Brazilian Agriculture

Brazilian Annual Agricultural Production (million tonnes - Mt)

- **Grains**: 219 Mt
- **Meat**: 26 Mt
- **Fruit**: 43.8 Mt
- **Milk**: 35 Billion Litres

**Contribution of Agriculture**
- 25% GDP
- 37% Jobs
- 42% Exports
- 63% of the Brazilian Trade Balance

**Brazil Numbers**
- World’s largest exporter of soybean, beef, coffee, sugar, orange juice, ethanol and chicken in 2016.
- In 2016 agribusiness exports reached US$ 85 billion.

**Growth in the Agricultural Productivity**

Grain production/area (millions t & ha)

- **Cropped area**
- **Grain production**

Source: Conab.
Embrapa is the Brazilian Agricultural Research Corporation of the Ministry of Agriculture and Food

- Embrapa has 46 research centres spread all over Brazil.
- Some Centres are regional (e.g. Humid-tropics, Semi-arid) other product Centres (e.g. Soybean, Wheat, Beef cattle) and some thematic (e.g. Satellite monitoring, Soils).

- Embrapa Agrobiologia is a thematic centre with the mission to substitute, where possible, chemical inputs in agriculture with biological processes:
  - A large proportion of our work is concerned with biological nitrogen fixation.
  - Legume crops, legume trees for rehabilitation of degraded areas, forage legumes in pastures.
  - We also work on mycorrhizal fungi and other plant-growth promoting microorganisms, their action, biodiversity, genomics and taxonomy (molecular biology).
  - Other related important areas are organic agriculture, biological control of pests, nutrient cycling and greenhouse gas emissions from all types of agricultural systems.

Biological nitrogen fixation is the conversion of $N_2$ gas from the atmosphere to forms of nitrogen that plants can use for growth

- The most efficient form of $N_2$ fixation is symbiotic $N_2$ fixation in nodules formed by rhizobium bacteria on legume plants.
- It is estimated that over 15,000 species of legumes can form nodules and fix $N_2$.
- The $N_2$ diffuses into the nodules (usually on the roots) and with sugars provided by the plant the enzyme complex nitrogenase produces amides or ureides which are translocated to the shoot.
- In world agriculture more $N_2$ is fixed by soybean than all other crops added together.
- Brazil produced 115 M t of soybean grain (~37 % protein) last year and exported 67 Mt with a total value of US$ 26 billion.
- Effectively all the N protein in the grain came from $N_2$ fixation (48 Mt protein)
But sometimes the strain of rhizobium bacteria best for the specific legume crop is not present in the soil. This was true for soybean when introduced into Brazil in the 1960s.

This is the basis of our cooperation project with the Ghanaian Savannas Research Institute (SARI-CSIR). The most important protein sources in the human diet in West Africa are Cowpea and Groundnut.

The original two projects were funded (US$ 80,000 each) under the Africa/Brazil Agricultural Innovation Marketplace organized by Embrapa and funded by Bill and Melinda Gates Foundation and the British DfID. Early results were very encouraging.

SARI Field station experiment Tamale (2012)

- In this trial P fertilizer (60 kg P₂O₅ ha⁻¹) was added. Even without inoculants grain yield was almost 1000 kg ha⁻¹

- As is often observed, there was a close relationship between nodule weight and grain yield.
A scaling up project was started last year “Marketplace Building on Success (M-BoSs)”

“Scaling-up of the Benefits of Rhizobium Inoculant Technology among Smallholder Legume Farmers in Northern Ghana”

- The M-BoSs project was a continuation of a Gates Foundation Project (Alliance for a Green Revolution in Africa - AGRA) used to build infrastructure and a large building for laboratories and an inoculant production facility.
- The inoculant is already being produced and is within the three year period to reach 30,000 farmers with inoculants for cowpea and groundnut.
- One challenge is to determine how many of the nodules are occupied by the rhizobium strain that was inoculated.
- There are immunological techniques but they tend not to be very specific for the kind of rhizobium that nodulate cowpea or groundnut.
- So a new technique was developed based on comparing DNA sequences of the type strain of the rhizobium species (Bradyrhizobium pachyrhizi) and that of the strain we use in inoculants (BR 3262).
- A short sequence (20 base pairs) of DNA was found to differentiate the BR 3262 strain from all other strains that were found to nodulate cowpea.

Gel electrophoresis of extracted DNA samples

- Ophelia arrived in Brazil with no prior knowledge of molecular biology.
- She stayed 1 year in Brazil when she left the DNA primer and the technique were developed and the paper submitted.
- The project was supervised by Dr Luc Rouws at Embrapa, the coordinator of the M-BoSs in Brazil, along with Jean Araújo and Jerri Zilli.

The Project was developed as part of the PhD thesis of Ophelia Osei at the Kwame Nkrumah University of Science and Technology Kumasi, Ghana.
The team has now found elite rhizobium strains which will increase yields of groundnut.

Bacteria related to *Bradyrhizobium yuanmingense* from Ghana are effective groundnut micro-symbionts.

Ophelia Osei, Robert C. Abaidoo, Benjamin D.K. Ahior, Robert M. Boddey, Luc F.M. Rouws.

So far seven Ghanaian students and technicians have received training at Embrapa Agrobiologia and six Brazilian Researchers have visited Ghana to learn how to distribute inoculants to hundreds of smallholders.

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**Arbuscular Mycorrhizal Fungi in Agricultural Crops**

*Instituto Nacional De Ciencias Agricolas - Cuba*
Dra. C. Yakelin Rodriguez Yon
Dr. C. Pedro Jose Gonzalez Cañizares

*Embrapa Agrobiologia - Brazil*
Dr. Orivaldo Saggin

Financed jointly by the Ministries of Education of Cuba and Brazil
2017
Mycorrhizal Symbioses

- A mutually beneficial association of these species of fungi which associate with the great majority of terrestrial plants.
- The fungal hyphae are extremely efficient at absorbing nutrients from the soil when they are at low availability.
- Until recently it was thought that inoculants would not be ineffective as the roots of nearly all crops are well colonized with these fungi.
- However, recent work in Cuba has shown that in many cases selected mycorrhizal strains can make large increases in yields.
- Much of the work in Brazil has been to understand the mechanisms of response and the taxonomy using molecular biology.
Increase (IE %) in yield in response to different species of mycorrhizal fungi inoculated on different root crops in Cuba

<table>
<thead>
<tr>
<th>Species</th>
<th>Potato</th>
<th>Cassava</th>
<th>Sweet potato</th>
<th>Malanga</th>
<th>Yam</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IE %</td>
<td>IE %</td>
<td>IE %</td>
<td>IE %</td>
<td>IE %</td>
</tr>
<tr>
<td><em>R. intraradices</em></td>
<td>43.9 a</td>
<td>48.8 a</td>
<td>397.6 a</td>
<td>110.0 a</td>
<td>47.8 a</td>
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<tr>
<td><em>R. fasciculatus</em></td>
<td>31.2 ab</td>
<td>27.4 bc</td>
<td>319.5 b</td>
<td>6.6 bc</td>
<td>39.8 b</td>
</tr>
<tr>
<td><em>F. mosseae</em></td>
<td>24.7 bc</td>
<td>1.1 d</td>
<td>186.5 c</td>
<td>20.0 b</td>
<td>29.5 c</td>
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<tr>
<td><em>R. clarus</em></td>
<td>18.0 bc</td>
<td>38.0 a</td>
<td>7.3 d</td>
<td>3.3 bc</td>
<td>35.4 bc</td>
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<tr>
<td><em>P. occultum</em></td>
<td>5.4 c</td>
<td>29.8 bc</td>
<td>3.6 d</td>
<td>18.3 b</td>
<td>22.5 d</td>
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<tr>
<td><em>A. scrobiculata</em></td>
<td>1.8 d</td>
<td>20.2 c</td>
<td>0.0 d</td>
<td>-10.0 c</td>
<td>17.7 d</td>
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<tr>
<td>cv %</td>
<td>12.8</td>
<td>7.1</td>
<td>6.9</td>
<td>8.6</td>
<td>3.5</td>
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</tbody>
</table>

2018 – New cooperative project funded by PROCISUR
(Programa Cooperativo para el Desarrollo Tecnológico Agroalimentario y Agroindustrial del Cono Sur)

Impact of the introduction forage legumes or N fertilizer on the emissions of greenhouse gases by grazed pasture systems

Argentina, Brazil, Chile, Uruguay, Paraguay, Costa Rica, Mexico

The emphasis is on enteric methane emissions by grazing cattle and the nitrous oxide emissions from pasture residues, N fertilizer additions and dung and urine
Thank you!

robert.boddey@embrapa.br

The basic infrastructure for the production and testing of inoculants has been provided by the AGRA project, but for high quality inoculant to be produced, certified and field tested the further funding is to be provided by the M-BoSs project.
Uninoculated and no P

Inoculated and no P

Uninoculated + 60 kg P₂O₅/ha

Inoculated + 60 kg P₂O₅/ha
Production - Harvest 2017- = 115 million tonnes.
Yield 3,300 kg ha\(^{-1}\)  
Estimate of N fixed = 6,400,000 Mg.
Price of N as urea = ~US$ 800.00/Mg
This N\(_2\) fixation is thus worth ~US$ 5 billion year
**Infrastructure – Laboratories (19)**

<table>
<thead>
<tr>
<th>- Nitrogen and Isotopes (15N e 13C)</th>
<th>- Microscopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Soil-Multi-user</td>
<td>- Mycorrhiza</td>
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<tr>
<td>- Organic Agriculture</td>
<td>- BNF Grasses</td>
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<td>- Organic matter</td>
<td>- Genetics/Biochemistry</td>
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<td>- Enzymes</td>
<td>- Genome</td>
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<td>- Biological control</td>
<td>- Molecular Techniques – Multi-user</td>
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<tr>
<td>- Soil fauna</td>
<td>- Inoculant Development</td>
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<tr>
<td>- BNF Leguminous Trees</td>
<td>- Inoculant Production</td>
</tr>
<tr>
<td>- Collection of cultures</td>
<td></td>
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<tr>
<td>- Microbial Ecology</td>
<td></td>
</tr>
</tbody>
</table>
Chromatography Lab – Four automated GCs for GHG analysis

DNA Sequencer

Multi-user lab; PCR and other equipment for molecular biology

Laser Con-focal microscope

Scanning Electron microscope
Germplasm bank

Diazotrophic Bacteria and other Microorganism Culture Collection

» Plant-Growth Promoting Rhizobacteria (PGPR) Collection - (Pseudomonas spp. - approximately 200 isolated) united with the N₂-fixing bacteria Collection to improve the structuring of collections, the quality system and the information database;

» 4000 cultures with BR identification

» 2000 cultures of N2-fixing bacteria have now been characterized to the Genus level through 16SDNA sequencing.

» Services: Transfer of genetic material, deposits of bacteria and fungi strains; training on inoculant production.

Organic farm (70 ha)
(Fazendinha Agroecológica)

A joint venture between Embrapa-Agrobiologia, the federal Rural University and PESAGRO – the Rio State Agricultural Research Institute
Participation in post graduation programs of UFRRJ

Countries (12):
Argentina, Colombia, Germany, England, France, Portugal, Uruguay, USA, Cuba, Mexico, Ghana e Kenya.

- Africa-Brazil Agricultural Innovation Marketplace
  - Country: Ghana
  - Partner: Savanna Agricultural Research Institute (SARI)

- Project: Enhancing small-holder cowpea legume production using rhizobium inoculants
Preparing inoculant

Training in Microbiology and Molecular Biology

- Visit of Williams Atakora (MSc student) for three-months training in rhizobiology:
Post project activities

Upscaling and production of inoculants for other important grain legumes – groundnut (*Arachis hypogaea*) and Bambara groundnut (*Vigna subterranea*).

Embrapa Agrobiology has a portfolio of technologies which helps in the search for institutional partners, aiming to make partnerships with business and obtain cooperation for development projects in Brazil and overseas in our various lines of research.

For more details visit [www.embrapa.br/en/agrobiologia](http://www.embrapa.br/en/agrobiologia)