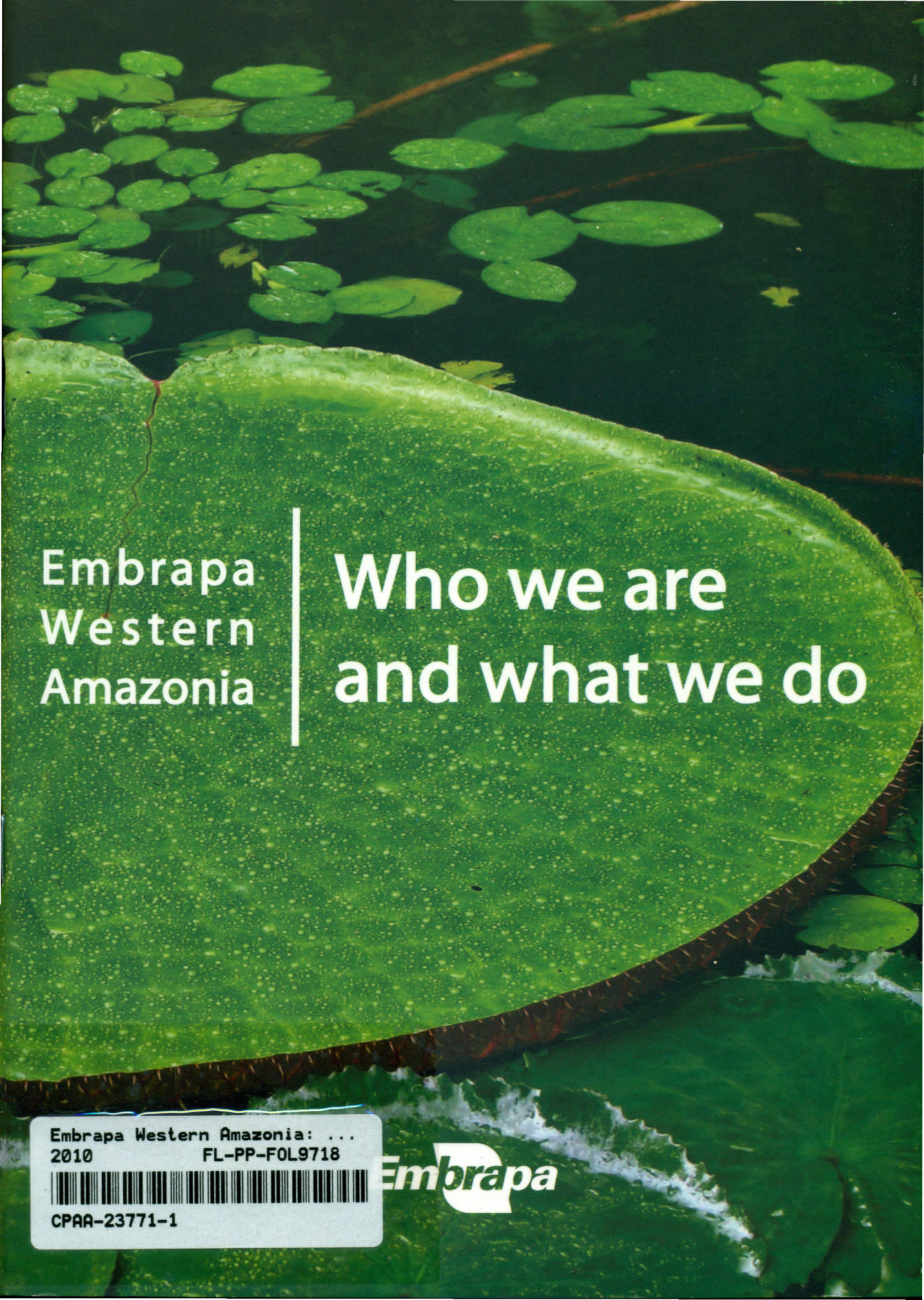

Embrapa Western Amazonia

Who we are and what we do

Embrapa

Preface

The challenges are great for Research, Development and Innovations Institutions in a region as the Amazonia, due to a strong and growing need to conciliate the reduction of deforestation, environmental preservation and food safety.

Over the 35 years of institutional history, in cooperation with the others research stations, Embrapa Western Amazonia has been producing a significant amount of knowledge, technologies, products and specialized technical services. In that manner, contributing for the ecological and economical sustainability of the producing processes, the farmer´s social inclusion and the population´s food safety.

It is important to have in mind that to achieve these results facing the challenge of conciliating development and preservation, the Embrapa Western Amazonia is working in line with government policies, universities and institutions of national and international research, technical assistance organization and rural extension, nongovernmental organizations, companies and associations, farmers, cooperatives among others important partners.

We invite you to meet a bit of who we are and what we have done to contribute for this great challenge of producing knowledge, technologies, services and products for the Brazilian Western Amazonia and, specially, for the State of Amazonas.

Maria do Rosário Lobato Rodrigues
General Head

Embrapa Western Amazonia

Embrapa Western Amazonia is one of the decentralized units of the Brazilian Agricultural Research Corporation-Embrapa, a public company under private law linked to the Ministry of Agriculture, Livestock and Food Supply-Mapa. Embrapa Western Amazonia has worked in the State of Amazonas since 1974. At the time, there were two organizations, namely, the State Research Unit and the National Center for Rubber Tree and African Oil Palm Research, which merged on 15 August 1989 to become the Western Amazonia Agroforestry Research Center, or Embrapa Western Amazonia. The Unit's headquarters are located in Manaus, the capital city of the State of Amazonas, and its ecoregion-oriented work follows a four-year strategic plan designed on the basis of an analysis of the national and international internal and external environments, government policies and prospective scenarios. Embrapa Western Amazonia has a staff of 285 people, including researchers, analysts and research assistants.


Embrapa
Amazônia Ocidental
Manaus
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Mission

To enable research, development and innovation solutions that ensure the sustainability of agriculture in Amazonia, with emphasis on the State of Amazonas, to the benefit of society at large.

Strategic Objectives

- To guarantee the competitiveness and sustainability of Brazilian agriculture.
- To attain a new competitive technological platform in agroenergy and biofuels.
- To intensify the development of technologies aiming at the sustainable use of the biomes and the productive integration of the Brazilian regions.
- To prospect the biological diversity with a view to developing differentiated, high added value products for introduction into new market segments (food, aromatic, essential oil, pharmaceutical, biocidal, phytotherapeutic, and cosmetic products);

Vision

A center of excellence generating knowledge, technology and innovation to enhance the sustainability of agriculture in Amazonia.

Photo: Maria do Rosário Rodrigues

Infrastructure

Photo: Siglia Souza

Experimental Fields

Headquarters Experimental Field – This experimental field is located in the Manaus Municipality, State of Amazonas (AM), at Km 29 of the AM-010 Highway. The research at this site covers aquaculture, forestry, fruits, manioc, food and agroindustrial products, forest management and agroforestry schemes, vegetables, and medicinal plants.

Suframa Agricultural District (DAS) Experimental Field – The site of this experimental field is located in the Manaus Municipality, AM, at Km 54 of the BR-174 Highway. The main line of research is sustainable land use alternatives and rehabilitation of altered/degraded areas, including forestry management, multiple-strata agroforestry systems, forestry, and African oil palm cropping systems.

Rio Urubu Experimental Field – The research is carried out in the Rio Preto da Eva Municipality, AM, at Km 54 of the ZF-7 secondary road, 140 km from Manaus. The research at this site revolves around African oil palm, including its management, nutrition, breeding, and production of pregerminated seeds. The site includes an oil and biodiesel extraction operational unit, as well as the most complete collection of African oil palm and American oil palm germplasm in the Americas, planted over 420 hectares.

Caldeirão Experimental Field – It is located in the Iranduba Municipality, AM, and harbors research on family or small-scale agriculture on floodplains (várzea) and upland (terra firme) ecosystems, with special focus on the sustainable production of manioc, fruits, guarana, grains, vegetables, and selected forest species for the production of energy to meet the needs of the oil extraction operations in the municipality. It is also a training center for sustainable rural development agents.

Maués Experimental Field – This experimental field is located in the Maués Municipality, AM. The main focus of the research at Maués is solving the technological bottlenecks in the farming phase of the guarana production chain. Maués also holds the largest guarana germplasm collection in the world, planted over approximately 40 hectares. It is also a training center for sustainable rural development agents.

Photo: Giglia Souza

Research Support and Technology Transfer Unit

The Research Support and Agricultural Technology Transfer Unit for the Lower Amazon River in the Parintins Municipality was created for the purpose of expanding the transfer of the technologies developed at Embrapa Western Amazonia to extension workers and farmers, as well as to strengthen its work in the hinterland of the State of Amazonas.

Laboratories

Embrapa Western Amazonia has twelve laboratories that provide specialized services to its researchers and external public, particularly teaching and research institutions. The laboratories also support the academic training and scientific initiation activities of said institutions through traineeships, courses and conferences.

Embrapa Western Amazonia's Soil and Plant Analysis Laboratory (LASP, Portuguese) also works with other institutions, being the only facility in the state to perform routine tests to determine the physical, chemical and physical-chemistry characteristics of soils. It analyses of fertilizers, soil correction products and water and performs routine analyses of plant tissues for use in leaf diagnoses.

LASP was evaluated by the Interlaboratory Plant Tissue Analysis Program (PIATV, in Portuguese), which awarded LASP the A-quality seal. PIATV is coordinated by the Brazilian Society of Soil Sciences, the "Luiz de Queiroz" Higher School of Agriculture of the University of São Paulo and the Quality Control Program in Fertility Laboratories of Embrapa Soils.

Photo: Siglia Souza

Photo: Regina Quisen

Agroclimatology Laboratory – This laboratory coordinates the agricultural climatology stations of Embrapa Western Amazonia and prepares agricultural meteorology bulletins that include water balances. The information is available to the population at large.

Seed Analysis Laboratory – It analyses the basic seeds of species produced in the region. It also support the Unit's researchers by a) collecting and managing the seeds of native forest species; b) performing germination analyses of such seeds; c) analyzing their viability and vigor; d) timing the dormancy break; e) determining seed tolerance and desiccation; and f) establishing each seed's storage and conservation parameters.

Soil and Plant Analysis Laboratory – This facility carries out research and executes routine analyses of plant nutrition and soil chemistry, fertility and physics.

Aquaculture Laboratory – This laboratory studies the cultivation of fish species under controlled conditions. It also performs the water analyses required in monitoring the environment of the fish farms, parasitological analyses and fish blood and plasma parameter analyses.

Molecular Biology Laboratory – This facility provides support to the genetic research projects. Molecular markers are used to characterize the agronomically important species. It also carries out research in structural and functional genomics and proteomics.

Tissue Culture Laboratory – The main activities are plant cell cultures, plant micropropagation, somatic embryogenesis, induced mutation, cultivation in bioreactors, and haploid cultures.

African Oil Palm and Agroenergy Laboratory – This laboratory provides support to the production of pre-sprouted seeds of the African oil palm and hybrids of the African and American oil palms. It analyses the composition of the plant oils and the characteristics of the biodiesel produced from the African oil palm.

Entomology Laboratory – Its research focuses on bioecology, biological control, chemical control, integrated pest management, toxicology, and ecotoxicoloy. It also performs pest diagnoses and recommends the appropriate insect and mite control methods in farming and forestry operations.

Plant Physiology Laboratory – This laboratory caries out anatomical, biochemical and ecophysiological analyses to support behavioral studies of tropical and neotropical species in the Amazonia biome, for the purpose of anticipating solutions to climate changes.

Phytopathology Laboratory – The main research line is the identification and integrated control of diseases to support Embrapa Western Amazonia's plant breeding programs, with special focus on resistance to the most important crop diseases.

Medicinal Plant and Phytochemistry Laboratory – This laboratory supports research on medicinal, aromatic and seasoning plant species, extracting volatile substances (essential oils) and fixating substances (resin oils and fixed oils).

Genetic Resource Laboratory – The laboratory focuses on the characterization and evaluation of the genetic resources of priority plant species in Amazonia. It executes physical-chemical and morphological analyses and evaluates production components (fruits, leaves and roots).

Main Research Areas and Technologies Developed

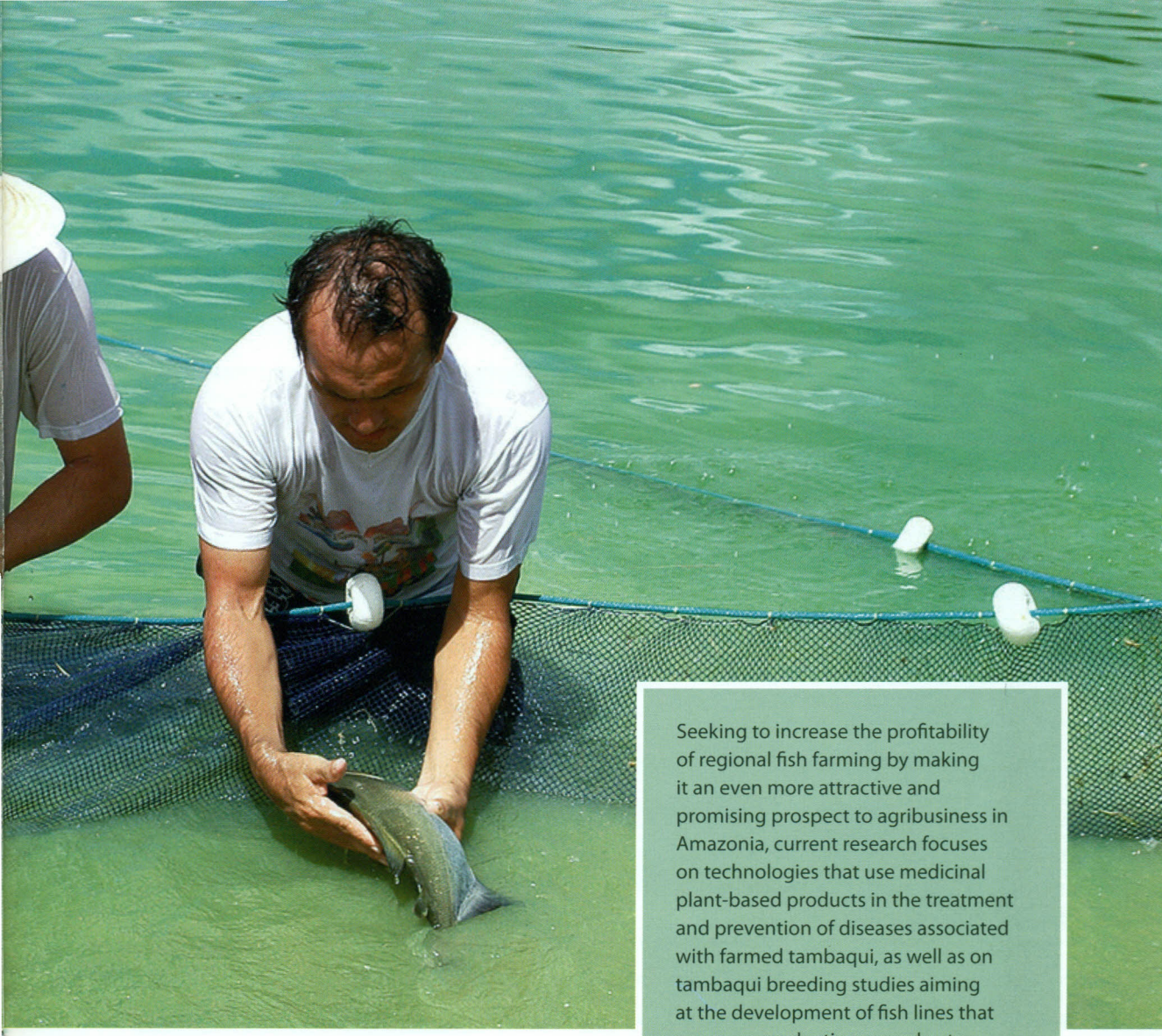
Photo: Maria do Rosário Rodrigues

Photo: Siglia Souza

Aquaculture

Research has focused on the sustainable development of aquaculture in the Amazon River, with special emphasis on *tambaqui (Colossoma macropomum)*, *pirarucu (Arapaima gigas)* and *matrinxã (Brycon amazonicus)*.

The *tambaqui* technology that has been made available to producers is based on fish production in excavated tanks, which shortens the production cycle from 36 to 12 months and ensures economically-viable *tambaqui* productivity rates. The good prospects drew the interest of producers to fish farming which, in turn, resulted in increased market supply and diminished



Seeking to increase the profitability of regional fish farming by making it an even more attractive and promising prospect to agribusiness in Amazonia, current research focuses on technologies that use medicinal plant-based products in the treatment and prevention of diseases associated with farmed tambaqui, as well as on tambaqui breeding studies aiming at the development of fish lines that are more productive, over shorter cultivation periods.

the pressure on natural fish stocks. Another technology made available to producers was commercial-scale, *matrinxã* farming in dams.

New studies are underway to adapt the fish farming systems to excavated tanks, dams and traps for the purpose of optimizing fish production and making it more economically attractive to rural producers, with minimum impact on the environment. To that end, emphasis is being placed on good aquaculture management practices that enable appropriate monitoring of the environmental quality and on providing guidance on the use of rations to prevent the degradation of the water quality and adapt the support capacity to each fish farming system studied.

Food Crops

Embrapa Western Amazonia is developing farming technologies for cowpea (*Vigna unguiculata)*, corn *(Zea mays)*, rice *(Oriza sativa),* and manioc (*Manihot esculenta*), important staple foods in the average diet in Amazon Region. Highly productive and pest-resistant cultivars of these crops have been selected, evaluated and recommended for the State of Amazonas.

In the case of manioc, Embrapa recommends the cultivar BRS Purus and the Aipim Manteiga variety for upland farming, while the cultivars Mãe Joana, Embrapa 8 and Zolhudinha are recommended for floodplains.

For upland and floodplain farming of cowpea, the recommended cultivars are BRS Nova Era, BRS Guariba, BRS Tracuateua, and BRS Xique-Xique, the latter having important nutraceutical properties. In addition to those cultivars, the researchers are also recommending water-stress-tolerant BRS Paraguaçu, for floodplain farming.

In addition to the cultivars, Embrapa Western Amazonia also provides farmers with production system technology for both upland and floodplain conditions. The technological level of the production systems available spreads over a wide range of needs, from family or small-scale farming to mechanized agriculture operations.

Photo: Mirza Pereira

Photo: Siglia Souza

Photo: Milton Almeida

The evaluation of new manioc, corn, rice, and cowpea genotypes is a permanent process that enables Embrapa Western Amazonia to update its recommendations of the more promising cultivars, better adapted to the farming conditions in the region. Research also focuses on the performance of the various crops under direct sowing conditions and of combinations of the different arrangements of species succession and/or crop rotation, as well as the occurrence of pests, diseases and weeds.

The results of those studies should provide information on the viability and profitability of using direct sowing systems in altered areas in the State of Amazonas.

Photo: Edson Barcelos

Agroindustrial Crops

African oil palm *(Elaeis guineensis)* and **American oil palm** *(Elaeis oleifera)*

Embrapa Western Amazonia has develop farming technology for the African oil palm, the highlights being the production systems and seven cultivars of the *tenera* type, duly registered at the National Cultivar Registration Authority (RNC/Mapa) and recommended for humid tropical regions. Trunk growth averages 45cm/year, while the average yield varies between 4 and 6 tons/hac/year in commercial farming operations.

For family agriculture, Embrapa Western Amazonia has developed a management system that enables consortia of the African oil palm with food crops (banana, manioc, pineapple, sweet potato, etc.) between rows, during the initial years after implementation. This system can be used in altered/degraded areas to make them more productive and can become an efficient way of generating jobs and income in the region, in addition to environmental gains and short-term capital gains, with amortization of as much as 100% of the costs of implementing and maintaining the African oil palm crop during the preproduction phase.

Embrapa has also studied the control of the lethal yellowing disease (LY), a fatal anomaly of unknown etiology and the main problem of African oil palm plantations in the Americas.

One of the main LY control strategies is the development of resistant cultivars, crossing African oil palms of African origin (Elaeis guineensis Jacq.) and African oil palms of American origin, called caiaué (American oil palm) or African oil palm of Amazonian origin (Elaeis oleifera Cortés). This crossing yields an LY-resistant, interspecific hybrid with greater resistance to pests and diseases, better oil quality (more unsaturated) and decreased vertical trunk growth, lowering harvest costs and increasing the plantation's commercial exploitation period. This research has enabled the release of the first interspecific hybrid commercially produced in Brazil, called BRS Manicoré, registered at RNC/Mapa.

Photo: Neuza Campelo

Guarana (*Paullinia cupana* var. *sorbilis*)

Embrapa Western Amazonia's long-standing breeding program has developed 16 clonal cultivars in the last few years with a view to increasing the profitability of guarana crops. All cultivars offer high yields and are resistant to anthracnose, an extremely important guarana disease that can wipe out the whole production. Because these cultivars are disease-resistant, no pesticides are needed.

When managed according to the production system recommendations the Embrapa cultivars produced in excess of 1.5 kg of dry seeds per plant, in contrast with the regional average of 200 g per plant.

Another technology developed at Embrapa Western Amazonia is the production of cloned plantlets using the stem cutting method, whereby the plantlet's development stage is reduced from twelve to seven months.

The guarana cultivars are also early producers, the average age of these plants when they start production being two years, as opposed to four years for other plants. The commercial production stabilizes three years after planting, while the production of plants obtained from seeds only becomes stable after five years.

Another line of research is breeding plants that originate from improved seeds, for the purpose of making available seed-propagated cultivars with the same advantages of the clonal cultivars, thus facilitating the multiplication of this genetic material by the guarana producers themselves, especially at Maués, State of Amazonas.

One of the research lines of the guarana breeding program is molecular marker-assisted selection, which comprises the development of the markers to be used, such as microsatellites and ISSR markers. The selection of material with enhanced nutraceutical characteristics is another of the program's objectives; this research line will be developed jointly with two Italian institutions, namely, Università degli Studi di Milano (UniMi) and Consiglio per la Ricerca e la Sperimentazione in Agricoltura (CRA).

With a view to exploiting the beauty and singularity of the guarana plant, its ornamental potential is being studied on the basis of a prebreeding program whereby the accesses in the Embrapa Western Amazonia's Guarana Germplasm Bank (BAG) will be characterized using the ecophysiological and aesthetic characteristics appropriate for various uses and landscaping effects.

In addition, studies are being carried out to design a production system for organic guarana, for the purpose of supplying new market niches.

Photo: Neuza Campelo

Photo: Neuza Campelo

New studies are underway to enable the use of the crown and panel combinations to improve the competitiveness of the natural rubber from Amazonia through gains in productivity. To that end, the selected crown and panel clones will be validated in commercial farming operations. The purpose of the research is to expand Hevea cultivation and, thus, offer another income source for the region.

Rubber tree *(Hevea brasiliensis* spp.*)*

To enable the cultivation of the rubber tree in Amazonia, where the climatic conditions favor the appearance of the crop's main disease, the South American leaf blight (*Microcyclus ulei)*, which thwarts the harvesting of the natural rubber or latex, Embrapa Western Amazonia has released a technology for producing tricomposed trees.

This technology consists in using a panel clone (trunk) with high latex production performance, removing the crown susceptible to leaf blight and replacing it, through grafting, with a leaf blight-resistant crown clone. The resistant crowns were obtained through selection of interspecific crossings of other *Hevea* species, as part of an intense research program with a three prong approach, namely, "breeding, physiology and phytotechny".

The combinations of crown and panel clones selected in the research program are early, high-yield producers (over 1,500 kg of dry natural rubber/ha/year. In addition, their trunk circumference is sufficiently large for latex harvesting by the sixth year after planting, thus anticipating production by two years.

Fruit cultivation

The conservation of germplasm, breeding programs that emphasize pest and disease resistance and increased productivity, the implementation of good agricultural practices, the design of production systems, and meeting the requirements of Integrated Fruit Production (IFP) of native and exotic species are the main fruit research lines at Embrapa Western Amazonia.

Photo: Milton Almeida

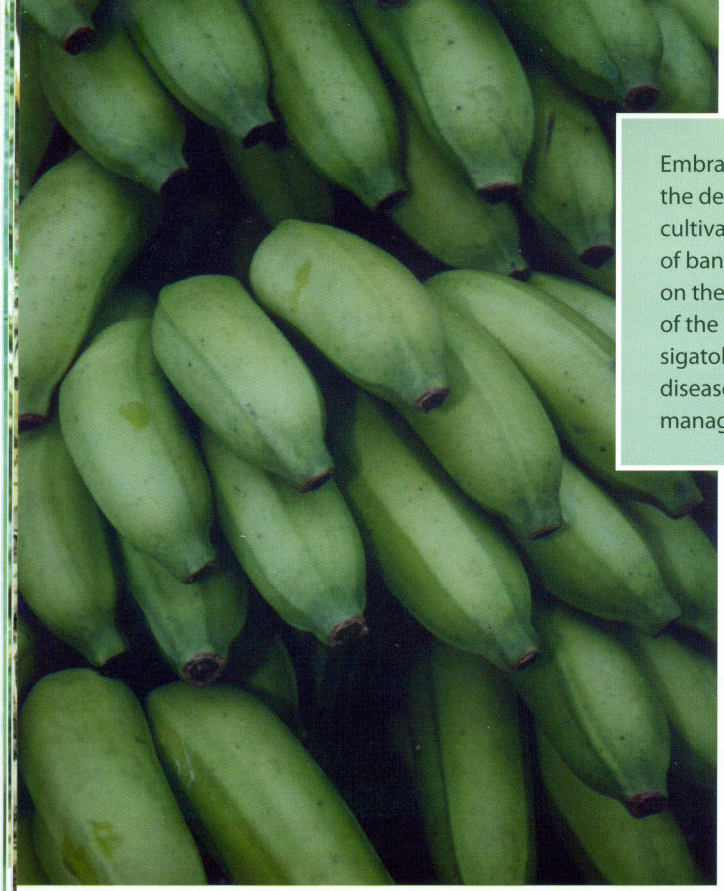


Photo: Neuza Campelo

Embrapa Western Amazonia emphasizes the development and release of new cultivars resistant to the main diseases of banana. A new line of study focuses on the analysis of the genetic diversity of the M. fijiensis fungi that cause black sigatoka, for the purpose of finding disease control strategies through the management of resistance genes.

Banana *(Musa* spp.*)*

On the basis of studies on the control of black sigatoka (*Mycosphaerella fijiensis),* Embrapa Western Amazonia has recommended the following resistant cultivars: BRS Caipira, BRS Thap Maeo, FHIA 18, and BRS Pelipita. It has also released cultivars Prata Ken, BRS Caprichosa and BRS Garantida. The latter was released in 2009 and was the first cultivar in Brazil to receive the Certificate of Protection from the Ministry of Agriculture, Livestock and Food Supply.

With the exception of FHIA 18, these cultivars are resistant to banana wilt or panama disease, caused by the fungus *Fusarium oxysporum* f. sp. *Cubense*. Their yield is 30-40 t/ha, while the yield of the bananas traditionally produced in the region, such as Prata, Maçã and the Pacovan platain, susceptible to black Sigatoka, is approximately 10 t/ha.

Embrapa Western Amazonia has also made available chemical control technology for black sigatoka, such as a more efficient application less fungicide in the plant's leaf axils.

In addition to resistant cultivars and chemical control, Embrapa Western Amazonia makes management recommendation to increase productivity.

Cupuaçu *(Theobroma grandiflorum)*

Cupuaçu, also spelled Cupuassu and Copoasu, is a tropical rainforest tree related to cacao. Embrapa Western Amazonia has a broad research program that involves breeding, entomology, phytopathology, and biotechnology and has invested heavily in the generation and adaptation of cupuassu farming technologies and agribusiness.

Among the technologies already available, special not should be made of the recommendations regarding good agricultural practices in cupuassu cultivation – especially the control of witches' broom (*Crinipellis perniciosa)*, the main cupuassu disease, and of the fruit weevil (*Conotrachelus* sp.) – and recommendations on fertilization, cleft grafting techniques to reduce the cuttings' formation time from 18 months to 8-12 months, and harvest and postharvest care, all of which have been identified as the most important problems for the development of cupuassu agribusiness.

Photo: Aparecida Claret

Embrapa Western Amazonia has developed cupuassu cultivars BRS 227, BRS 228, BRS 229, BRS 311, and BRS 312, all of which are resistant to the witches' broom disease. Average yield of these cultivars is 7,000 fruits/ha, way above the average yield in the State of Amazonas, (1,880 fruits/ha). These clonal cultivars also have superior pulp and nut yields.

In addition, Embrapa Western Amazonia has a permanent program of cultivar selection and good agricultural practice enhancement to support the development of cupuassu cultivation.

Citrus *(Citrus* sp.*)* and **Pineapple** *(Ananas comosus)*

Embrapa Western Amazonia has developed a citrus production system with the required technical base to enable citrus cultivation in the State of Amazonas. It also recommends various compatible rootstock combinations with mandarin, orange, lemon, citrumelos, and lime grafts, which help achieve better productivity, health and longevity conditions in Amazonian orchards.

Photo: Marcos Garcia

Photo: Neuza Campelo

Citrus and pineapple researches are being oriented toward Integrated Production – an evaluation of compliance with agricultural practices based on product monitoring and traceability, whose purpose is to produce better quality fruit, achieve lower productions costs, diminish consumption of pesticides and, thus, also reduce environmental damage, as well as increase consumers' credibility and reliance on the fruit marketed.

Photo: Siglia Souza

Papaya *(Carica papaya)*

With the growing interest in cultivating papaya in the Northern Region, Embrapa Western Amazonia has studied the performance of various cultivars under the climate and soil conditions that prevail in the State of Amazonas, with a view to selecting and recommending highly productive cultivars that yield evenly-sized quality fruit. The research program is also trying to define, in the middle term, an irrigation system for the production of papaya throughout the year under the existing conditions in Amazonia.

Medicinal Plants and Condiments

Agronomical studies of native medicinal species, such as Santiago or *caapeba* (*Pothomorphe peltata*), spiked pepper or *pimenta-de-macaco* (*Piper aduncum*), *sacaca* (*Croton cajucara*), and cricket-vine or *crajiru* (*Arrabidaea chica),* as well as exotic species, such as sweet wormwood *(Artemisia annu)*, are being carried out for the purpose of developing production systems for these species. In addition, Embrapa Western Amazonia has undertaken studies with bioactive extracts and is monitoring the substances of interests in these plants.

The purpose of the research on the species used as seasoning, such as tumeric *(Curcuma longa)*, basil *(Ocimum basilicum)*, ginger *(Zingiber oficinalis),* and mint varieties *(Mentha* sp.*),* is to select optimum material and define crop management practices appropriate for family or small-scale agriculture.

The definition of the production systems for the medicinal species will enable farmers to supply quality raw material and, thus, strengthen the production chain of the natural products, adding value to regional biodiversity products.

Photo: Siglia Souza

Photo: Siglia Souza

Embrapa Western Amazonia will continue research on cultivar introduction and evaluation and on appropriate production systems for table vegetables cultivation in floodplain and upland environments in order to ensure production, quality, precocity, and pest resistance.

Among the production systems to be evaluated, special mention should be made of the Direct Sowing System, under both protected and open sky conditions, in floodplain and upland ecosystems.

Vegetables

Embrapa Western Amazonia supports the production chain of table vegetable species with emphasis on crops of interest to family farming.

The research focuses on cultivar recommendation of various species appropriate for floodplain and upland environments, as well as protected cultivation, rotation and consortium systems. Embrapa Western Amazonia also studies non-conventional vegetables from Amazonia with potential as commercial crops.

Photo: Siglia Souza

The research of protected cultivation systems on cultivation substrates and crops rotation using corn, tomatoes and paprika, as a strategy to reduce soil salinization and soil pathogens, such as bacterial wilt, allow the farmer a better growing condition with economic and environmental gains.

The watermelon research aims at the development and adaptation of technologies to permit the its cultivation in upland ecosystems, as an alternative crop in between floodplain harvests. These technologies have allowed farmers to increase their productivity from 3,500 units/ha (state average) to 6.600 units/ha. The development of a drip irrigation scheme has not only reduced irrigation water consumption from 38,000 liters to 11,000 liters, with obvious gains to the environment, but also brought down the incidence of leaf diseases in watermelon patches.

Forestry and Agroforestry

Embrapa Western Amazonia also studies forest management, forestry and agroforestry systems with special emphasis on the potential of species of economic and ecologic interest of the Amazon Forest in the reclamation/rehabilitation of altered/degraded forest areas and in the sustainable use of wood and non-wood products.

Photo: Siglia Souza

The studies of agroforestry systems has gradually adapted the capoeira management systems (improved with legumes and non-legumes), such as cutting and grinding to incorporate the organic material into the soil, as a practical alternative to the conventional slash-and-burn practice.

The successful adoption of the agroforestry systems requires integrated work involving research, technology validation and socioeconomic assessment of the systems, training technicians and farmers, and retrieval of good traditional practices in areas of strong anthropic pressure and high poverty rates.

Agroforestry Systems

Agroforestry research at Embrapa Western Amazonia focuses on the evaluation of agroforestry systems to reclaim degraded areas and generate environmental services and income and provide food security to small landholders and their families.

The most important results available are related to the agronomic, forestry and ecologic behavior of the main agroforestry tree components (Brazil nut tree, *colubrina*, mahogany, *andiroba*, rubber tree, *paricá*, teak, etc.), perennial and semi-perennial fruit trees (cupuassu, coconut, orange, heart-of-palm, *açaí, acerola*, papaya, passion fruit, banana, *guarana*, *urucu*, pineapple, etc.), green manure crops (*ingá, gliricídia, tefrosia, flemingea*), and annual crops (manioc, cassava, rice, corn, and bean) in agroforestry schemes. Knowledge about agroforestry practices, such as green manure and agroforestry schemes and management, was obtained from 20-year long agroforestry experiments implemented in degraded areas, which are the oldest agroforestry systems in the state.

The agroforestry alternatives are built taking into account the interest of the farmers, the environmental characteristics of each area and the food needs of the families and markets, in order to adequately and efficiently manage the natural resources of the agricultural properties in the rural landscape. This type of farm management, based on the agroforestry principles, permits the integration of the various land uses (forest, plantations, *capoeira*, vegetable gardens, pastures, agroforests, agrosilvoforests, fish farming), for the purpose of ensuring sustainability, soil preservation, water resources conservation, and legal reserve areas.

Photo: Jeferson Macêdo

Forestry and Forest Management

The research focusing on the analysis of reforestation capacity has contributed significantly to the use of native and exotic tree species to produce wood. Ten species are being recommended for use in the timber/furniture production chain and to produce energy, namely, Brazil nut tree *(Bertholletia excelsa), jatobá (Himenaea courbaril)*, tonka bean tree *(Dipteryx odorata),* and *andiroba (Carapa guianensis)*, for multiple uses (wood, fruit); *morototó (Schefflera morototoni)* and *paricá (Schizolobium amazonicum)*, for use as timber; *taxi-branco (Sclerolobium paniculatum)* and wattle (*Acacia mangium* and *A. auriculiformis)*, to produce energy from firewood and charcoal; and pekea *(Caryocar villosum)* and *tucumã* palm *(Astrocaryum aculeatum)*, for the use of their byproducts as sources of energy.

Recommendations about spacing, selection of origin and superior progenies, nutritional demands, propagation, seed and seedling production, technological properties, and quality of the wood are already available for those species.

There are also studies on the environmental services generated by forest species, on the basis of studies of biomass production, carbon absorption and analyses of the environmental impact of the planting systems. Ecophysiological evaluations are also being performed, together with the quantification of the impacts caused by global climate changes on forest species, by means of the simulation of future scenarios based on regional climate data projections.

Forest management is one of the main sustainable use alternatives as counterpoint to the deforestation of Amazonia. The research has generated data, information and knowledge that have proven the relevance of forest management to the conservation of the forest in the region.

Embrapa Western Amazonia's Phenological Park covers 400 hectares of primary forest, specifically set aside and demarcated for forestry and ecological studies because the area has not undergone environmental changes or suffers from border effects. The Phenological Park is currently divided into one-hectare areas that are part of Redeflor (Amazonia Forest Dynamics Monitoring Network), created by the Ministry of Environment for the purpose of disseminating information about the growth and production dynamics of the forest, obtained through continuous monitoring, for different site conditions in the Brazilian Amazonian Region and the National Permanent Parcels System. The technologies on forest management available at Embrapa Western Amazonia are used in phonological studies of promising forest species, their growth and production dynamics, modeling, and tree biomass.

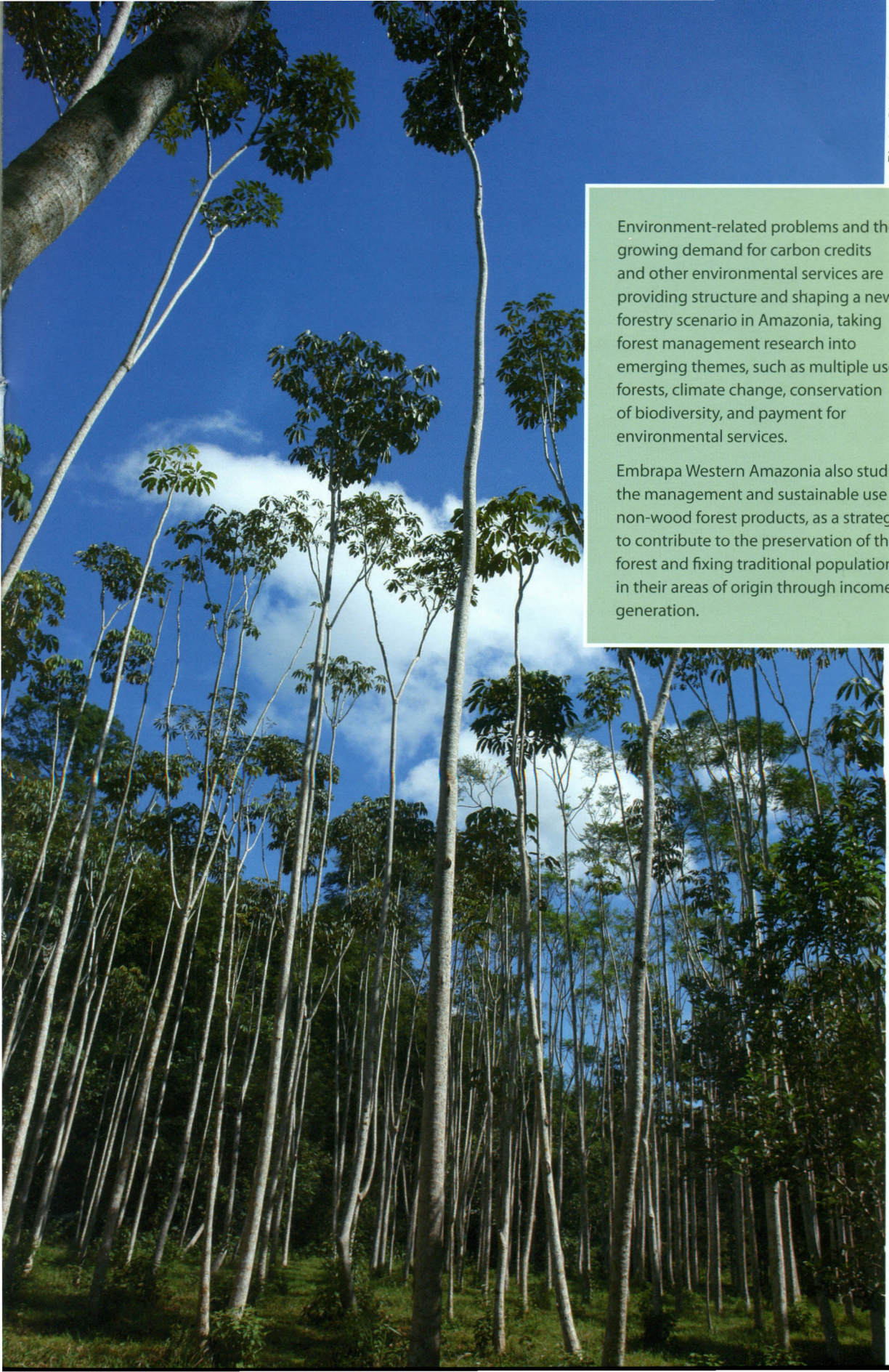


Photo: Siglia Souza

Environment-related problems and the growing demand for carbon credits and other environmental services are providing structure and shaping a new forestry scenario in Amazonia, taking forest management research into emerging themes, such as multiple use forests, climate change, conservation of biodiversity, and payment for environmental services.

Embrapa Western Amazonia also studies the management and sustainable use of non-wood forest products, as a strategy to contribute to the preservation of the forest and fixing traditional populations in their areas of origin through income generation.

Photo: Siglia Souza

Crop-livestock-forestry integration (iCLF) system

Embrapa Western Amazonia has been studying Crop-livestock-forestry integration (iCLF) system as a way to reclaim degraded pasture areas and provide more sustainable and competitive livestock operations for the State of Amazonas.

The main idea behind the study of those systems, which integrate farming, livestock and forestry systems, is to develop technologies to transform the current production systems into systems that integrate the livestock operations into the sustainable production of grain and/or

The Technology Reference Units (TRU) were established in an effort to conciliate research activities and the demonstration of the main technologies developed for cattle raising. The focus of the TRU activities is the selection of more productive and better adapted annual-crop cultivars, as well as the intensive management of pastures, aiming at increasing animal productivity, regardless of the final product being meat or milk.

trees, as a strategy to diversify the sources of income and add value to the properties, as well as enable the reclamation of degraded, legal reserve and permanent preservation areas.

Among the technology and information available for the State of Amazonas, the most important are a) a rotation grazing system for cattle in floodplain and upland areas; b) sheep raising in upland areas; c) food complements for sheep kept on a grazing system; d) prescribed soil-cover grass and legume species; e) green manure and animal nutrition; f) yield of the species that make up an iCLF system; and g) contributions of the iCLF system to the physical and chemical characteristics of the soil.

Transversal Research Actions

Characterization and Use of the Amazonian Biome

The relevant role of Embrapa Western Amazonia in the characterization and use of the Amazonian biome is set apart by its experience in evaluating and defining the farming potential of the different areas, as well as its proposed sustainable farming practices for the conservation of natural resources and eradication of deforestation. Consequently, Embrapa Western Amazonia participates in the national committee for the Economic Ecologic Zoning (EEZ) of Amazonia and in the state EEZ committees, contributing, thus, to the definition of public land use, management and monitoring policies. In the State of Amazonas, Embrapa Western Amazonia also participates in the Zoning of the BR 319 (Manaus – Porto Velho) highway, the Suframa Agricultural District and the Tarumão-Mirim River Basin.

Soils

One of the limiting factors of agricultural activities in Amazonia is the low fertility of most of its soils. Thus, Embrapa Western Amazonia is seeking soil management alternatives that permit the use of sustainable and economical farming systems, for both floodplain and upland soils.

The soils in floodplain ecosystems are very fertile. Consequently, the research aiming at the selection and recommendation of cultivars and management systems for short-cycle food crops with high nutritional demands concentrates on floodplain soils. For upland ecosystems, where most low fertility soils are located, the studies seek alternative management systems and more productive and resistant cultivars adapted to upland conditions, as well as technological solutions for farming traditional floodplain crops – such as cowpea and watermelon – in upland areas, as an alternative during the period in which the floodplains are submersed.

Terra Preta de Índio – The origin of the Terra Preta de Índio (TPI) soils is associated with the pre-Columbian populations in Amazonia, which used fire management practices and incorporated plant and animal residues to the soil, for the purpose of improving the quality of the soils for farming. Those soils are very fertile and have large amounts of available nutrients,


Photo: Gilvan Coimbra

such as calcium, magnesium, zinc, manganese, phosphorous, and carbon. Because this type of soil maintains its fertility for long period of time, the national and international scientific communities have tried to understand how the soils were formed and evolved, for the purpose of reproducing their fertility conditions.

Embrapa Western Amazonia participates in this enterprise and, using the studies of the TPIs as starting point, endeavors to develop farming technologies based on the conditioning of the soil by carbonized residues and to evaluate their potential to increase, reclaim or maintain their production capability, Among other advantages, the use of burned residues in agriculture not only improves fertility and extends the use of certain areas for farming, but also contributes to carbon sequestration through the retention of CO_2 in the soil, the reduction of emissions from forest fires, or the natural mineralization of organic matter.

Soil Ecotoxicology – Another soil research line at Embrapa Western Amazonia is the definition and validation of sustainability indicators and methodologies for the evaluation of environmental risks of chemical substances on the soil. The main purpose of the studies is to evaluate the effects of pesticides on the soil biota. Petroleum and its products are also evaluated in order to produce basic information for the remediation procedures required in the case of accidents and contamination.

The studies of the soil macrofauna, which focus on the evaluation of the use of worms as bioindicators of soil quality, are also important to understand the importance and function of such organisms in maintaining nutrient cycling and soil structure, important tools in the reclamation of degraded areas.

Climate Change and Agroenergy

In a scenario of world concern over climate changes, growing demand for energy, social pressure to replace fossil fuels, and valorization of renewable sources of energy, Embrapa Western Amazonia has joined efforts to develop, adapt and validate technologies that contribute to the sustainable production of energy, with a view to increasing the competitiveness of Brazilian agribusiness and supporting public policies.

The main research in this area focuses on the African oil palm, the oleaginous species with the greatest production potential and highest energy-conversion efficiency in Amazonia. The African oil palm can effectively contribute to biodiesel production in the region, a fact already acknowledged by the Federal Government when it assigned priority to this species in the National Program for the Production and Use of Biodiesel in the Northern Region of the country and granted tax incentives by means of the Social Fuel Seal. As a perennial species, the African oil palm can be grown under Amazonian conditions, helps protect the soil, has a low environmental impact, is better adapted to the natural low fertility of Amazonian soils and, thus, is appropriate for long term production on altered or degraded areas.

As contribution to the agroenergy production systems, Embrapa Western Amazonia is also studying the characterization and development of technologies for cultivating Amazonian species with high oil-production potential and byproducts suitable for generating energy. The main species are pekea *(Caryocar villosum), andiroba (Carapa guianensis)* and *tucumã (Astrocaryum aculeatum).*

Along the same line, Embrapa Western Amazonia is studying species to be used in energy forest, with the evaluation and selection of potential species with high calorific power and biomass production, to be used as firewood. Thus, Embrapa Western Amazonia has developed technology for energy forests, as an alternative to meet the demands of the local production sectors with firewood, as a renewable source of energy under sustainable production, because of the considerable current consumption of firewood from native forests, with resulting high rates of deforestation. The main area being thusly exploited is the Municipality of Iranduba, near Manaus, where most ceramics works are located. Research has shown that *taxi-branco (S. paniculatum)* and wattle *(A. mangium* and *A. auriculiformis)* are promising species for forest plantation to be used as sources of energy.

Photo: Siglia Souza

Plant Health

The purpose of the phytopathology and entomology studies is to control the diseases and pests that affect crops of interest to the region.

In the field of phytopathology, the main emphasis has been on studying the stability and predictability of the resistance to the main *guarana* and banana diseases, as well as evaluating the resistance of cupuassu genotypes to witches' broom. One of the objectives of research is to select and recommend cultivars with stable resistance and high adaptability, so that banana, *guarana* and cupuassu growing become economically and socio-environmentally sustainable activities. In addition, the laboratory acts as a plant health clinic to help farmers and rural extension workers by diagnosing the diseases and indicating the necessary control measures.

Entomology research focuses on integrated pest management, a practice that leads to diminished pesticide use and safer food crops, with low residue rates, which in turn promotes environmental preservation. Another objective of the entomology studies is to identify the pest species present in the Brazilian Amazon Region, assessing their economic importance, identifying the host plants and natural enemy species, and carrying out plant health educational campaigns.

Basidiocarps of *Moniliophthora perniciosa* (whitches' broom)

Photo: Maria Geralda de Souza

Photo: Siglia Souza

Photo: Siglia Souza

Banana plantlets produced by tissue culture.

Plant Tissue Culture

The objective of the research with plant tissue cultures at Embrapa Western Amazonia is to adapt, use and develop *in vitro* culture techniques for the production and conservation of plants that contribute to the enhancement of knowledge and the solution of technological bottlenecks to large-scale propagation of superior, pathogen-free plant genotypes of various tropical species of economic and ecologic importance to the Amazon Region.

To that end, micropropagation and somatic embryogenesis studies are being performed in order to define the *in vitro* cloning protocols, both to mass produce plantlets and to support the breeding program of perennial species such as cupuassu, guarana, rubber tree, and African oil palm, as well as forestry and ornamental tropical species. The most recent research line focuses on the *in vitro* induction of mutations in native *Heliconia* spp., which are used as a promising alternative to generate genetic variability by incorporating new attractive characteristics of interest to the ornamental plant industry.

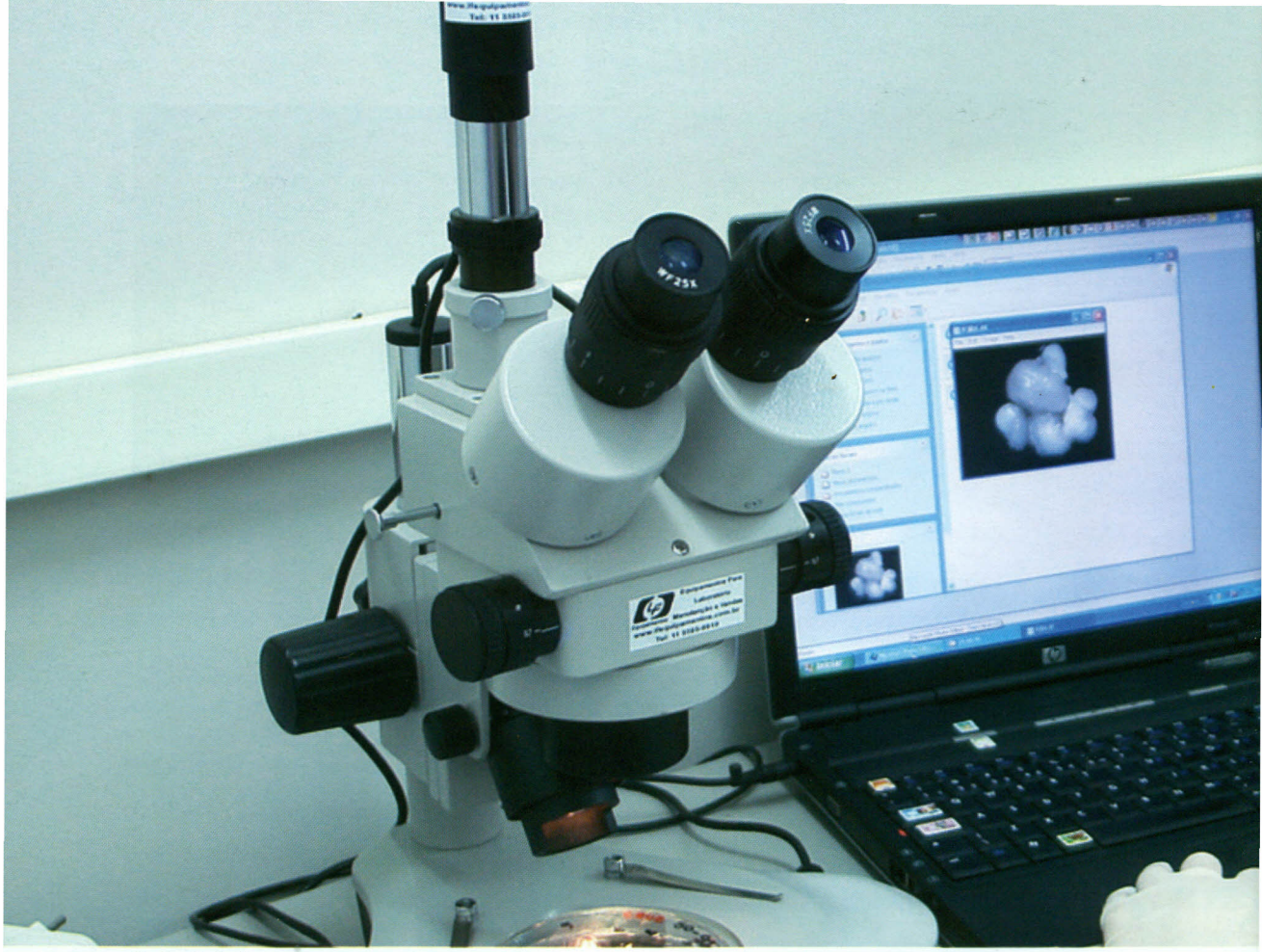


Photo: Siglia Souza

Molecular Biology

The research at Embrapa Western Amazonia's Molecular Biology Laboratory meets the methodological innovation requirements of the germplasm conservation programs, breeding programs on species of agricultural interest to the Amazon Region and phytopathogenic microorganism programs. The infrastructure includes the equipment necessary to work in molecular genetics, genomics (structural and functional) and proteomics.

In the plant area, the main objectives achieved are the analysis of the diversity of germplasm accesses and support to the cupuassu and *guarana* breeding programs. The research outcomes include *guarana* (*P. cupana* var. *sorbilis*), cupuassu (*T. grandiflorum*), manioc (*M. esculenta*), natural populations of rosewood (*Aniba rosaeodora*), and medicinal plants such as *sacaca* (*C. cajucara*) and cricket-vine (*A. chica*). The team has been working on the development and/or utilization of various molecular markers to access the genetic variability of the species of interest. Among the markers used, special mention should be made of the following: RAPD, SSR, ISSR, ERIC and REP-PCR, ITS or ITS-RFLP, as well as *retrotransposons*-based markers (IRAP and REMAP).

As regards phytopathogens, there are studies underway with the fungus *M. fijiensis,* the causal agent of black sigatoka in the banana tree, such as the analysis of the fungus' diversity in Brazil and the characterization of genes related to its pathogenicity. Adding their effort to the combat against phytopathogens of agricultural crops, the team has invested, in the functional genomics area, on gene *knockout* and *gene knockdown* (silencing via interference RNA) techniques which enable the study of the genes supposedly responsible for the disease and, thus, make it possible to generate technologies with low environmental impact, varying from classic breeding to the use of molecular tools.

The laboratory is also linked to the local biotechnology research networks, such as the Proteomic Network of the State of Amazonas, which, *inter alia*, studies the *Chromobacterium violaceum* bacterium seeking to identify polypeptides with biotechnological potential for antagonic interaction with plant diseases and pests, with the study of the interaction between the proteins of that bacterium and its potential against the fungus that causes anthracnose. The state research network is also analyzing the proteome of the fruit and seeds of the *guarana* plant.

Agroecology

Agroecology is a transdisciplinary endeavor to establish the foundations for the development of sustainable production systems, as opposed to an agricultural model that depends on chemical inputs, large tracks of land and high capital investments and is associated with environmental degradation.

The concept of agroecological transition contemplates a gradual process of change in the types of agroecosystem management, with a passage from the agrochemical model of production to agricultural styles that incorporate ecology-based principles and technologies that promote the conservation and sustainable use of natural resources and value practices based on agrobiodiversity.

The Agroecological approach has gained momentum at Embrapa with the Agroecology Benchmark published in 2006. To that end, Embrapa Western Amazonia has begun a series of studies that contemplate the principles of agroecology, such as a) rational use of natural resources; b) diversification of agroecosystems; c) reduced use of pesticides; d) elimination of agricultural practices harmful to the environment; and e) reduced deforestation and reclamation of degraded areas.

Photo: Sigila Souza

Technical Cooperation and Institutional Partnerships

Photos: Maria José Tupinambá

In its search for new approaches and additional expertise in the field of science, Embrapa Western Amazonia has increased its partnerships with national and international research institutes and networks with a view to joint action on several fronts, from professional training, exchange of researchers, sharing infrastructure, exchange of germplasm, to the development of new products and technologies.

Through this international technical-scientific cooperation program, Embrapa Western Amazonia has been engaged in important research work since the 1980s, with emphasis on African oil palm cultivation, forestry, nutrient cycling in tropical soils, sustainable use and conservation of soils, agroforestry systems, and reclamation of degraded areas.

New themes have been recently added to Embrapa Western Amazonia's international cooperation agenda, as follows:

a) Genetic studies of the *M. fijiensis* fungus (black sigatoka agent), for the purpose of reducing the amount of pesticides used in banana plantations. Studies using cellular biology, genomics and molecular marker-assisted selection for *E. guineensis e E. oleifera* species.

b) Identification of a quick method to detect and quantify aflatoxigenic *Aspergillus* spp. and mycotoxins in Brazil nut seeds.

c) Development of techniques to protect the biodiversity of soils under different types of use and evaluation of the role of biodiversity in maintaining soil sustainability, on the long term, in tropical agroecosystems.

d) Improved agricultural productivity in Amazonia and reduced environmental impact of the slash-and-burn system through the sustainable use of plant biomass.

e) Characterization of anthropic soils known as Terra Preta de Índio (TPI), for the purpose of reproducing their fertility.

f) Prospection, physical-chemical characterization, evaluation of nutritional, functional and sensorial properties of Amazonian fruits of economic interest.

g) Study of the nutraceutical properties, allergenicity and agroindustrial processing of Amazonian products, for the purpose of developing processes and products destined to the market.

Among the main international partner institutions working in cooperation with Embrapa Western Amazonia, special mention should be made of the following:

- Centre de coopération internationale en recherche agronomique pour le dévelopement (Cirad), France.
- North Carolina State University (NCSU), USA.
- University of Hamburg, University of Göttingen, University of Bonn, Germany.
- College of Agriculture and Life Sciences (Cornell University), USA.
- Wageningen University & Research Centre (WUR),The Netherlands.
- Max Planck Institut, Germany.

- Rothamsted Research, The United Kingdom.
- University of Miami , USA.
- University of Guelph, Canada.
- University of Bayreuth, Germany.
- University of Kansas, USA.
- University degli Studi di Milano, Italy.

In Brazil, Embrapa Western Amazonia has built a large network of partner institutions in the fields of scientific research, agriculture and technical and academic training. Among those institutions, the following stand out:

a) State Secretariat for Rural Production (Sepror/AM).

b) Institute for Agricultural and Forestry Development of the State of Amazonas (Idam), which works with rural extension.

c) National Institute for Research on Amazonia (Inpa).

d) State Secretariat for Science and Technology (Sect/AM).

e) Brazilian Service of Support to Micro and Small Businesses (Sebrae).

f) Federal Institute of Education, Science and Technology (Ifam).

g) Federal University of Amazonas (Ufam).

h) State University of Amazonas (UEA).

i) Federal Superintendency of Agriculture (SFA/AM)

j) Ministry of Land Development (MDA).

k) Center for Business Incubation and Development (Cide).

l) Superintendency of the Free Zone of Manaus (Suframa).

Embrapa Western Amazonia collaborates in partnerships with municipal governments, private companies, farmer's associations and cooperatives. Embrapa also cooperates among its own research centers in the country. Obtains financial support from the Financier of Studies and Projects (Finep), the National Council for Scientific and Technological Development (CNPq) and Foundation of Support to Research of the State of Amazonas (Fapeam) among others.

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