11,105/05 and Decree no. 5.591/05 (National Biosecurity Policy);

Although the Brazilian Forestry Code has been adopted in 1965 through Law no. 4,771, it is often updated by the means of "Provisional Measures" and statutory laws. It was partially regulated by Decree no. 5,975/06.

Law no. 6,938/85 establishes the National Environmental Policy, its goals, as well as its formulation and enforcement mechanisms, the National Environmental System (Sistema Nacional do Meio Ambiente - Sisnama) and the Environmental Defense Register. The National Environmental Policy has the goal to preserve, improve and recover environmental quality fit for life in order to ensure the conditions allowing socioeconomic development, national security and protection of human life dignity in Brazil. Agencies and organizations within federal, state, Federal District and county administrations, as well as foundations established by these latter that are responsible for the protection and improvement of environmental quality make up the National Environmental System – SISNAMA. This Law was regulated by Decree no. 99,274/90.

Law no. 9,605/98 provides legal and administrative sanctions to behaviors and activities that damage the environment. Decree no. 6,514/08 provides infractions and administrative sanctions regarding the environment, establishing the federal fact finding administrative procedures to be implemented.

Law no. 9,985/00 established the National System of Nature Conservation Units – SNUC, defining criteria and standards for the creation, implementation and management of conservation units.

Decree no. 4,339/02 established principles and directives for the implementation of the National Biodiversity Policy. This policy has the general goal to promote, in an integrated way, conservation of biodiversity and sustainable use of its components, with fair and equitable sharing of the benefits arising from the use of genetic resources, components of genetic heritage and traditional knowledge associated to these resources. It includes seven thematic components: (i) biodiversity knowledge; (ii) biodiversity conservation; (iii) sustainable use of biodiversity components; (iv) monitoring, evaluation, prevention and mitigation of impacts on biodiversity; (v) access to genetic resources and traditional knowledge on biodiversity, as well as benefit-sharing; (vi) education and public awareness, and (vii) legal and institutional strengthening toward biodiversity management.

Decree no. 4,703/03 changed the name of the National Biodiversity Program to National Biodiversity Committee – CONABIO, defining its structure as a matrix, with seven thematic components (the same as in the National Biodiversity Policy) and seven biogeographical components (Brazilian biome sets: Amazon; Caatinga, Costal and Marine Areas; Atlantic Forest and Southern Fields; Cerrado and Pantanal).

Law no. 11,105/05 established security standards and inspection mechanisms applicable to activities involving genetically modified organisms (OGMs) and their derivates. Furthermore, it created the National Council for Biosecurity (Conselho Nacional de Biosegurança – CNBS) through the restructuring of the National Technical Committee for Biosecurity (Comissão Técnica Nacional de Biossegurança – CTNBio). This Law provides the National Biosecurity Policy and was regulated by Decree no. 5,591/05.

8.3. ACCESS AND BENEFIT-SHARING

Awareness about the economic importance of biodiversity and the need for its conservation and sustainable use are relatively recent among the international community. Increasing awareness and concern led to the establishment of an international legal framework, in which stand out the Convention on Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

Following the entry into force of these instruments, research institutions using native biodiversity and/or associated traditional knowledge have been induced to introduce the necessary changes into their activities. In order to conduct research involving access to genetic resources, as well as to send materials abroad with research purposes, institutions are required to have a government permit, issued by a national authority. Access to and availability of associated conventional knowledge are now regulated and require holders' previous approval and a government-issued permit. Table 15 lists the number of requests submitted to the national authority, in this case represented by CGEN and IBAMA.

Table 15. Permit requests to access genetic heritage submitted to the Council for the Management of Genetic Heritage (CGEN) and IBAMA.

Requests	Year							
	2002**	2003	2004	2005	2006	2007	2008	Total
On file****	66	67	43	44	82	41	27	368
Granted	0	0	4	13	20	21	10	69
Renewed	-	-	0	0	1	4	-	5
Accredited	5	13	29	27	9	6	3	92
IBAMA***	-	n.a.	n.a.	50	62	n.a.	n.a.	

*Includes simple and special permit requests to access genetic heritage for scientific research; after Det. 40 of 09/23/2003, these came within the competence of IBAMA; **including accreditation requests; ***number of requests related only to plant genetic resources; n.a. – not available (data updated as of 09/23/2008)

Permits must be obtained previously to access and/or transfer, and are granted only to national institutions conducting research and development activities on biology and similar areas, as provided by Provisional Measure no. 2,186-16/01 and other legal instruments. Permits may be simple or special. The difference between them stems from their object - access to genetic heritage or to associated conventional knowledge- and from their purpose –scientific research, bioprospection or technology development.

Permit demands for scientific research purposes can be filed with the Brazilian Institute for Environment and Natural Renewable Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA), registered with CGEN in 2003 and recently restructured as the Chico Mendes Institute. Permits involving access to associated traditional knowledge or that will be used with the goal to perform bioprospection and/or technology development must be filed directly with the CGEN.

There are general conditions to be observed for permits, whatever their purpose, such as institutional corroboration, research project and deposit of samples at an accredited institution. Specific requirements are established according to the permit's purpose.

The Brazilian legal framework for access to genetic resources and associated traditional knowledge is made up of laws and delegated legislation including, importantly:

- Statute no. 2/94 and Decree no. 2,519/98 (Convention on Biological Diversity);
- Provisional Measure no. 2,181-16/01 and Decree no. 3,945/01 (Access to Genetic Resources and Associated Traditional Knowledge);
- Statute no. 70/06 and Decree no. 6,476/08 (International Treaty on Plant Genetic Resources for Food and Agriculture),
- Decree no. 5,459/05 (administrative sanctions disposed by the Access Provisional Measure);
- Resolutions, determinations and technical guidelines issued by the Council for the Management of Genetic Heritage (CGEN).

The Convention on Biological Diversity (CBD) was approved by the Brazilian Parliament through Statute no. 2/94 and incorporated into the national legislation by Decree no. 2,519/98. The Brazilian government deposited the instrument of ratification of the Convention on February 28, 1994; it entered into force in Brazil in May 29, 1994, as disposed by its article 36.

The legal framework developed for the implementation of CBD regarding access to genetic resources and associated conventional knowledge involves a number of not easily understandable technical, legal and economic aspects. The legislation includes specific points, such as building previous consent with indigenous, local or *quilombola* communities; negotiating contracts for the use of components of genetic heritage and associated conventional knowledge and benefit-sharing; and controlling the transfer of germplasm and of associated traditional knowledge.

Also related to access and benefit-sharing, but concerning specifically plant genetic material for food and agriculture, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) was approved by the Brazilian Parliament through Statute no. 70/06 and enacted by Decree no. 6,476/08. The Brazilian government deposited the instrument of ratification on May 22, 2006; it entered into force in Brazil in August 21, 2006, as provided by its article 28.

8.3.1. Provisional Measure Concerning Access to Genetic Resources and Associated Traditional Knowledge

Early initiatives to regulate this matter in Brazil date back from 1995, with a Bill introduced by Senator Marina Silva (Bill 306/95). In the following legislative process, a reviewed version of this Bill introduced by Senator Osmar Dias was adopted by the Senate in 1998 (Bill 4,842/98). Two other two Bills, sponsored by the Representative Jaques Wagner and by the Executive, respectively, were also forwarded to the House of Representatives that same year, (Bill 4,579/98 and Bill 4,751/98, respectively). The Proposed Constitutional Amendment No. 618/98 was introduced together with the Executive's Bill. While all these Bills were being debated by the House, a contract signed in 2000 between a Social Organization -Bioamazônia- and the Novartis Corporation was publicly disclosed and considered unacceptable by both the society and the Presidential Chief of Staff. Realizing that this matter would not be legislated urgently, the government resorted to one legal tool to swiftly enact a new Law, the Provisional Measure. Once this was done, the text was reviewed and modified several times before reaching its final version in Provisional Measure 2,186-16/01, still in force.

Provisional Measure no. 2,186-16, of August 23, 2001, regulates articles 1, 8, section "j", 10, section "c", 15 and 16, sections 3 and 4 of the Convention on Biological Diversity, with the goal to *provide access to genetic heritage, protection of and access to associated conventional knowledge, benefit-sharing and access to technology, as well as technology transfer aimed at its conservation and use*. This Provisional Measure has the goal to regulate rights and obligations concerning access to components of the genetic heritage and to the associated conventional knowledge for purposes of scientific research and technology development, bioprospection or conservation for their industrial or otherwise application.

The expression "Genetic Heritage" is used to designate genetic resources, in the strict compliance with the provisions established by the Brazilian Constitution in its article 225, subparagraph II. According to this definition, the Genetic Heritage encompasses the whole biodiversity originating from the country. Nevertheless, is it restricted enough not to confuse genetic heritage with other resources used in economic activities such as, for instance, those involved in agriculture and agribusiness (domestic animal husbandry, grain, vegetable and fruit growing), timber, fisheries and others. So, it is broad enough to ensure the desired protection, but narrow enough so as not to interfere in lawful and essential activities for the country's economy, such as agriculture, industry and trade.

Regarding knowledge associated to components of the genetic heritage, only the conventional knowledge is included. It does not claim to encompass either passport data pertaining to harvesting or characterization data or modern technologies linked to materials, not even those protected by intellectual property rights. The concept of conventional knowledge associated to genetic heritage it adopts means individual or collective information or practices of a local or indigenous community with actual or potential value. This legal text also includes the idea that this community-based knowledge associated to components of the genetic heritage has existed continuously, for generations; this allows its application only in the case of communities that actually hold this knowledge, not allowing opportunistic appropriations that might directly or indirectly vitiate recognition and benefit-sharing.

Provisional Measure no. 2,186-16/01 grants holders' right to decide on access of third parties to conventional knowledge associated to components of the genetic heritage. Therefore, the free will of local and indigenous communities is guaranteed, and cultural characteristics that will define, on a case by case basis, whether the aforementioned knowledge should be disseminated or not are respected.

In order to ensure improved control and, at the same time, promote the development of lawful access activities in the country, Provisional Measure no. 2,186-16/01 establishes that access permit to samples of components of genetic heritage be exclusively granted to a public or private national institution performing research and development on biology or similar areas. Foreign institutions interested in access samples of components of genetic heritage should associate with the national public institution that will mandatorily coordinate these activities.

The absence of an international regime or standard ensuring the compliance of the national legislations of all party countries to the Convention on Biological Diversity and the application of the principles of fair and equitable sharing of benefits arising from the utilization of samples of the genetic heritage accessed has induced the option for contracts, the only current way to enforce the Law, which must apply to Brazilian and foreign citizens alike.

The Contract for the Utilization of Genetic Heritage and for Benefit-sharing is signed by the research institution and the provider or providing institution, and must be approved by the Federal Government, represented by the authority ensuring the enforcement of this Law. Should the stakeholder institution obtain or invent a process or a product whose obtainment or variation derives from the accessed component of the genetic heritage, it should share the benefits eventually obtained.

Benefit-sharing can take various forms, negotiable on a case by case basis by the research institution that signs the Contract for the Use of Genetic Heritage and Benefit-sharing. These forms include: benefit or royalties-sharing; technology transfer; product and process licensing, free of charge, for Brazil; and capacity building.

Provisional Measure no. 2,186-16/01 bestows on the federal government the competence to establish standards, grant permits and inspect access and utilization of genetic resources. It creates, under the Ministry of Environment, the National Council for the Management of Genetic Heritage, made up of federal agencies' representatives. It is regulated by two Decrees enacted in 2001 and 2005 - Decrees no. 3,945 and no. 5,459, respectively.

Decree no. 3,945 was modified by three subsequent decrees: Decree no. 4,946, December 31, 2003; Decree no. 5,439, May 3, 2005; and Decree no. 6,159, July 17, 2007. Decree no. 4,946/03 deeply modified Decree no. 3,945/01 regarding requirements to obtain access and transfer permits provided by Provisional Measure no. 2,186-16/01. It added a new special permit mode for accessing genetic heritage with the purpose to constitute and integrate *ex situ* collections for activities with potential economic use, such as bioprospection or technology development. Decree no. 5,439/05 introduced only punctual modifications into composition and quorum of the Council for the Management of Genetic Heritage. Decree no. 6,159/07 regulated special permits for bioprospection and allowed contracts to be filed after application for access permits are filed.

Decree no. 5,459, of June 7, 2005, disciplines sanctions applicable to behaviors and activities that damage the genetic heritage and associated conventional knowledge. Following its enactment, institutions performing research using components of the Brazilian biodiversity without the Council for the Management of Genetic Heritage's authorization are liable to administrative proceedings which can cause the establishment to be shut and subject to fines.

8.3.2. Access and Transfer Activities regulated by the Law in force

The access and transfer activities that are regulated by Provisional Measure no. 2186-16/01 and that require a permit issued by the Federal Government are those which use:

- Native animal, microbial, fungi or plant materials, or exotic domesticated material which have developed characteristic properties;
- Traditional knowledge associated to genetic resources held by local or indigenous communities.

It should be stressed that access permits are not required for access activities using materials from international banks or foreign countries, as long as not harvested in Brazil. Associated traditional knowledge are individual or collective information or practices of a local or indigenous community that have actual or potential value and is associated to genetic heritage.

In addition to these first two requirements, access activities are required to use information on genetic origin and must be carried out with research, bioprospection or technology development purposes.

For the transfer of genetic heritage components samples to foreign countries, a previous Material Transfer Agreement (MTA) in compliance with specific conditions must be signed by legal representatives of the relevant institutions. MTA is the instrument the recipient institution must sign prior to any transfer of genetic heritage components samples; MTA should indicate if associated conventional knowledge was accessed.

The transport of genetic heritage components samples to foreign countries requires a previous Material Transport Agreement (MTrA), signed by legal representatives of the institutions involved and in compliance with specific conditions.

Following the adoption of the FAO International Treaty on Plant Genetic Resources for Food and Agriculture, species in the Multilateral System on Access and Benefit-sharing (listed in its Annex I) are utilized in compliance with standards established by the Governing Body, pursuant to article 19 of Provisional Measure no. 2,186-16/01. It must be stressed that Brazil is one of the few, or the only country whose legislation, specifically adopted for the implementation of the CBD, already took into account in 2000 the future implementation of FAO International Treaty, which was then under discussion. Article 19 allowed the country to implement the International Treaty without having to enact new specific legislation, thus avoiding conflicts like those facing, for example, countries in the Andean Community of Nations.

8.4. INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Since June 2008, when the International Treaty was enacted, public institutions can use the instrument approved by its Governing Body (in which Brazil participates), the Standard Material Transfer Agreement (SMTA), as a basis for the movement of genetic material included by the parties in the Multilateral System. This same instrument includes rules to which signatory institutions adhere for sharing benefits from the commercialization of products derived from any materials in the Multilateral System. Simple as it may seem, the implementation of the Treaty is still incipient in Brazil due to its recent enactment. Since SMTA use is controlled based on annual reports to be submitted to FAO, which is the third party beneficiary and monitors the implementation of the SMTAs, there are no national controls either of its use or of its possible impact on agricultural research. Embrapa data indicate that five instruments have been signed with CGIAR International Centers for the introduction of germplasm and three are being prepared toward the transfer to African institutions of genetic material being developed.

Dissemination of this Treaty and building capacity of public and private institutions for its implementation come within national authorities' competence. The Ministry of Agriculture, Livestock and Food Supply and the Ministry of Environment expect to strengthen these activities from 2009 on, since first it was necessary to allocate *ad hoc* financial funds to the relevant institutions. As a public institution directly responsible for the conservation of genetic resources (see CHAP. 5), Embrapa started joint work with the Secretariat of the International Treaty toward the development and test of an online information system on germplasm available within the Multilateral System. Several Embrapa and Biodiversity International technical staff members took part in this effort, whose results were presented during the Second Meeting of the Governing Body. Embrapa Genetic Resources and Biotechnology was required to take an inventory with the cassava (*Manihot esculenta*) germplasm active banks in order to select accessions and relevant information, which will be available in 2009, in the framework of the Multilateral System. During 2008, accessions were multiplied and are being taken to *in vivo* culture so as to be more readily available. Over the next years, the same procedure will be applied to each one of the species the

Brazilian authorities have defined as priorities in order to fulfill the country's obligations in the framework of ITPGRFA. New efforts will continue to be made in conjunction with the Secretariat of the Treaty with the goal to progress and accumulate experience in the implementation of this instrument, at both national and international levels.

8.5. FARMERS RIGHTS

Brazil has not yet passed specific legislation regulating farmers' rights, which, it should be reminded, stem from the recent (2006) ratification by Brazil of the International Treaty on Plant Genetic Resources for Food and Agriculture. Pursuant to the Treaty, parties should recognize farmers' rights, compensating local and indigenous communities, as well as farmers, for their contribution to conservation and development of local, traditional or creole varieties in conventional agricultural systems, and for all important traditional knowledge associated to plant genetic resources for food and agriculture. This Legislative drawback lead to an analysis of the measures to be taken for the protection and promotion of these rights, included in other legislations, relative to the three elements on article 9.2, (a), (b) and (c) of the International Treaty, in other words, protection of conventional knowledge, benefit-sharing and participation in decision-making processes; and on article 9.3, concerning farmer's rights to save, use, exchange and sell seed or propagating material.

Resolution no. 3 of the Nairobi Conference for the Adoption of the Convention on Biological Diversity text, about *The interrelationship between the Convention on Biodiversity and the Promotion of Sustainable Agriculture*, recognized the need to give special treatment to plant genetic resources for food and agriculture, which was done through the International Treaty. This is an ongoing process. Meanwhile, Provisional Measure 2,186-16/01, as it regulates some of the provisions of the Convention on Biological Diversity, addresses the protection and access to this traditional knowledge in a broad fashion, though lacking specific thematic distinctions.

Article 9.1 of the International Treaty concerns local and indigenous communities and farmers. Therefore, it will be studied by public policy-makers, who may or may not consider persons practicing extractive activities as beneficiaries of farmers' rights. According to the definition included in the Rural Credit Handbook for Family Agriculture 2004-2005, by the Ministry of Agrarian Development, a person practicing extractive activities is a *rural producer in exploitation systems based on sustainable harvesting and extraction of renewable natural resources* (http://www.pronaf.gov.br/plano_safra/2004_05/docs/MANUAL%20DO%20PLANO%20SAFRA%20%2004%2005.doc). As such, they are beneficiaries of rural credit facilities made available by the National Program for Strengthening Family Agriculture (Pronaf), as are indigenous peoples and *quilombolas*, inasmuch they meet this program's requirements. These latter include the provision that they should be family farmers and obtain a minimum percentage of their yearly gross family income from agricultural, not livestock, activities developed on their land (http://www.mda.gov.br/saf/index.php?sccid=1243). Therefore, Brazil already has a whole recognition framework of farmers which could be included in the future specific legislation.

Regarding benefit-sharing, the second measure proposed by ITPGRFA for the protection and promotion of farmers' rights, it is worth mentioning that the facilitated access to Annex I plant genetic resources and their associated information is considered an important benefit *per se*, as this increases opportunities for the society as a whole to obtain better food products. Clearly, the most outstanding benefit to be gained from it is the availability of new varieties to farmers and, as a consequence, to the market.

The International Treaty is relatively recent and its implementation is in its early stages in Brazil. Hence, there are no concrete benefit-sharing cases so far to be reported relating directly to farmers' rights arising from the use of plant genetic resources for food and agriculture after the implementation of the Multilateral System.

The third measure proposed by the International Treaty relates to farmers' participation in decision-making processes. In this sense, Law no. 8,171/91, providing agricultural policy, already includes among its goals the actual participation of all rural stakeholder groups in the definition of the course of the Brazilian agriculture. Furthermore, it establishes that agricultural planning should be pursued in a democratic and participatory way, based on national multi-year agricultural development plans, as well as on yearly harvest and operational plans (articles 3 and 8).

Municipal, State and National Councils for Rural Sustainable Development, which are part of the National Program for Strengthening Family Agriculture and include family farmers' representatives or representing institutions, are instruments of guidelines proposal toward the design and the implementation of public policies, as well as of connection between government and civil society organizations (http://www.mda.gov.br/saf/index.php?sccid=1243).

Another essential aspect of farmers' rights is the guarantee they should be granted of their freedom to save, use, exchange or sell seed or propagating material they save (article 9.3). In this respect, it is often mentioned that the Law for cultivars protection (Law no. 9,456/97) grants the so-called "farmers' privilege or exception", which already guarantees these rights.

This legislation indeed grants the rural producer the right to propagate protected cultivars seeds, for donation or exchange, pursuant to requirements it describes, as well as to save and plant seeds for their own use or to sell their crop as food or feedstock, except for propagation, without violating property rights over cultivars protected under this law (article 10). Nevertheless, such guarantees are related to the use of their own improved and protected cultivars, not of creole varieties; no rights are granted over non-protected varieties.

Such guarantee, only regarding the exchange of local, conventional or creole cultivar seeds and seedling between family farmers, is granted by the so-called Seed Law (Law no. 10.711/03). This same Law, as it requires farmers or farming businesses practicing the aforementioned activities with seeds and/or seedlings, exempts from register family farmers, settlers involved with agrarian reform and indigenous persons who propagate seeds and seedlings for distribution, exchange or commercialization with each other. It also exempts these same groups from the obligation of registering their cultivars with the National Cultivar Register (articles 8, § 3, 11, § 6 and 48).

8.6. INTELLECTUAL PROPERTY

Brazilian legislation on intellectual property rights related to plant genetic resources has two constituents: industrial property and cultivars protection. Pursuant to Patent Law, genetically modified microorganisms, as well as processes, may be patented as genes resulting from genetic engineering. Higher plants species are protected under the Cultivar Protection Law.

Major legal instruments include:

- Law no. 9,279/96 (Industrial Property);
- Law no. 9,456/97 and Decree no. 2,366/97 (Cultivars Protection);
- Statute no. 30/94 and Decree no. 1,355/94 (Trade-related Intellectual Property Rights Agreement);
- Statute no. 28/99 and Decree no. 3,109/99 (International Convention for the Protection of New Varieties of Plants).

The Trade-Related Intellectual Property Rights Agreement (TRIPS), Annex 1C of the Marrakech Treaty, was adopted in Brazil through Statute no. 30/94, which incorporated the Final Proceedings of the Uruguay Round of GATT Multilateral Trade Negotiations; this Statute was ratified by Decree no. 1.355/94.

The International Convention for the Protection of New Varieties of Plants, adopted in December 2, 1961, reviewed in Geneva on November 10, 1972 and on October 23, 1978, was approved by Statute no. 28/99 and enacted by Decree no. 3.109/99.

Law no. 9,279/96 regulates rights and obligations relative to industrial property by the granting of patents for inventions and for utility models, industrial design register, trademark register, repression of fake geographical indications and repression of unfair competition. The Brazilian legislation does not consider living beings, in whole or in part, as patentable, exception made for transgenic microorganisms meeting the three patentability requirements -novelty, inventive step and industrial application- and that are not a mere discovery. The national law enforcement authority in this case is the National Industrial Property Institute (www.inpi.gov.br), under the Ministry of Development, Industry and External Trade.

Protection of intellectual rights over cultivars is granted by the means of a cultivar protection certificate, pursuant to Law no. 9.456/97. This certificate is the only form of cultivar and right protection that could thwart free authorization of plants, in whole or in part, propagation or vegetative multiplication in the country. Decree no. 2,366/97 regulates the aforementioned Law and provides the National Service for Cultivar Protection (SNPC), under the Ministry of Agriculture, Livestock and Food Supply.

Since the creation of the National Service for Cultivar Protection in 1998, 1,628 protection applications have been filed, of which 1,284 have been granted; of these latter, 1,118 certificates have not yet expired. Established in 2006, the National Laboratory for Analysis, Differentiation and Characterization of Cultivars, under the Ministry of Agriculture, Livestock and Food Supply (LADIC/MAPA) is in charge of protected cultivars storage in its cold chambers at -20°C. As of November 2008, the cultivar bank included 821 samples forwarded by private sector companies, state level research companies, and universities, as well as by Embrapa itself, as displayed on Table 16. The difference between the number of stored cultivars and the number of cultivars for which protection is currently in force represents cultivars that cannot be kept at -20℃ and are held by breeders under MAPA control.

The implementation of the cultivar protection legislation is considered successful by breeders of new cultivars. It is a big step toward the development of higher quality seed domestic market, including in this effort the public and private sectors alike.

Table 16. Number of protected cultivars store at MAPA, by holding institution.

Cultivar	Embrapa	Private sector	State Research Institutions	Universities	TOTAL
Pineapple	3	-	-	-	3
Lettuce	-	15	-	-	15
Cotton	22	33	-	-	55
Rice	32	24	5	-	61
Oats	-	5	1	1	7
Brachiaria	1	-	-	-	1
Coffee	-	-	1	-	1
Tanzania grass	-	1	-	-	1
Elephant grass	-	1	-	-	1
Onion	1	-	-	-	1
Carrot	-	3	-	-	3
Barley	4	-	-	-	4
Sweet pea	-	2	-	-	2
Beans	13	6	6	-	25
Pigeon pea	1	-	-	-	1
Green beans	-	2	-	-	2
Macrotyloma	-	1	-	-	1
Millet	-	5	-	-	5
Maize	28	4	-	3	35
Soybean	145	314	15	14	488
Sorghum	12	2	2	-	16
Wheat	33	47	9	-	89
Triticale	3	1	-	-	4
Total	298	466	39	18	**821**

8.7. PLANT HEALTH

The introduction of plant genetic resources in Brazil to commercial or scientific purposes is regulated by laws and delegated legislations. Major legal plant health instruments include:

- Decree no. 24,114/34 (Regulation of Plant Sanitary Defense);
- Decree no. 5,759/06 (International Convention for the Protection of New Varieties of Plants).
- Law no. 7,802/89 and Decree no. 98,816/90 (Agro toxics);
- Rulings of the Ministry of Agriculture, Livestock and Food Supply: Ruling no. 6/05, Ruling no. 14/05, Ruling no. 23/04 (Pest Risk Analysis);
- Rulings of the Ministry of Agriculture, Livestock and Food Supply: Ruling no. 1/07, Ruling no. 13/06, Ruling no. 16/06, Ruling no. 29/07, Ruling no. 37/07, Ruling no. 42/06, Ruling no. 41/06, Ruling no. 1/00, Ruling no. 9/06, Ruling no. 23/07, Ruling no. 32/06, Ruling no. 23/08, Ruling no. 16/03, Ruling no. 3/08, Ruling no. 2/07, Ruling no. 5/08, Ruling no. 48/07, Ruling no. 17/05 (Pest Prevention and Management);
- Rulings of the Ministry of Agriculture, Livestock and Food Supply: Ruling no. 1/98, Ruling no. 14/05, Ruling no. 23/04 (Plant Quarantine);
- Rulings of the Ministry of Agriculture, Livestock and Food Supply: Ruling no. 54/07, Ruling no. 55/07 (Plant Circulation).

Decree no. 24,114/34 approves the Regulation of Plant Sanitary Defense and establishes rules for plant and plant parts export and import, as well as measures needed for surveillance, eradication, treatment, inspection, points of entry/exit, quarantine, etc.

It is mandatory that any plant material introduced for research in the country undergo post-entry quarantine either at the Brazilian Agricultural Research Corporation or the Campinas Agronomical Institute, both accredited by the Ministry of Agriculture, Livestock and Food Supply. This often continues to be a major bottleneck for research development and enrichment of germplasm banks. Insufficiently trained staff and lack of facilities have hindered process fluidity. More investment is needed, chiefly because the same services have to be shared with the private sector, whose demand has notably increased in recent years.

However, despite lack of adequate facilities, quarantine services report entry and exit of a very significant number of accessions, which means that plant breeding programs and strategic genetic material conservation projects, which depend on circulation and access to new materials, continue to be quite active in different Brazilian public and private institutions.

According to the last report issued by the relevant Embrapa sector, between 2005 and 2007 alone 967 procedures for addressing germplasm exchange requests were opened. Embrapa received 891 materials for analysis, and 538 products could be approved. The remaining was condemned due to contamination with quarantine-important pests. Between 1977 and 2006, in excess of 500 thousand accessions circulated. Of the 1,730 pests detected over the last two years, 95 are alien to the country. Based on yearly averages, we can say that over 15 thousand pests have been identified since this work began. These data reveal the vastness of this work, as well as the continuous need to optimize protocols used for pest identification and diagnosis, which are absolutely crucial for the security and protection of the Brazilian agriculture.

8.8. OTHER APPLICABLE LEGISLATION

Beyond hereinabove legislation, other with an impact on conservation and sustainable use of plant genetic resources include, especially:

- Law no. 10,711/03 and Decree no. 5,153/04 (Seed and Seedling);
- Decree no. 6,041/07 (Biotechnology Development Policy).

Law no. 10,711/03 provides the Seed and Seedling National System (SNSM), which has the goal to ensure the identity and quality of the propagation and multiplication material of plants produced, marketed and utilized nationwide. It was regulated by Decree no. 5,153/04 and by rules of practice, rulings and decrees of the Ministry of Agriculture, Livestock and Food Supply:

The Seed and Seedling National System has the following activities within its competence: National Seed and Seedling Register (Renasem); National Cultivar Register (RNC); seed and seedling production; seed and seedling certification; seed and seedling analysis; seed and seedling commercialization; inspection of seed and seedling production, processing, sampling, analysis, storage certification, transport and commercial; seed and seedling utilization.

The National Cultivar Register is the register of cultivars fit for seed and seedling production, commercialization and utilization nationwide.

The Seed and Seedling National Register stores registrations of persons or companies that carry out seed and seedling production, processing, packaging, storage, analysis, trade, import and export.

Decree no. 6,041/07 institutes the Biotechnology Development Policy, creating the National Biotechnology Committee. The Biotechnology Development Policy has as its goals to establish an adequate environment for the development of innovative biotechnological products and processes, to encourage an improved efficiency of the Brazilian production structure, to increase the innovation capacity of Brazilian companies, to assimilate technologies, to generate business and to increase exports.

Among priority sectors for the Biotechnology Development Policy, agriculture stands out. The directive applicable to this area concerns encouraging the generation of strategic agricultural products in order to attain new levels of competitiveness, as well as food security; this is to be achieved by the means of product differentiation and introduction of innovations that allow penetration into new markets.

The Growth Acceleration Program (Programa de Aceleração do Crescimento – PAC) was adopted in 2008 by President Luiz Inácio Lula da Silva’s Administration and is due to be implemented until 2010. Based on the support PAC shall provide innovation with, different Brazilian research areas are expected to update their laboratories and hire more personnel. In order to respond to opportunities opened by the expansion of the food and biofuel markets, Brazil should increase its grain and feedstock production, which is closely dependent on the offer of new varieties, more adapted to biotic and abiotic pressures. In spite of a few sensitive spots, the Brazilian legislation on this matter is sufficiently robust to support these activities.

CHAPTER 9

THE CONTRIBUTION OF PGRFA MANAGEMENT TO FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

9.1. INTRODUCTION

Sustainable development is one of the most challenging goals for humankind, and especially for Brazil. Throughout centuries, the country's development model has evolved from extractive activities and subsistence agriculture to an intensive agroindustrial exploitation based on modern technologies and, in many instances, disorderly territory occupation and utilization of environmental resources, which put the rich Brazilian biodiversity at risk.

This pressure tends to intensify in the future due to the country's agricultural calling. Therefore, Brazilian agriculture, which has been our most responsive economic sector over the last decade, is under a pressure for growth and expansion that is not quite compatible with the time and efforts needed to steer it toward more sustainable production models. Hence, it is hard to imaginable how technological progress based on conventional innovation strategies could allow Brazil to take important leaps toward increasingly safer and sustainable systems in a short period of time.

Conversion models, often relying upon solutions stemming from the environment itself, should be searched for that will make these activities less harmful. To a certain extent, the Brazilian agriculture shows examples of how it is possible to make progress toward this goal. Brazil is a leader in crop management based on direct planting, which significantly helps decrease erosion and improve general soil quality and groundwater recharge. Biological nitrogen fixation, through inoculation technique with endophytic diazotrophic bacteria, has led to a significant decrease in the amount of chemical fertilizers applied to crops such as soybean and, more recently, sugar-cane. This, in turn, has significantly reduced environmental impacts such as, for example, water resources contamination with nitrates or other harmful elements. Biological control, regularly used in a number of crops such as soybean, sugar-cane, cotton and fruit-bearing plants, has also reduced the need for chemical pest and disease control in several management systems, which has a positive impact on environment, rural workers' quality of life and products' safety and quality. Finally, the great success of genetic breeding programs is worth mentioning. Over the last decades, these programs have proved it possible to mobilize genetic variability in order to adapt crops to very variable environmental conditions in the tropics. This is 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.

Due to the diversity and complexity of the Brazilian agriculture, however, we must bear in mind that, though relevant, this progress will hardly suffice to increase this activity's sustainability in the future. When assessing the Brazilian agriculture as a whole, there is clear evidence that conventional technologies are no longer able to solve all problems, and that they take a toll on the environment and on human health, especially due to their intensive use of chemical inputs. The increase in productivity during the 60s, 70s and 80s, stemming from genetic breeding, input application and improved crop management, did not persist in the 90s, signaling a gradual downward turn in the effectiveness of technological solutions based on the Green Revolution paradigm.

On the other hand, the technological standards of global agribusiness are now being substantially modified by the introduction of new technologies brought forth by recent progress in scientific knowledge. 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 shape up a new technological standard. These requirements include chiefly: a) attention to the environmental services needed to enhance the sustainability and productivity of the agricultural 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 industrial branches, so broadening the genetic resources' scope of usefulness and, additionally, creating opportunities for agriculture to increase its participation in the rising bioindustry.

In this context, the efforts will be constantly intensified to enhance the characterization and valorization of genetic resources aiming at integrating new variabilities into breeding programs and at diversifying species, systems and processes. Adequately studied and known, many biological functions found in genetic resources collections, or even in non domesticated species, could be gradually incorporated into species of importance for food and agriculture. On the other hand, features not often considered in genetic breeding programs, such as those relating to environmental quality, should attract growing interest among the technology innovation community.

If scenarios and perspectives heretofore described were to be confirmed, valuing and sustainable use of genetic resources should garner growing attention in the future. Pre-breeding and genetic breeding, combined with new innovation avenues associated with modern biotechnology, will offer new alternative uses of genetic resources in order to meet the important challenges facing Brazilian and global agriculture alike.

Nevertheless, in order to make this happen it is crucial to establish a wide alliance including professionals from different areas of expertise. When competencies and leaders act in isolation, this alliance is not achieved. If we are to offset risks and achieve new levels of productivity, quality and competitiveness for our production systems, we must both combine purposes and join efforts in a multidisciplinary convergence.

9.2. GENETIC RESOURCES, SUSTAINABLE DEVELOPMENT AND FOOD SECURITY IN THE FUTURE.

Research on genetic resources and plant breeding is one of the most relevant innovative activities for the country, as it has generated results that have significantly contributed to the main qualitative and quantitative progress of the Brazilian agriculture over the last decades. Brazilian's is one of the best plant breeding system in the world, having importantly contributed during the 20th century, especially to capacity building and to the development of a wide diversity of plants that are adapted to tropical conditions.

Access to, organization and maintenance of an important collection of exotic variability, as well as significant efforts made in order to harvest, characterize, conserve and promote the use of indigenous species of agricultural interest helped lay the basis for the various genetic breeding programs in the country. The effort Brazilian agricultural research has made in terms of access to and use of plant genetic resources for the adaptation of crops to several agro-ecological conditions has played a crucial role in the qualitative and quantitative expansion of Brazilian agriculture over the last decades. Having access to innovations in genetics, crop management, and mechanization, the Brazilian agriculture has migrated from the coastal strip into interior areas since the 1950s, expanding toward areas previously considered barren, such as the Cerrado and Semi-Arid regions.

Being a long term activity, genetic breeding requires organization and management focused on medium and long term risks, challenges and opportunities. This activity will only be successful if based on prospective efforts that capture as precisely as possible its main clients' and users' future needs. We will see in the future an agriculture geared to both food production and a set of other needs it should meet: broader food diversity, enhanced environmental sustainability and increased productivity of natural resources' base. Furthermore, a number of factors are expected to deeply influence the use of genetic resources in the future. These factors are: (i) the enhanced use of production systems based on biological inputs and processes; (ii) the search for competitive products, whose added value stem from differentiation and specialization; (iii) efforts to overcome sanitary, environmental and social barriers to market access; (iv) the application of new knowledge assets based on modern information and biotechnology technologies progress.

9.2.1. Genetic Resources, Global Climate Changes and Agricultural Sustainability.

A careful cost-benefit analysis of current production systems would probably show that environmental inputs–i.e., natural resources such as water, soil, biodiversity, etc.-and environmental services-materials recycling, water supply, atmosphere quality, etc.-used in agricultural production are undercompensated vis-à-vis their social and environmental value. This is due, inter alia, to distortions of agricultural products' prices stemming from subsidies producers enjoy in developed countries. Therefore, in order to ensure future production sustainability, investment is needed in scientific and technological knowledge that allow the development of innovative production systems; these should have the goal to increase productivity of natural resources and environmental services used in agriculture. This supposes not only enhancing production systems by classic means, but also seeking innovative technological routes for production models and strategies, as well as an intensive use of advanced genetics, environmentally safer inputs, etc. This will be an even tougher target to achieve due to the risks and challenges associated with global climate changes, which should bring about a significant increase of biotic and abiotic stress, especially in the tropics.

A broad discussion was raised by the Summary Report of Workgroup I of the Intergovernmental Panel on Climate Change (IPCC). This was due to its conclusions concerning different aspects of the evolution of Climate on Earth over the next 100 years. As important as forecasts are surveys reviewed and summarized in this document that report on direct observations of recent climate changes. One of the conclusions of the Summary Report is that "eleven of the last twelve years (1995 -2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850)." There is growing evidence that predicted climate changes will lead to increased hydric, thermal and nutritional stress. This, in turn, will strongly influence production systems regarding crop adaptation, productivity and physico-chemical and nutritional composition of agricultural products. Furthermore, it is possible that the swiftness of global changes make conventional agricultural innovation methods obsolete. These methods –genetic breeding, chemical pest management, etc.– have been our main instruments for the adaptation of organisms used in agriculture. Temperature and humidity changes in the various agroecosystems might lead to increased biotic stress, which would bring forth new pests (insects, microorganisms, nematodes, acarians, etc.) heretofore not very expressive or of secondary importance. This would hinder productivity and quality, and pose risks, still hard to establish, to food security.

In order to dampen the predictable effects of global climate changes on production systems, research should develop and make available to society a new armamentarium. The latter should encompass tools and strategies based on management, inputs and genetics that would rise to this important challenge: alleviating already set effects, and contributing to diminish foreseeable future effects, especially those due to new greenhouse gases emissions. Therefore, priorities should include the development of systems fit to high temperatures, lack or excess of rain, and stronger winds and pest attacks. The same priority should be given to the development of systems aiming at carbon sequestration, fossil fuels substitution and a decrease in the use of environmentally unfriendly inputs.

The most promising avenue to face the aforementioned challenges is the exploitation of the vast variability in genetic resources. Embrapa's units and partner institutions conducting research programs on genetic resources and cultivar development have played a prominent role in the Brazilian agriculture over the last three decades. From now on, these institutions face the challenge of finding a new paradigm: the exploitation of the genetic resources potential in order to seek and master biological functions and environmental services that promote an agriculture able to overcome new difficulties in a competitive and sustainable fashion.

9.2.2. Genetic Resources and Biological Security

Alien invasive species are inflicting astronomical losses on modern society: production and productivity reduction, costly control measures and unemployment are some of its consequences. Biological invasions, by alien species, are currently considered as the second main cause of global biodiversity reduction, ranking behind only direct conversion of environments for human use, with habitat destruction, deforestation and consequent changes in land use.

Invasive species have high potential for dissemination, colonization and control of the invaded environment; therefore, they can put pressure on native species and sometimes exclude these latter. Growing globalization, more possibilities for transportation, and the expansion of international trade and tourism, combined with climate changes, tend to significantly increase opportunities for the introduction and expansion of alien invasive species.

Studies and critical analysis of the factors threatening the integrity and balance of the different Brazilian ecosystems are key to the designing and dimensioning of public policies, competencies and institutional capability directed to ensure increased biological security in the country. Therefore, research on plant genetic resources and genetic breeding have an increasingly crucial role to play in the mobilization of genetic variability for the development of safe alternatives as a support to the Brazilian biological security strategies (resistance/tolerance to different types of biotic stress).

9.2.3. Genetic Resources and Food-Nutrition-Health Integration

Genetic breeding for food production should be increasingly targeted to the promotion of food security and health, as well as for disease prevention. Integration of the concepts of food-nutrition-health seems to be an unavoidable avenue, since insisting on the "cure paradigm", based only on medical progress and advances by the pharmaceutical industry, has proven inefficient. Proof of this is the persistence of exclusion and poverty in the greatest part of the globe, and also the fatigue caused by demographic changes (increase of the population's median age), with the consequent exhaustion of health and social security systems even in developed countries.

Gradual migration to a paradigm based on disease and food deficit prevention will require food to be increasingly adapted to the needs of legions of excluded people in developing nations (biofortified food with better quality vitamins, minerals and protein), to demographic changes (aging population) and to a better performance in different functions (physical, intellectual, etc.) Genetic breeding and related activities should still be concentrated on the development of food and feedstock that, inter alia, (i) combine convenience and high quality; (ii) can be swiftly made available in a form that is adequate for consumption; (iii) have a long shelf life with high quality; (iv) generate minimum residues, and (v) allow low cost manufacturing, with high productivity and quality.

Therefore, genetic improvement should join efforts with food diversification and specialization strategies, contributing to foster innovations that make possible: (i) an increase in food security and safety (for instance, control of mycotoxins and antinutritional factors); (ii) the development of new ingredients; (iii) the incorporation of new functionalities into food; (iv) the development of biomarkers or biosensors (for quality, health and specific nutritional functions); (v) the regulation of biological processes, and (vi) the development of food that is more adequate to organisms prone to diseases or even of food for the control/modulation of metabolic processes in the human organism.

9.2.4. Genetic Resources and Agricultural Diversification

Growing interest in agriculture's diversification and added value –in the forms of new food, fibers, flavors, biomaterials and other feedstock for various industrial branches- will inevitably lead genetic breeding to the biodiversity area, in the search for species, systems and processes diversification. If adequately studied and known through new progress in biology, many important biological functions can be mobilized among different species, and gradually incorporated into agriculture.

As its early achievements indicate, modern biotechnology can establish a radically new scientific and technological base that goes much beyond current transgenics applied to commodities. Among the main routes biotechnology should open are those allowing to master organisms' metabolic processes (plant, animal and microorganism) and to direct them toward the production of high added value materials and substances for non-food uses (sustainable energy as well as medical, pharmaceutical, nutritional and industrial uses). In such a scenario, it is plausible that agriculture in developed countries–whose dynamism is now virtually exhausted, and that survives thanks to subsidies and trade barriers- would regain competitiveness. This would increase both the competitive pressure on developing nations' agriculture and the exclusion of its products from rich nations' markets. This is a substantial risk, because it is very tough to develop and adapt tools, processes and knowledge on the frontier of biology-based knowledge. Most developing countries still lack the legal framework, the institutional capability and the leadership and management models required to place their innovation processes at such position.

9.2.5. Genetic Resources and the Potential of Modern Biotechnology

The notable progress biology has experienced opens significant possibilities to potentiate the use of the vast genetic variability in biodiversity, germplasm banks and collections. Thus, countries increasingly seek to assert their sovereignty over biological resources; in many instances, these are treated as strategic or national security assets. As its early achievements indicate, modern biotechnology, and especially genomics, can establish new paradigms for dealing with challenges linked with food security and sustainable development in the future. Thus, it is expected that a combination of modern biotechnology strategies, on the one hand, and new access to and use of genetic variability strategies, on the other, proves the way toward the discovery and incorporation of biological functions which pave the way for an agriculture that is responsive to the country's requirements.

Innovative strategies that can be foreseen at the crossroads of modern biotechnology and genetic resources include: (a) the development of collections and information, giving priority to challenges and opportunities for the characterization and discovery of important genes, features and biological functions that are relevant to enhance food production capability, recovery and preservation of environmental services related to soil, water and air quality, etc.; (b) the identification of morphologic, cytogenetic, biochemical and molecular markers applicable to the characterization of genetic resources to be used in genetic pre-breeding and breeding programs; (c) the conduction of research on the genetic structure of populations, as well as of analysis of genetic variability in natural populations, genetic breeding working collections, or components of assets held in germplasm banks and collections in order to allow a more efficient use of variability in genetic pre-breeding and breeding programs; (d) support to the development of source-populations, segregating populations, recombinant endogamic lines and other resources that allow an analysis of the biological bases of functions and features of strategic importance, such as tolerance to biotic and abiotic stress, quality and new functionalities; and (e) the development of competencies allowing increased scientific exchange between national and international institutions dedicated to added value and sustainable use of genetic resources assets.

9.2.6. Genetic Resources, Ethnobiology and Traditional Knowledge.

Brazil has striven to establish a new paradigm to approach the 'conservation, valuing and sustainable use of biodiversity resources' complex. Traditional approaches suppose a gap between in situ conservation strategies at the ecosystem level for natural biodiversity and ex situ conservation of plant genetic resources for food and agriculture. These approaches will have to evolve to include elements of sustainable extraction management and cultivation of native plants of economic interest (native biodiversity), as well as of on farm dynamic conservation, including participatory breeding (agrobiodiversity). The attention given to productive (extraction management) and dynamic (landraces) conservation can lead to the achievement of significant impacts in the future. Such a strategy will help diminish genetic erosion by developing feasible technical alternatives to deforestation or monoculture. These alternatives could be effective, first of all, in areas not very altered yet, but also in areas already attacked and marginalized (mitigation), as well as around Full Conservation Units in Brazil.

A number of traditional, small producers and indigenous communities hold genetic resources and knowledge of interest to the development of biodiversity use, sustainable management and conservation programs. Because they suffer cultural dilution, these communities have lost genetic material and knowledge that should be recovered and valued by the scientific community and by society as a whole. In this context, innovation programs in ethnobiology aiming at the study and use of biodiversity in a sustainable way, as well as at the promotion of traditional and indigenous communities' well-being, should be increasingly important within the innovation environment in the country.

It is extremely important that strategies and procedures are implemented in the future with the goal to access, organize and make knowledge and information available that can benefit traditional and indigenous communities, especially with on farm management as an agro-biodiversity promoting strategy. Priority subjects include: i) the identification of traditional practices of genetic and biological resources conservation, preserving ethnobiological knowledge related to indigenous peoples' and traditional communities' agriculture; ii) strategies for the identification, harvesting and conservation of these groups' food genetic resources; iii) strategies for the identification of scant or disappeared genetic material in order to strengthen or recover it; iv) management technologies which are adequate to these groups' culture and environment; v) the development and application of participatory methodologies directed to the reintroduction, circulation and on farm management of genetic resources.

In Brazil, a concrete example with a clearly social nature in the history of conservation of genetic resources began in the 1970s. Then, seeds of maize varieties resistant to adverse soil and climate conditions were harvested in the area of the Xavante ethnicity, whose members named it Pôhypey. About 25 years later, these maize varieties had disappeared as a result of a Brazilian policy to aboriginal communities according to which hybrid seeds were distributed to the country's indigenous tribes. This replacement caused a drastic decrease in production, because hybrids are more demanding; moreover, it entailed changes in the cultural and food habits of the concerned communities. Fortunately, this valuable treasure was kept in the Embrapa Genetic Resources and Biotechnology's cold chambers. A ceremony, covered by both the national and the international press, took place in 2001 during which this genetic material was returned to the Krahôs. Not only are, indigenous species currently being returned; in addition, this process is being monitored, and technologies adapted to the community's conditions are being transferred. Recovery of lost or deteriorated genetic materials, as well as valuation of all related knowledge should be treated as priorities.

9.3. NEW FORMS OF ORGANIZATION AND USE OF GENETIC VARIABILITY

The substantial progress achieved in genomics also opens significant possibilities to potentiate the use of the vast genetic variability in germplasm banks and breeders working assets. This progress tends especially to promote paradigm changes in access, characterization, conservation and use of plant genetic resources. The priority in traditional plant genetic resources programs is given to genetic breeding programs as the main users of their results, which are usually characterized and duly conserved organisms (accessions).

However, recent progress in genomics has opened new avenues for detailed research on important biological functions, for which it is crucial to have properly characterized organisms available. In fact, in order to understand the relations between structure (genes) and biological function (features), it is essential to have adequately organized plant genetic resources on which to carry out more detailed analysis. Thus, modern biotechnology brings forth other important users of plant genetic resources, such as genomics-based programs. These new users will be interested in plant genetic resources that can be adequately used in sophisticated analysis of structure-gene function relations and that can help understand a broad range of features and biological functions. Furthermore, these new users' interests go beyond the universe of traditionally harvested and conserved resources, since, due to new progress achieved in biology, functions and features identified in any biodiversity species could potentially be mobilized into species of interest for food and agriculture. Thus, in order to meet these new users' needs, germplasm banks have to broaden their assets, especially to enable them to search for functions and features usually not available in traditional collections.

Efforts have been made toward the development of mutant banks of model species in order to supply genotypes of interest for detailed functional analysis. Though extremely useful for functional analysis, the large-scale production of mutants usually generates random variants and ordinarily does not yield large numbers of phenotypes that could readily be of practical use; examples of these latter would be tolerance to biotic and abiotic stress, nutritional quality, etc., which usually have complex heritage and require sophisticated screening (phenotyping) and selection methods. Furthermore, plant genetic breeding programs, which have advanced phenotyping and selection capabilities, could help identify adequate genotypes on which to study important biological functions. This would open new opportunities for interactions between plant genetic resources, pre-breeding and plant breeding programs, on one hand, and functional genomics-based innovation programs, on the other hand. Beyond discovering new genes, regulation processes, etc., this interaction could benefit genetic breeding, as information from these genotypes could facilitate their utilization in the breeding programs themselves. For example, they could be used to generate molecular markers and allow the rapid introgression of features or the development of genetically modified plants that, included in breeding programs, would potentiate the breeder's capability toward the development of important germplasm for overcoming challenges related to food security and agricultural future sustainability.

9.4. PRE-BREEDING AND AVAILABILITY OF NEW GENETIC VARIABILITY

Owing to the above mentioned challenges, society must be shown the relevance of the conserved genetic resources assets to both the present and future. In a system in which most cultivars on the market have a narrow genetic base, an enhanced use of genetic resources is crucial to achieve introgression of features that allow resistance to biotic and abiotic stress and incorporation of new functionalities into crops of agrifood and agroindustrial importance. Pre-breeding programs could become strategic providers of new genetic variability to the country, thus playing the essential role of making variability conserved in germplasm banks become useful tools for the construction of a sustainable future.

Pre-breeding programs can be defined as those with the goal to identify genes and/or characteristics of interest in alien germplasm or in populations that have not undergone any breeding processes (wild relatives and landraces), and to subsequently incorporate them into agronomically adapted elite materials. Examples of alien germplasm are*, inter* alia, wild relatives, landraces, obsolete cultivars, breeding advanced lines, and mutants.

Toward the future, however, it is important to consider more inclusive concepts, which would recognize new opportunities to the utilization of genetic variability, as well as new users who look for "customized" resources to different ends. In keeping with this vision, pre-breeding can be described as a set of "activities aimed at identifying desirable characteristics, biological functions, genes or gene sets in non-adapted or semi-adapted materials, as well as in materials not having undergone any kind of selection, and their mobilization into materials potentially useful to different genetic variability users." This concept opens new perspectives to variability identification and "customization" in order to meet many users' needs in the future.

By valuing and using germplasm through pre-breeding, it is possible to: a) help breeding programs broaden crops genetic base; b) conduct molecular and evolutionary research; c) open new perspectives to plant species in terms of use, new markets or functions, among others. Accordingly, pre-breeding activities' goals are perfectly in line with those in the Convention on Biological Diversity (CBD), the International Treaty on Plant Genetic Resources for Food and Agriculture and other related public policies.

The Treaty, especially, has as its goals conservation and sustainable use of plant genetic resources for food and agriculture, as well as fair and equitable sharing of benefits derived from their utilization. These are expected to help widen crops genetic base and increase the number of species utilized to ensure global food security. Most of the few species currently used as food have low genetic diversity, which puts food security at risk.

Hence, there are many reasons why plant species pre-breeding activities should be included in agricultural innovation programs directed to the country's food security and sustainable development. It is known that only 15 of the 300 species regularly used in agriculture account for 90% of all human food. Moreover, intensive breeding of most important species for food and agriculture has entailed a natural narrowing of the genetic base, which can put food security at risk in case challenges and threats come up for which there would be no variability allowing a prompt response. Therefore, pre-breeding is one road toward a different situation, as it allows the development and availability of an additional variability pool that can ensure response capability to offset risks and overcome challenges. Moreover, pre-breeding can help our production systems attain new levels of productivity, quality and competitiveness.

An alternative road for Brazil could be enhancing public efforts in pre-breeding, particularly stressing the development of pre-technological products customized to the needs of several (private or public) users who are not ready to invest in long term programs that seek useful variability in germplasm banks. Consequently, in Brazil we can design and possibly implement models of technological business that allow the organization and management of pre-processed variability assets that would be available to breeding programs and other clients interested in biological resources for various ends (research on biological functions, bioindustrial uses, etc.). Such a model would open new avenues in Brazil for strengthening a pre-technology market, which would supply components for the production of biology-based innovations, in arrangements based on partnerships between public and private research companies. This model could help consolidate an unprecedented road toward the enhancement of public-private partnerships based on pre-breeding for the identification of desirable characteristics, biological functions, genes or gene sets and their efficient mobilization into potentially useful materials for different users of genetic variability.

Being a long term activity, pre-breeding requires organization and management with a focus on the future, trying to foresee medium and long term risks, challenges and opportunities to breeding programs. This activity will only be successful if based on prospective efforts that would capture as precisely as possible its main clients' and users' future needs.

9.5. EVOLUTION OF ORGANIZATION, LEADERSHIP AND GOVERNANCE MODELS.

Technological development is on the global agenda and enjoys considerable media coverage, as well as a great deal of attention in the discussions regarding the society's interests. This poses substantial challenges to organizations dealing with technological innovation, which are forced out of conventional operational models. Conventional organizations are forced to migrate from a discipline-based, punctual operational model to a more complex one, which aligns multiple disciplines and competencies in innovation networks that allow them to deal with increasingly complex risks, challenges and opportunities. Obviously arising from this new reality is the fact that individual organizations seldom possess all the competencies needed to have an impact on technological innovation in the modern world.

Investment in the organization and management processes of its genetic resources assets, in order to strengthen and update them, would give Brazil the tools it needs to be at the forefront of GR technology, something consonant with its genetic wealth. Network-based organization models, including multi-Institutional Platforms and Consortia, could be the most adequate arrangements to allow an efficient management of genetic resources. This is especially the case in a vast country such as Brazil, with its rich biological diversity, highly differentiated biomes and a wide variety of agrifood and agroindustrial systems.

The future configuration of genetic resources and breeding research programs depend on the knowledge available to guide Brazilian strategic decisions. These decisions concern structures, methods and capabilities toward advancements and exploration of new opportunities and technological spaces that could be instrumental in helping the State strengthen food security and sustainable development. Research organizations require information that is not always available about expected short, medium and long term risks, challenges and opportunities. Systematic prospective studies, prioritization mechanisms and cost-benefit analysis are required that could guide decisions on how to organize and manage the future of plant genetic resources and breeding programs in Brazil.

9.6. FINAL CONSIDERATIONS

Differently from temperate climate countries, which are usually more environmentally homogeneous, most of the Brazilian territory has fragmented environments, with sharp edaphoclimatic differences and a complex land ownership structure, as well as quite uneven technology, infrastructure and logistics utilization patterns. Yet, the country is the global leader in tropical agricultural production, both in production diversity and in agrifood and agroindustrial system productivity and efficiency. Over the last years, all strategically important Brazilian crops have been experiencing continuous productivity increases.

Despite obvious progress in the Brazilian agriculture, one set of events modifies public and private institutions' relations, performance and space in technological innovation. Some of these events require deeper consideration of their possible consequences and impacts on food security and sustainable development in the future, especially on activities related to access to and use of plant genetic resources, which are vital for the country's economic performance and competitiveness. Most significant events include: (a) the implementation of the new legal framework for the protection of knowledge, represented by industrial property (patents) and cultivars protection legislation adopted in the second half of the 1990s, and, more recently, by legislation concerning access to the national genetic heritage; (b) progress in biotechnology, including molecular markers, genetic engineering and, more recently, genomics and associated innovation avenues; (c) the dynamics of the cultivars market, which is increasingly sophisticated and concentrated due to the Brazilian agricultural growth and to the new technological possibilities; (d) industrial integration influenced by the biotechnology revolution, which leads to a growing presence of transnational conglomerates in the market, with the consequent shrinkage of the small and medium agents share -these latter would ensure market diversity and capillarity; and (e) the State reorganization process, with considerable challenges to and pressures on institutions dedicated to science, technology and innovation in Brazil.

Furthermore, the expansion of agriculture encroaching on new environments has been disputed by sectors of society. This process' cost-benefit structure itself requires the search for more productivity in the current agricultural land in order to slow down or contain encroachment on ecosystems that require better conservation, so as to be able to ensure agricultural sustainability. Different kinds of stress, such as pests and diseases, drought, waterlogging, aluminum toxicity, low macro and micro nutrient availability, etc., directly affect agricultural productivity. Furthermore, the vast agricultural areas established in tropical regions have already entailed an increase in sanitary problems, due either to monocultures extension and contiguity or to the high number of predatory and harmful organisms, naturally more abundant and aggressive in these environments.

In order to overcome the aforementioned constraints and potentiate the Brazilian agriculture on sustainable bases, advanced methods should be applied to conservation and facilitation of the sustainable use of genetic diversity. This shall be done chiefly through the enrichment, characterization, valuation, documentation and use of information related to plant genetic resources in the country. For the future, the great challenge will be to facilitate-taking into account risks, challenges and opportunities in view- a qualitative leap in technological innovation based on access to and safe use of genetic resources. This way, it will be possible to strive for food security, facilitating the sustainable utilization of the natural resources base and generating surpluses to promote both economic growth and the improvement in quality of life.

ANNEXES

Table 1
Germplasm Banks of Forest and Palm Tree Species, by Institution and respective number of acessions.

GERMPLASM BANKS OF FOREST AND PALM TREE SPECIES				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Açai palm	Embrapa Eastern Amazon	*Euterpe oleracea*	137	**N**
		Euterpe precatoria		**N**
Açai palm	UFRB	Euterpe oleracea	10	**N**
African oil palm	Embrapa Western Amazon	*Elaeis guineensis*	320	**E**
American oil palm	Embrapa Western Amazon	*Elaeis oleifera*	244	**N**
Babassu palm	Embrapa Mid-North	*Orbignya phalerata*	185	**N**
		Orbignya spp.		**N**
		Attalea spp.		**N**
Bacaba palm	Embrapa Eastern Amazon	*Oenocarpus bacaba*	208	**N**
		Oenocarpus spp.		**N**
Carnauba palm	CNPAT/UFC	*Copernicia prunifera*	20	**N**
Eucalypts	Embrapa Forestry	*Eucaliptus* spp.	2,000	**E**
		Corymbia spp.	25	**E**
Native and exotic forest trees	Embrapa Forestry	*Araucaria angustifolia*	162	**N**
		Pinus spp.		**E**
		Acacia melanoxylon		**E**
		Acrocarpus fraxinifolius		**E**
		Calycophyllum spruceanum		**E**
		Cryptomeria japonica		**E**
		Cupressus spp.		**E**
		Grevillea robusta		**E**
		Liquidambar styraciflua		**E**
Palmito Juçara	UFRB	*Euterpe edulis*	5	**N**
Palmito Juçara	IAC	*Euterpe edulis*	36	**N**
		Euterpe oleracea		**N**
		Euterpe spp.		**N**
Pataua palm	Embrapa Eastern Amazon	*Jessenia bataua*	122	**N**
		Bactris gasipaes	38	**L**
		Bactris gasipaes	72	**L**
Peach-palm	IAC	*Bactris gasipaes*	332	**L**
Peach-palm	CEPLAC	*Bactris gasipaes*	18	**L**
Peach-palm	UFRB	*Bactris gasipaes*	2	**L**
Peach-palm	EBDA	*Bactris gasipaes*	2	**L**

Table 1A. Germplasm Banks of Forest and Palm Tree Species, by Institution and respective number of acessions. (cont.)

Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Peach-palm	EBDA	*Bactris gasipaes*	2	**L**
Tucumã palms	Embrapa Eastern Amazon	*Astrocaryum* spp.	215	**N**
E = Exotic; **L** = Landrace; **N** = Native				

Table 2
Germplasm Banks of Cereal and Pseudocereal Species, by Institution and respective number of accessions

GERMPLASM BANKS OF CEREAL AND PSEUDOCEREAL SPECIES				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Barley	Embrapa Wheat	*Hordeum vulgare*	2,467	E
Barley	IAPAR	*Hordeum vulgare*	656	E
Barley	APTA	*Hordeum vulgare*	2,500	E
Barley and wild relatives	Embrapa Wheat	*Hordeum vulgare*	1,375	E
		Hordeum stenostachys		N
Maize	Embrapa Maize & Sorghum	*Zea mays*	3,800	E/L
		Zea mays ssp. *mexicana*		E
		Tripsacum spp.		E
Maize	UENF	*Zea mays*	80	E/L
Maize	IAPAR	*Zea mays*	2,500	E/L
Maize	IPA	*Zea mays*	25	E/L
Maize	EMPARN	*Zea mays*	42	E/L
Maize	IAC	*Zea mays*	550	E/L
Maize pipoca	IAC	*Zea mays*	25	E/L
Oats	Embrapa Wheat	*Avena sativa*	331	E
		Avena spp.		E
Oats	IAPAR	*Avena sativa*	500	E
Oats	APTA	*Avena sativa*	350	E
Pearl millet	Embrapa Maize & Sorghum	*Pennisetum glaucum*	7,225	E
Pearl millet	IPA	*Pennisetum glaucum*	3	E
Rice	Embrapa Rice & Beans	*Oryza sativa*	10,980	E/L
Rice	IAPAR	*Oryza sativa*	1,400	E/L
Rice	UFRPE	*Oryza sativa*	304	E/L
Rye	Embrapa Wheat	*Secale cereale*	106	E
		Secale spp.		E
Sorghum	Embrapa Maize & Sorghum	*Sorghum bicolor*	7,225	E
Sorghum	Fepagro- Fruticultura	*Sorghum bicolor*	220	E
Sorghum	IAPAR	*Sorghum* spp.	100	E
Sorghum	IPA	*Sorghum bicolor*	250	E
Subtropical maize	Embrapa Temperate Agriculture	*Zea mays*	200	E/L
Triticale	Embrapa Wheat	*Triticum aestivum x Secale cereale* (= *xTriticosecale* spp.)	162	E
Triticale	IAPAR	*Triticum aestivum x Secale cereale* (= *xTriticosecale* spp.)	390	E

Table 2 Germplasm Banks of Cereal and Pseudocereal Species, by Institution and respective number of acessions. (cont.)				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of**	**Origin**
			Accessions	**E/L/N**
Triticale	IAC	*Triticum aestivum x Secale cereale* (= *xTriticosecale* spp.)	50	**E**
Wheat	Embrapa Wheat	*Triticum aestivum*	11,252	**E/L**
Wheat	IAPAR	*Triticum aestivum*	6,010	**E**
		Triticum durum	609	**E**
Wheat	IAC	*Triticum aestivum*	5,659	**E**
		Triticum durum	892	**E**
Wild wheat relatives	Embrapa Wheat	*Triticum* spp.	2,212	**E**
		Aegilops spp.		**E**

Table 3A
Germplasm Banks of Forage Plants by Institution and respective number of accessions

GERMPLASM BANKS OF FORAGE PLANTS				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Alfalfa	Embrapa Dairy Cattle	*Medicago sativa*	8	E/L
Brachiaria	Embrapa Beef Cattle	*Brachiaria* spp.(= *Urochloa* spp.)	461	E
Buffel grass	Embrapa Tropical Semi-arid	*Cenchrus* spp.	120	E
Elephant grass	Embrapa Dairy Cattle	*Pennisetum purpureum*	110	E
		Pennisetum spp.	7	E/N
Elephant grass	IPA	*Pennisetum purpureum*	500	E
Forage peanuts	Embrapa Acre	*Arachis pintoi*	103	N
		Arachis repens		N
		Arachis glabrata		E/N
Forage plants (Poaceae)	Embrapa Cerrados	*Andropogon gayanus*	2,812	E
		Brachiaria spp.(= *Urochloa* spp.)		E
(Fabaceae)		*Aeschynomene* spp.		N
		Arachis spp.		N
		Calopogonium spp.		E/N
		Cassia spp.		N
		Centrosema spp.		E/N
		Cratylia spp.		N
		Crotalaria spp.		E/N
		Desmodium spp.		E/N
		Galactia spp.		N
		Indigofera spp.		N
		Macroptilium spp.		N
		Neonotonia wightii		E
Forage plants (Poaceae)	EPAGRI - Lages	*Agrostis* spp.	1,383	E
		Arrhenatherum elatius		E
		Avena spp.		E
		Bromus spp.		E/N
		Dactylis spp.		E
		Festuca spp.		E
		Holcus lanatus		E
		Lolium spp.		E
		Paspalum spp.		N

Table 3
Germplasm Banks of Forage Plants by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
		Phalaris spp.		E
		Phleum pratense		E
		Poa spp.		E
(Fabaceae)		*Adesmia* spp.		N
		Desmodium spp.		E/N
		Lathyrus sativus		E
		Medicago spp.		E
		Melilotus alba		E
		Ornithopus spp.		E/N
		Pisum sativum		E
		Trifolium spp.		E/N
		Vicia spp.		E/N
Forage plants (Poaceae)	Instituto de Zootecnia SP	*Acroceras macrum*	1	E
		Andropogon gayanus	8	E
		Avena spp.	3	E
		Axonopus spp.	4	N
		Brachiaria spp.(= *Urochloa* spp.)	24	E
		Cenchrus spp.	2	E
		Chloris spp.	5	E
		Coix lacryma-jobi	1	E
		Crysopogon montanus	1	E
		Cynodon spp.	3	E
		Dichantium aristatum	1	E
		Digitaria spp.	13	E
		Echinochloa spp.	4	N
		Eragrostis spp.	4	E
		Hemarthria altissima	3	E
		Heteropogon spp.	2	E
		Homolepis aturensis	1	N
		Hyparrhenia spp.	6	E
		Lolium spp.	3	E
		Melinis minutiflora	1	E
		Panicum maximum (= *Megathyrsus maximus*)	16	E
		Panicum spp.	49	E

Table 3
Germplasm Banks of Forage Plants by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
Forage plants (Poaceae)	Instituto de Zootecnia SP	*Paspalum* spp.	18	N
		Pennisetum spp.	5	E
		Setaria spp.	11	E
		Tripsacum fasciculatum	1	E
		Urochloa spp.	2	E
		Zoysia japonica	1	E
(Fabaceae)		*Canavalia* spp.	16	E/N
		Cassia spp.	4	N
		Centrosema pubescens	48	E
		Centrosema virginianum	11	N
		Centrosema spp.	55	E/N
		Chamaecrista spp.	16	N
		Cleobulia multiflora	1	N
		Clitoria spp.	13	N
		Codariocalyx gyroides	1	E
		Collaea spp.	3	N
		Cologania sp.	1	N
		Cratylia spp.	4	N
		Crotalaria spp.	17	E/N
		Desmanthus spp.	12	N
		Desmodium barbatum	11	N
		Desmodium incanum	11	N
		Desmodium spp.	49	E/N
		Dolichos spp.	3	E
		Dypterix alata	1	N
		Eriosema spp.	4	N
		Galactia spp.	33	N
		Galactia striata	10	N
		Glycine spp.	25	E
		Indigofera spp.	49	N
		Lablab purpureus	3	E
		Leucaena leucocephala	9	E
		Leucaena spp.	7	E
		Macroptilium spp.	41	N

Table 3 Germplasm Banks of Forage Plants by Institution and respective number of acessions. (cont.)				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
(Fabaceae)	Instituto de Zootecnia SP	*Macrotyloma* spp.	6	E
		Medicago sativa	2	E
		Mimosa spp.	55	N
		Mucuna pruriens	1	E
		Neonotonia wightii	53	E
		Ornithopus sativus	1	E
		Periandra spp.	3	N
		Poiretia spp.	2	N
		Psophocarpus tetragonolobus	6	E
		Pueraria phaseoloides	3	E
		Rhynchosia spp.	22	N
		Schrankia leptocarpa	2	N
		Senna spp.	5	N
		Sesbania spp.	30	E/N
		Stylosanthes guianensis	51	E/N
		Stylosanthes scabra	20	E/N
		Stylosanthes spp.	96	E
		Tephrosia spp.	8	N
		Teramnus spp.	36	N
		Trifolium spp.	4	E
		Vicia sativa	1	E
		Vigna spp.	43	E/N
		Zornia spp.	21	N
		Aeschynomene spp.	48	N
		Alysicarpus vaginalis	3	N
		Arachis sp.	1	N
		Bauhinia sp.	1	N
		Cajanus spp.	7	E
		Calliandra calothyrsus	1	E
		Calopogonium mucunoides	12	E/N
		Camptosema spp.	8	N
(Chenopodiaceae)	Instituto de Zootecnia SP	*Atriplex nummularia*	1	E
Forage plants (Poaceae)	Embrapa Cattle-Southeast	*Paspalum* spp.	200	N
		Bromus auleticus		N

Table 3 **Germplasm Banks of Forage Plants by Institution and respective number of acessions. (cont.)**				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Forage *Sorghum*	IPA	*Sorghum sudanense*	21	**E**
Indian fig *Opuntia*	IPA	*Opuntia ficus-indica*	1,216	**E**
		Nopalea cochenillifera		**E**
Indian fig *Opuntia*	UFAL	*Opuntia* spp.	28	**E**
Jureminha	Embrapa Coastal Tablelands	*Desmanthus virgatus*	32	**N**
Mororó	IPA	*Bahuinia* spp.	100	**N**
Native forages	Embrapa Mid-North	Several genera (Poaceae e Fabaceae)	215	**E/N**
Native forages	Embrapa Pantanal	*Hemarthria altissima*	30	**N**
		Hymenachne amplexicaulis		**N**
		Mesosetum chaseae		**N**
		Panicum laxum		**N**
		Paspalum oteroi		**N**
Panicum	Embrapa Beef Cattle	*Panicum maximum* (= *Megathyrsus maximus*)	426	**E**
Paspalum	Embrapa Cattle-Southeast	*Paspalum* spp.	327	**N**
Ryegrass	Embrapa Dairy Cattle	*Lolium* spp.	213	**E/L**
Stylosanthes	Embrapa Beef Cattle	*Stylosanthes* spp.	1,062	**E/N**
Velvet grass	Embrapa Dairy Cattle	*Holcus lanatus*	3	**E**

Table 4
Germplasm Banks of Fruit Tree Species, by Institution and respective number of acessions

GERMPLASM BANKS FRUIT TREE SPECIES				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Abiu	EBDA	*Pouteria caimito*	2	N
Abiu	UFRB	*Pouteria caimito*	2	N
Acerola	Embrapa Cassava & Tropical Fruits	*Malpighia* spp.	154	E
Acerola	UFRPE	*Malpighia glabra*	42	E
Acerola	IPA	*Malpighia glabra*	14	E
Acerola	EMPARN	*Malpighia glabra*	5	E
Acerola	EBDA	*Malpighia glabra*	4	E
Acerola	IAPAR	*Malpighia glabra*	65	E
Annona	UNESP/FCAV	*Annona* spp.	20	E/N
Annona	IAC	*Rollinia emarginata*	6	E/N
		Annona cherimola		E
		Annona cherimola x Annona squamosa		E
Annona	UFRB	*Annona spp.*	7	N
Apple	EPAGRI - Caçador	*Malus domestica*	474	E
		Malus spp.		E
Apple	IAPAR	*Malus domestica*	1,464	E
Araca boi	UFRB	*Eugenia stipitata*	6	N
Avocado	Embrapa Cerrados	*Persea americana*	44	E
Avocado	EBDA	*Persea americana*	33	E
Avocado	IAPAR	*Persea americana*	41	E
Bacuri	Embrapa Coastal Tablelands	*Platonia insignis*	78	N
Bacuri	Embrapa Eastern Amazon	*Platonia insignis*	48	N
Banana	Embrapa Cassava & Tropical Fruits	*Musa* spp.	400	E
Banana	INCAPER	*Musa* spp.	60	E
Banana	EMPARN	*Musa acuminata x Musa balbisiana*	13	E
Banana	UENF	*Musa* spp.	14	E
Banana	Embrapa Cassava & Tropical Fruits	*Musa spp.*	400	E
Bilimbi	UFRB	*Averrhoa bilimbi*	10	E
Blackberry	IAPAR	*Rubus* spp.	60	E
Brazil nut	Embrapa Eastern Amazon	*Bertholletia excelsa*	45	N
Brazilian cherry	IPA	*Eugenia uniflora*	117	N
Brazilian cherry	EBDA	*Eugenia uniflora*	5	N

Table 4 Germplasm Banks of Fruit Tree Species, by Institution and respective number of acessions. (cont.)				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Brazilian cherry	UFRB	*Eugenia uniflora*	10	N
Brazilian guava	IPA	*Psidium araca*	110	N
Butia palm	Fepagro Porto Alegre	*Butia capitata*	12	N
Cabelluda	UFRB	*Eugenia tomentosa*	5	N
Caimito	EBDA	*Chrysophyllum cainito*	2	E
Caimito	UNESP/FCAV	*Chrysophyllum cainito*	2	E
Caimito	UFRB	*Chrysophyllum cainito*	5	E
Camu camu	Embrapa Eastern Amazon	*Myrciaria dubia*	10	N
Camu camu	Embrapa Western Amazon	*Myrciaria dubia*	10	N
Camu camu	INPA	*Myrciaria dubia*	40	N
Camu camu	UFRB	*Myrciaria dubia*	10	
Canistel	EBDA	*Pouteria campechiana*	2	E
Canistel	UNESP/FCAV	*Pouteria campechiana*	2	E
Canistel	UFRB	*Pouteria campechiana*	2	E
Cashew	UFAL	*Anacardium occidentale*	35	N
Cashew	UNESP/FCAV	*Anacardium occidentale*	5	N
Cashew	EMPARN	*Anacardium occidentale*	12	N
Cashew	EBDA	*Anacardium occidentale*	5	N
Cashew	Embrapa Tropical Agroindustry	*Anacardium occidentale*	621	N
		Anacardium spp.		N
Chempedak	EBDA	*Artocarpus integer*	2	E
Chichá	Embrapa Mid-North	*Sterculia striata*	14	N
Citrus	Embrapa Cassava & Tropical Fruits	*Citrus* spp.	811	E
Citrus	UFAL	*Citrus* spp.	40	E
Citrus	Epagri	*Citrus* spp.	20	E
Citrus	Fepagro	*Citrus* spp.	229	E
Citrus	IAPAR	*Citrus* spp.	400	E
Citrus	IAC	*Citrus aurantium*	48	E
		Citrus grandis	47	E
		Citrus limon	140	E
		Citrus limonia	58	E
		Citrus paradisi	64	E
		Citrus reticulata	172	E
		Citrus sinensis	651	E

Table 4 Germplasm Banks of Fruit Tree Species, by Institution and respective number of acessions. (cont.)				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Citrus	IAC	*Citrus* spp.	308	E
		Citrus - Hibridos Interespecíficos	360	E
		Poncirus spp.	25	E
		Outros gêneros	18	E
		Híbridos intergenéricos	210	E
Cocoa	IAC	*Theobroma cacao*	178	E/N
Cocoa	CEPLAC	*Theobroma cacao*	1,270	E/L
Coconut	EBDA	*Cocos nucifera*	2	E
Coconut	Embrapa Coastal Tablelands	*Cocos nucifera*	22	E
Coconut	EMPARN	*Cocos nucifera*	3	E
Cupuassu	Embrapa Western Amazon	*Theobroma grandiflorum*	524	N
		Theobroma spp.	16	N
Cupuassu	UFRB	*Theobrama grandiflorum*	5	N
Date palm	Embrapa Tropical Semi-arid	*Phoenix dactylifera*	20	E
Date palm	EMPARN	*Phoenix dactylifera*	10	E
Durian	EBDA	*Durio zibethinus*	2	E
Feijoa	EPAGRI - São Joaquim	*Acca sellowiana*	193	N
Grapes	Embrapa Grape & Wine	*Vitis vinifera*	1,345	E
		Vitis spp.		E
Grapes	Embrapa Tropical Semi-arid	*Vitis* spp.	223	E
Grapes	IAC	*Vitis bourquina*	360	E
		Vitis labrusca		E
		Vitis vinifera		E
		Hybrids		E
Grapes	UENF	*Vitis* spp.	20	E
Grumichama	UFRB	*Eugenia brasiliensis*	5	N
Guabiroba	EBDA	*Compomanesia xanthocarpe*	2	N
Guabiroba	IPA	*Compomanesia xanthocarpe*	41	N
Guabiroba	UNESP/FCAV	*Compomanesia xanthocarpe*	5	N
Guabiroba	UFRB	*Compomanesia xanthocarpe*	5	N
Guarana	Embrapa Western Amazon	*Paullinia cupana*	150	N
Guarana	Embrapa Eastern Amazon	*Paullinia cupana*	88	N
Guava	IPA	*Psidium guajava*	55	N
Guava	UNESP/FCAV	*Psidium guajava*	14	N

Table 4
Germplasm Banks of Fruit Tree Species, by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
Guava	UFRB	*Psidium guajava*	5	N
Guava	EBDA	*Psidium guajava*	31	N
Guava	UENF	*Psidium guajava*	30	E/N
Guava	IAC	*Psidium guajava*	105	E/N
Guava & wild relatives	Embrapa Tropical Semi-arid	*Psidium guajava*	152	N
		Psidium spp.		N
Huito	EBDA	*Genipa americana*	2	E/N
Huito	UFRB	*Genipa americana*	5	E/N
Jabuticaba	EBDA	*Plinia cauliflora*	3	N
Jabuticaba	IPA	*Plinia cauliflora*	5	N
Jabuticaba	UNESP/FCAV	*Plinia cauliflora*	5	N
Jabuticaba	UFRB	*Plinia cauliflora*	5	N
Jackfruit	IPA	*Artocarpus heterophyllus*	42	E
kaki	EBDA	*Diospyros kaki*	3	E
kaki	IAC	*Diospyros kaki*	37	E
Litchi	UNESP/FCAV	*Litchi chinensis*	10	E
Litchi	EBDA	*Litchi chinensis*	3	E
Macadamia	EBDA	*Macadamia integrifolia*	11	E
Macadamia	UNESP/FCAV	*Macadamia integrifolia*	6	E
Macadamia	INCAPER	*Macadamia integrifolia*	15	E
Malacca apple	EBDA	*Eugenia malaccensis*	2	E
Mamey	UFRB	Mammea americana	10	N
Mangaba	Embrapa Coastal Tablelands	*Hancornia speciosa*	11	N
Mangaba	Embrapa Mid-North	*Hancornia speciosa*	16	N
Mangaba	EMEPA	*Hancornia speciosa*	540	N
Mangaba	UFAL	*Hancornia speciosa*	20	N
Mango	Embrapa Tropical Semi-arid	*Mangifera indica*	150	E
		Mangifera spp.		E
Mango	EMPARN	*Mangifera indica*	20	E
Mango	UNESP/FCAV	*Mangifera indica*	60	E
Mango	EBDA	*Mangifera indica*	50	E
Mango	UFAL	*Mangifera indica*	10	E
Mulberry	APTA	*Morus* spp.	88	E
Northern native fruits	Embrapa Eastern Amazon	*Bertholletia excelsa*	290	N

Table 4 **Germplasm Banks of Fruit Tree Species, by Institution and respective number of acessions. (cont.)**				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Northern native fruits	Embrapa Eastern Amazon	*Byrsomina crassifolia*		**N**
		Myrciaria dubia		**N**
		Platonia insignis		**N**
		Spondias monbim		**N**
Nut trees	IAC	*Macadamia integrifolia*	12	**E**
		Castanea spp.	19	**E**
Olive tree	Embrapa Temperate Agriculture	*Olea europaea*	24	**E**
Papaya	UFAL	*Carica papaya*	10	**E**
Papaya	INCAPER	*Carica papaya*	18	**E**
Papaya	UENF	*Carica papaya*	17	**E**
Papaya	Embrapa Cassava & Tropical Fruits	*Carica papaya*	165	**E/N**
		Jaracatia spinosa		**E/N**
		Vasconcellea spp.		**E/N**
Passiflora	UENF	*Passiflora udulis*	144	**E/N**
Passion fruit	Embrapa Cassava & Tropical Fruits	*Passiflora* spp.	212	**N**
Passion fruit	Embrapa Tropical Semi-arid	*Passiflora edulis*	59	**N**
Passion fruit	UFPI	*Passiflora edulis*	12	**N**
Passion fruit	UNESP/FCAV	*Passiflora edulis*	60	**N**
Passion fruit	Embrapa cerrados	*Passiflora edulis*	145	**N**
Passion fruit	UESC	*Passiflora edulis*	523	**N**
Passion fruit	IAPAR	*Passiflora edulis*	80	**E/N**
Passion fruit	IAC	*Mitostemma* spp.	2	**E/N**
		Passiflora spp.	57	**E/N**
		Tetrastylis ovalis	1	**E/N**
Peaches and nectarines	APTA	*Prunus persica*	29	**E**
Pear	EPAGRI - Cacador	*Pyrus communis*	210	**E**
Pear and quince	Embrapa Grape & Wine	*Pyrus* ssp.	198	**E**
Pecan	UFV	*Carya illinoinesis*	15	**E**
Pineapple	Embrapa Cassava & Tropical Fruits	*Ananas* spp.	741	**N**
Pineapple	Embrapa Cassava & Tropical Fruits	*Pseudananas sagenarius*		**N**
Pineapple	IAC	*Ananas comosus*	137	**E/N**
		Ananas spp.	19	**E/N**
		Pseudananas sagenarius	5	**E/N**
Pitomba	UFRB	*Tlisia esculenta*	5	**N**

Table 4
Germplasm Banks of Fruit Tree Species, by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
Plums	IAPAR	*Prunus salicina*	265	E
Pomegranate	IPA	*Punica granatum*	35	E
Pomegranate	EBDA	*Punica granatum*	2	E
Pomoideae	IAC	*Chaenomeles* spp.	60	E
		Cydonia sp.		E
		Eriobotrya japonica		E
		Malus spp.		E
		Pyrus spp.		E
Prunoideae	Embrapa Temperate Agriculture	*Prunus domestica*	1,006	E
		Prunus persica		E
		Prunus spp.		E
Prunoideae	IAC	*Prunus mume*	109	E
		Prunus persica		E
		Prunus salicina		E
Purple mombin	IPA	*Spondias purpurea*	11	E
Rambutan	INPA	*Nephelium lappaceum*	8	E
Rambutan	EBDA	*Nephelium lappaceum*	45	E
Sapodilla	IPA	*Manilkara sapota*	270	E
Sapodilla	UNESP/FCAV	*Manilkara sapota*	6	E
Sapodilla	EBDA	*Manilkara sapota*	4	E
Sapucaia	Embrapa Coastal Tablelands	*Lecythis pisonis*	16	N
Sapucaia	Embrapa Mid-North	*Lecythis pisonis*	16	N
Soursop	IPA	*Annona muricata*	63	E/N
Soursop	Embrapa Eastern Amazon	*Annona muricata*	25	E/N
Soursop	UNESP/FCAV	*Annona muricata*	5	E/N
Soursop	EBDA	*Annona muricata*	12	E/N
Southern native fruits	Universidade Federal de Pelotas	*Acca sellowiana*	165	N
		Inga uruguensis		N
		Myrcianthes pungens		N
		Psidium cattleyanum		N
		Rollinia rugulosa		N
Southern native fruits	Embrapa Temperate Agriculture	*Acca sellowiana*	76	N
		Butia capitata		N
		Campomanesia xanthocarpa		N

Table 4
Germplasm Banks of Fruit Tree Species, by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
Southern native fruits	Embrapa Temperate Agriculture	*Eugenia* spp.		N
		Inga uruguensis		N
		Myrcianthes pungens		N
		Plinia trunciflora		N
		Psidium spp.		N
		Rollinia sylvatica		N
		Rubus spp.		N
Spondias	Embrapa Coastal Tablelands	*Spondias* spp.	42	E
Spondias	Embrapa Cassava & Tropical Fruits	*Spondias* spp.	21	E
Starfruit	IPA	*Averrhoa carambola*	69	E
Starfruit	UNESP/FCAV	*Averrhoa carambola*	5	E
Starfruit	EBDA	*Averrhoa carambola*	45	E
Strawberry	Embrapa Temperate Agriculture	*Fragraria* spp.	20	E
Strawberry	IAC	*Fragraria* spp.	140	E
Sugar apple	Embrapa Mid-North	*Annona squamosa*	48	E/N
Sugar apple	IPA	*Annona squamosa*	85	E/N
Sugar apple	EBDA	*Annona squamosa*	52	E/N
Tamarind	EBDA	*Tamarindus indica*	2	E
Tamarind	UNESP/FCAV	*Tamarindus indica*	3	E
Umbu	Embrapa Tropical Semi-arid	*Spondias tuberosa*	80	N
Umbu	IPA	*Spondias tuberosa*	31	N
Umbu	EBDA	*Spondias tuberosa*	2	N
Umbu	EMPARN	*Spondias tuberosa*	10	N
Uvaia	UFRB	Eugenia uvalha	5	N
Wild cashew	Embrapa Mid-North	*Anacardium* spp.	35	N
Yellow mombin	Embrapa Mid-North	*Spondias mombin*	30	N
Yellow mombin	IPA	*Spondias mombin*	33	E
Yellow mombin	EMEPA	*Spondias mombin*	21	E
Yellow mombin	EBDA	*Spondias mombin*	2	E
Yellow mombin	UFRB	*Spondias mombin*	3	E
Yellow mombin	Embrapa Mid-North	*Spondias mombin*	11	N
Yellow mombin	IPA	*Spondias mombin*	36	N

Table 5
Germplasm Banks of Vegetables, by Institution and respective number of accessions

GERMPLASM BANKS OF VEGETABLES				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Arracacha	Embrapa Vegetables	*Arracacia xanthorrhiza*	22	**E**
Black pepper	Embrapa Eastern Amazon	*Piper* spp.	20	**E**
Brassicaceae	Embrapa Vegetables	*Brassica campestris*	934	**E**
		Brassica napus		**E**
		Brassica oleracea		**E**
		Eruca sativa		**E**
		Raphanus sativus		**E**
Cabbage	IAC	*Brassica oleracea* var. *acephala*	20	**E**
Capsicum	IAC	*Capsicum* spp.	300	**N**
Capsicum peppers	IAC	*Capsicum annuum*	642	**E**
Capsicum peppers	IAC	*Capsicum annuum*	1,379	**E**
		Capsicum baccatum		**E/L/N**
		Capsicum chinense		**E/N**
		Capsicum frutescens		**E/N**
Capsicum peppers	Embrapa Vegetables	*Capsicum* sp.	2,000	**E/N**
		Capsicum annuum		**E**
		Capsicum baccatum		**E/L/N**
		Capsicum chinense		**E/N**
		Capsicum frutescens		**E/N**
Capsicum peppers	Embrapa Temperate Agriculture	*Capsicum annuum*	347	**E/L**
		Capsicum baccatum		**E/L/N**
		Capsicum chinense		**E/L/N**
		Capsicum frutescens		**E/L/N**
Capsicum peppers	UFRPE	*Capsicum annuum*	50	**E**
Capsicum peppers	UFPI	*Capsicum spp.*	69	**N**
Capsicum peppers	UESC	*Capsicum spp.*	150	**N**
Carrot	Embrapa Temperate Agriculture	*Daucus carota*	77	**E/L**
Chick pea	IAC	*Cicer arietinum*	50	**E**
Cucumber	Embrapa Vegetables	*Cucumis sativus*	1,200	**E**
		Cucumis spp.		**E**
Cucurbita	IAC	*Cucurbita maxima*	130	**E/L**
		Cucurbita moschata	156	**E/L**

Table 5
Germplasm Banks of vegetables, by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
Cucurbita	IAC	*Cucurbita pepo*	79	E/L
Cucurbita	UENF	*Cucurbita* spp.	55	E/L
Cucurbits	Embrapa Vegetables	*Cucurbita maxima*	4,000	E/L
		Cucurbita moschata		E/L
		Cucurbita ficifolia		E/L
		Cucurbita spp.		E/L
		Lagenaria siceraria		E
		Luffa aegyptiaca		E
Cucurbits	Embrapa Temperate Agriculture	*Cucurbita maxima*	426	E/L
		Cucurbita moschata		E/L
		Cucurbita ficifolia		E/L
		Cucurbita pepo		E/L
		Citrullus lanatus		E/L
		Cucumis melo		E/L
		Cucumis spp.		E
		Luffa aegyptiaca		E/L
		Lagenaria siceraria		E/L
		Momordica charantia		E/L
		Sicana odorifera		E/L
Cucurbits	Embrapa Tropical Semi-arid	*Citrullus lanatus*	753	E/L
		Cucumis spp.	200	E/L
		Cucurbita maxima	230	E/L
		Cucurbita moschata	599	E/L
Cucurbits	UFERSA	*Cucumis melo*	200	E/L
		Cucumis anguria	18	E/L
		Citrullus lanatus	29	E/L
Cucurbits	IAC	*Luffa cylindrica*	52	E/L
		Luffa acutangula		E/L
Cucurbits	IAC	*Cucumis anguria*	29	E/L
		Lagenaria siceraria	39	E
		Momordica charantia	8	E
		Sicana odorifera	7	E/L
Egg plant	Embrapa Vegetables	*Solanum melongena*	287	E

Table 5
Germplasm Banks of vegetables, by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
Forage turnip	IAPAR	*Raphanus sativus*	200	**E**
Garlic	Embrapa Vegetables	*Allium sativum*	148	**E**
Garlic	IAC	*Allium sativum*	20	**E**
Gilo	IAC	*Solanum aethiopicum*	2	**E/L**
Lettuce	APTA	*Lactuca sativa*	3	**E**
Lettuce	UFRPE	*Lactuca sativa*	100	**E**
Lima beans	Embrapa Cotton	*Phaseolus lunatus*	813	**E/L**
Lima beans	UFCG	*Phaseolus lunatus*	50	**E/L**
Lima beans	Embrapa Genetic Resources & Biotechnology	*Phaseolus lunatus*	1,225	**E/L**
Lima beans	UFRPE	*Phaseolus lunatus*	36	**E/L**
Lima beans	UFPI	*Phaseolus lunatus*	549	**E/L**
Melon	Embrapa Vegetables	*Cucumis melo*	1,200	**E/L**
Melon	UFERSA	*Cucumis melo*	200	**E/L**
Melon	IPA	*Cucumis melo*	85	**E/L**
Okra	IAC	*Abelmoschus esculentus*	50	**E**
Onion	Embrapa Temperate Agriculture	*Allium cepa*	172	**E/L**
Onion	Embrapa Vegetables	*Allium cepa*	120	**E**
Onion	Embrapa Tropical Semi-arid	*Allium cepa*	27	**E**
Onion	IAC	*Allium cepa*	1	**E**
Onion	IPA	*Allium cepa*	6	**E**
Potato	APTA	*Solanum tuberosum*	200	**E**
Pulses	Embrapa Vegetables	*Cicer arietinum*	775	**E**
		Lens culinaris	522	**E**
		Pisum sativum	1,958	**E**
		Solanum spp.	1,735	**E**
Tomato	UENF	*Solanum lycopersicum*	1,688	**E**
		Solanum spp.		**E**
Tomato	IPA	*Lycopersicon esculentum*	10	**E**
Tropical vegetables	Embrapa Vegetables	*Colocasia* sp.	3	**E**
		Dioscorea spp.	10	**E/N**
		Maranta sp.	1	**E**
		Pachyrrhizus sp.	8	**E**
Tropical vegetables	Embrapa Vegetables	*Pereskia* sp.	2	**N**
Watermelon	Embrapa Vegetables	*Citrullus vulgaris*	280	**E/L**
Watermelon	UFERSA	*Citrullus lanatus*	29	**E**

Table 6
Germplasm Banks of Industrial Plants by Institution and respective number of acessions

GERMPLASM BANKS OF INDUSTRIAL PLANTS				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Bamboo	UFAL	Several genera	13	**E**
Coffee	IAC	*Coffea arabica*	2,000	**E**
		Coffea canephora	1,000	**E**
		Coffea spp.	152	**E**
		Interspecific hybrids	1,000	**E**
		Psilanthus ebracteolatus	6	**E**
Coffee	IAPAR	*Coffea* spp.	3,335	**E**
Rubber tree	Embrapa Cerrados	*Hevea brasiliensis*	762	**N**
Rubber tree	IAPAR	*Hevea* spp.	106	**N**
Rubber tree	IAC	*Hevea* spp.	1,000	**N**
Rubber tree	CEPLAC	*Hevea* spp.	820	**N**
Sugarcane	UENF	*Saccharum officinarum*	72	**E**
Sugarcane	C.T. Canavieira	*Saccharum officinarum*	5,000	**E**
Sugarcane	Ridesa	*Saccharum officinarum*	2,700	**E**
Sugarcane	IAC	*Saccharum officinarum*	36	**E**
		Saccharum spontaneum	2	**E**
		Saccharum barberi	1	**E**
		Saccharum (*Erianthus* sp.)	1	**E**
		Saccharum (interspecific hybrids and varieties)	255	**E**
Sugarcane	UFAL	*Saccharum spp.*	1,241	**E**
Sugarcane	UFRPE	*Saccharum spp.*	163	**E**

Table 7
Germplasm Banks of Pulses, Fibrous and Oil plant Species, by Institution and respective number of accessions

GERMPLASM BANKS OF PULSES, FIBROUS AND OIL PLANT SPECIES				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Assorted Fabaceae	IAC	*Aeschynomene* sp.	1	**N**
		Arachis sp.	2	**N**
		Astragalus sinicus	1	**E**
		Cajanus cajan	10	**E**
		Calopogonium mucunoides	1	**E**
		Canavalia spp.	3	**E**
		Centrosema pubescens	1	**E**
		Clitoria ternatea	1	**N**
		Cratylia floribunda	1	**N**
		Crotalaria spp.	13	**E/N**
		Cyamopsis tetragonoloba	30	**E**
		Desmodium sp.	1	**N**
		Lablab purpureus	2	**E**
		Galactia striata	1	**N**
		Indigofera spp.	2	**N**
		Lathyrus sativus	2	**E**
		Lens culinaris	2	**E**
		Leucaena spp.	2	**E**
		Lupinus albus	15	**E**
		Lupinus spp.	2	**E**
		Macroptilium atropurpureum	1	**E**
		Medicago sativa	1	**E**
		Melilotus sp.	1	**E**
		Mucuna pruriens	7	**E**
		Neonotonia wightii	2	**E**
		Phaseolus lunatus	3	**E/L**
		Pisum sativum	10	**E**
		Psophocarpus tetragonolobum	1	**E**
		Pueraria spp.	2	**E**
		Sesbania bispinosa	1	**E**
		Stylosanthes humilis	1	**N**
		Tephrosia spp.	2	**N**

Table 7
Germplasm Banks of Pulses, Fibrous and Oil plant Species, by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
Assorted Fabaceae	IAC	*Trifolium repens*	1	E
		Vicia spp.	3	E
		Vigna spp.	25	E/N
		Zornia sp.	1	N
Beans	Embrapa Rice & Beans	*Phaseolus vulgaris*	14,460	E
Beans	Embrapa Temperate Agriculture	*Phaseolus vulgaris*	403	E/L
Beans	IAPAR	*Phaseolus vulgaris*	7,460	E/L
		Phaseolus coccineus		E
		Phaseolus lunatus		E/L
Beans	IAC	*Phaseolus vulgaris*	1,981	E/L
		Phaseolus lunatus		E/L
Beans	UENF	*Phaseolus* spp.	70	E
Beans	IPA	*Phaseolus vulgaris*	135	E/L
Castor bean	Embrapa Genetic Resources & Biotechnology	*Ricinus communis*	100	E/L
Castor bean	IAC	*Ricinus communis*	500	E/L
Castor bean	EBDA	*Ricimus comunis*	859	E/L
Cotton	Embrapa Cotton	*Gossypium* spp.	3,018	E/N
Cotton	IAPAR	*Gossypium* spp.	310	E/N
Cotton	IAC	*Gossypium* spp.	400	E/N
Cotton	Embrapa Algodão	*Gossypium hirsutum*	4,500	E/N
Cowpea	Embrapa Mid-North	*Vigna unguiculata*	957	E/L
Cowpea	IPA	*Vigna unguiculata*	80	E/L
Cowpea	UFRPE	*Vigna unguiculata*	200	E/L
Cowpea	UFC	*Vigna unguiculata*	500	E/L
Cowpea	EMPARN	*Vigna unguiculata*	50	E/L
Curauá	Embrapa Eastern Amazon	*Ananas comosus* var. *erectifolius*	20	N
Green beans	Embrapa Vegetables	*Phaseolus vulgaris*	64	E/L
Groundnut	Embrapa Cotton	*Arachis hypogaea*	240	E/L
Groundnut	Embrapa Temperate Agriculture	*Arachis hypogaea*	10	E/L
Groundnut	IAPAR	*Arachis hypogaea*	240	E/L
Groundnut	IAC	*Arachis hypogaea*	2,000	E/L
Jatropha	Embrapa Cotton	*Jatropha curcas*	143	E
Mamona	Embrapa Cotton	*Ricinus communis*	1,000	E/L

Table 7
Germplasm Banks of Pulses, Fibrous and Oil plant Species, by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
Sesame	Embrapa Cotton	*Sesamum indicum*	1,450	**E**
Sisal	Embrapa Cotton	*Agave sisalana*	90	**E**
Soybean	Embrapa Soybean	*Glycine max*	11,800	**E**
Soybean	IAC	*Glycine max*	1,500	**E**
Sunflower	Embrapa Soybean	*Helianthus* spp.	2,400	**E**
Vigna	Embrapa Mid-North	*Vigna angularis*	1	**E**
		Vigna mungo	5	**E**
		Vigna radiata	49	**E**
		Vigna umbellata	1	**E**
Wild *Arachis* species	Embrapa Genetic Resources & Biotechnology	*Arachis glabrata*	116	**E/N**
		Arachis kuhlmannii	41	**N**
		Arachis pintoi	144	**N**
		Arachis repens	44	**N**
		Arachis stenosperma	62	**N**
		Arachis spp.	1,635	**E/N**

Table 8
Germplasm Banks of Medicinal, Aromatic, Stimulating, Dyeing and Insecticide Plants by Institution and respective number of acessions

GERMPLASM BANKS OF MEDICINAL, AROMATIC, STIMULATING, DYEING AND INSECTICIDE SPECIES				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Basil	UESB	*Ocimum spp.*	22	**E**
Basil	UFS	*Ocimum basilicum*	10	**E**
Cymbopogom	UFS	*Cymbopogon spp.*	4	**E**
Dimorphandra	IAC	*Dimorphandra* spp.	21	**N**
Erva cidreira	UFS	*Lippia alba*	92	**N**
Geranium	UFS	*Pelargonium sp.*	20	**E**
Long pepper	Embrapa Acre	*Piper hispidinervum*	1,900	**N**
		Piper aduncum	800	**N**
Maytenus	Embrapa Temperate Agriculture	*Maytenus* spp.	33	**N**
Medicinal and aromatic plants	UNICAMP	Medicinal and aromatic plants	2,073	**E/N**
Medicinal and condimentary plants	IAPAR	Medicinal and condimentary plants	400	**E/N**
Medicinal, aromatic and condimentary plants	Embrapa Western Amazon	*Croton* spp.	28	**N**
		Arrabidaea spp.		**N**
Patchuli	UFS	*Pogostemon cablin*	7	**E**
Repellent and insecticide plants	IAPAR	Repellent and insecticide plants	200	**E/N**
Sambacaita	UFS	*Hyptis pectinata*	6	**N**
Timbó	Embrapa Eastern Amazon	*Derris* spp.	110	**N**
		Serjania paucidentata		**N**
		Clitoria sp.		**N**
		Phyllantus brasiliensis		**N**
Urucu	Embrapa Eastern Amazon	*Bixa orellana*	12	**N**
Urucu	EMEPA	*Bixa orellana*	41	**N**
Urucu	UESB	*Bixa orellana*	50	**N**
Vetiver	UFS	*Chrysopogon zizaniooides*	9	**E**

Table 9
Germplasm Banks of Ornamental Plants by Institution and respective number of accessions

GERMPLASM BANKS OF ORNAMENTAL PLANTS				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Bromeliads	Jardim Botânico - SP	*Aechmea* spp.	1,272	**N**
		Billbergia amoena		**N**
		Catopsis berteroniana		**N**
		Dyckia brevifolia		**N**
		Ernesea bocainenesis		**N**
		Hohenbergia augusta		**N**
		Neoregelia spp.		**N**
		Nidularium spp.		**N**
		Orthophytum albopictum		**N**
		Portea alatisepala		**N**
		Quesnelia arvensis		**N**
		Racinea aeris-incola		**N**
		Tillandsia spp.		**N**
		Vriesea spp.		**N**
Cuphea	Embrapa Genetic Resources & Biotechnology	*Cuphea* spp.	50	**N**
Gladiolus	APTA	*Gladiolus* spp.	50	**E**
Heliconia	UFRPE	*Heliconia spp.*	42	**E/N**
Heliconia	UESC	*Heliconia spp.*	40	**E/N**
Hippeastrum	APTA	*Hippeastrum hybridum*	400	**E**
Native cacti	UFBA	Cactaceae	213	**N**
Native cacti	UEFS	Cactaceae	107	**N**
Ornamental plants	IAC	*Heliconia* spp. (including hybrids)	109	**E/N**
		Dimerocostus strobilaceus	1	**E**
		Cheilocostus speciosus	1	**E**
		Tapeinochilos ananassae	1	**E**
		Costus arabicus	18	**E**
		Costus spp.	18	**E/N**
		Etlingera spp.	22	**E**
		Alpinia spp.	10	**E**
		Zingiber spp.	3	**E**
Ornamental plants	IAC	*Anthurium* spp.	500	**E/N**
		Alstroemeria spp.	200	**E/N**

Table 9
Germplasm Banks of Ornamental Plants by Institution and respective number of acessions. (cont.)

Germplasm Bank	Institution	Scientific Name	No. of Accessions	Origin E/L/N
Ornamental plants	IAC	*Hippeastrum* spp.	200	E/N
		Hemerocallis spp.	100	E
		Gladiolus spp.	50	E
		Assorted native ornamentals	50	N
Ornamental plants	Embrapa Tropical Agroindustry	*Heliconiaceaee*	150	E/N
		Bromeliaceae		E/N
		Araceae		E/N
		Costaceae		E/N
		Marantaceae		E/N
		Zingiberaceae		E
		Cactaceae		E/N
Ornamental plants	UENF	*Arecaceae*	13	E/N
		Bromeliaceae	50	E/N
		Costaceae	2	E/N
		Heliconiaceae	11	E/N
		Orchidaceae	9	E/N
		Strelitziaceae	3	E
		Zingiberaceae	5	E/N
		Cycadaceae	1	E
Ornamental plants of Eastern Amazon	Embrapa Eastern Amazon	*Alocasia* spp.	59	E/N
		Monstera spp.		N
		Philodendrum spp.		N
Safflower	Embrapa Cotton	*Carthamus tinctorius*	800	E

Table 10
Germplasm Banks of Roots and Tubers, by Institution and respective number of acessions.

GERMPLASM BANKS OF ROOTS AND TUBERS				
Germplasm Bank	**Institution**	**Scientific Name**	**No. of Accessions**	**Origin E/L/N**
Cassava	Embrapa Temperate Agriculture	*Manihot esculenta*	12	**N**
Cassava	EPAGRI - Urussanga	*Manihot esculenta*	624	**N**
Cassava	Fepagro- Fruticultura	*Manihot esculenta*	160	**N**
Cassava	IAPAR	*Manhiot esculenta*	420	**N**
Cassava	Embrapa Cassava & Tropical Fruits	*Manihot esculenta*	1,961	**N**
Cassava	Embrapa Cerrados	*Manihot esculenta*	378	**N**
Cassava	Embrapa Semi-Árido	*Manihot esculenta*	529	**N**
Cassava	Embrapa Eastern Amazon	*Manihot esculenta*	58	**N**
Cassava	Embrapa Western Amazon	*Manihot esculenta*	236	**N**
Potato	IAC	*Solanum* spp.	80	**E/N**
Potato	Embrapa Temperate Agriculture	*Solanum tuberosum*	331	**E**
		Solanum (sect. *Tuberarium*) spp.		**N**
Sweet potato	Embrapa Vegetables	*Ipomoea batatas*	1,043	**E/L**
Sweet potato	Embrapa Temperate Agriculture	*Ipomoea batatas*	55	**E/L**
Sweet potato	UENF	*Ipomoea batatas*	13	**E/L**
Wild cassava species	Embrapa Cassava & Tropical Fruits	*Manihot anomala*	152	**N**
		Manihot caerulescens	35	**N**
		Manihot dichotoma	104	**N**
		Manihot flabellifolia	215	**N**
		Manihot glaziovii	91	**N**
		Manihot peruviana	260	**N**
		Manihot tomentosa	31	**N**
		Manihot spp.	40	**N**