Embrapa Agrobiologia 2018

Presentation:
Robert M. Boddey
robert.boddey@embrapa.br

Director:
Gustavo Xavier
gustavo.xavier@embrapa.br

Embrapa
Agrobiologia

Embrapa Agrobiologia
Seropédica,
Rio de Janeiro State

Embrapa

Ministry of Agriculture, Livestock and Food Supply

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

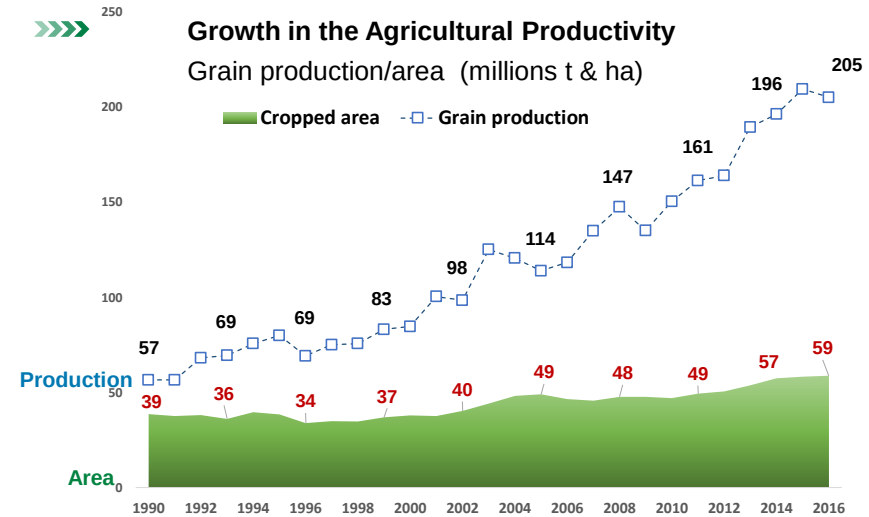
42% Exports

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.**

Brazilian Agriculture



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 area 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

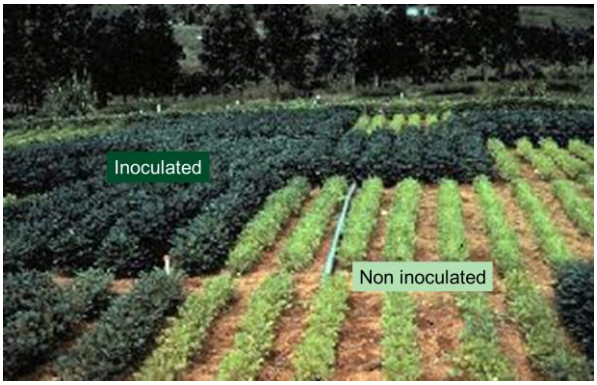
- Embrapa Agrobiologia is a thematic centre with the mission to substitute, where possible, chemical inputs in agriculture with biological processes:
- A large proportion of our work is concerned with biological nitrogen fixation.
- Legume crops, legume trees for rehabilitation of degraded areas, forage legumes in pastures.
- We also work on mycorrhizal fungi and other plant-growth promoting micro-organisms, 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.

Mature soybean nodule fixing nitrogen. The pink colour due to leghaemoglobin present in all types of nodules

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



Embrapa

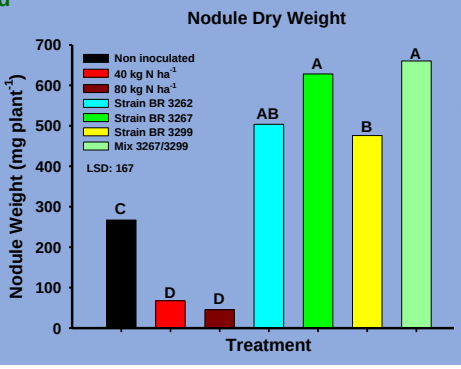
Ministry of Agriculture, and Food

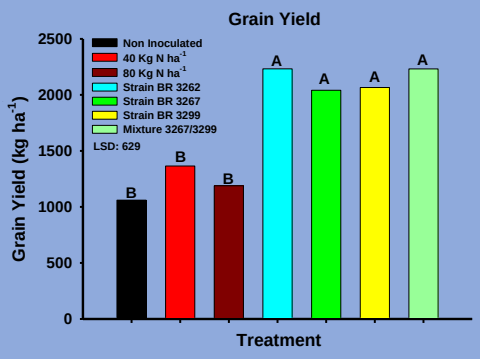
This is the basis of our cooperation project with the Ghanaian Savannas Research Institute (SARI-CSIR). The most important protein sources in the human diet in West Africa are Cowpea and Groundnut

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 DfOD. Early results were very encouraging.

SARI Field station experiment Tamale (2012)

- In this trial P fertilizer (60 kg P_2O_5 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 the 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

The Project was developed as part of the PhD thesis of Ophelia Osei at the Kwame Nkrumah University of Science and Technology Kumasi, Ghana.

- **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.**

Plant Soil (2017) 417:535–548
DOI 10.1007/s11104-017-3271-4

METHODS PAPER

PCR assay for direct specific detection of *Bradyrhizobium* elite strain BR 3262 in root nodule extracts of soil-grown cowpea

Ophelia Osei · Jean L. Simões Araújo · Jerri E. Zilli · Robert M. Boddey · Benjamin D. K. Ahiabor · Robert C. Abaidoo · Luc F. M. Rouws

The team has now found elite rhizobium strains which will increase yields of groundnut

https://doi.org/10.1016/j.apsoil.2018.03.003

Contents lists available at ScienceDirect

Applied Soil Ecology

journal homepage: www.elsevier.com/locate/apsoil

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

Ophelia Osei[a], Robert C. Abaidoo[b,c], Benjamin D.K. Ahiabor[d], Robert M. Boddey[e], Luc F.M. Rouws[e,*]

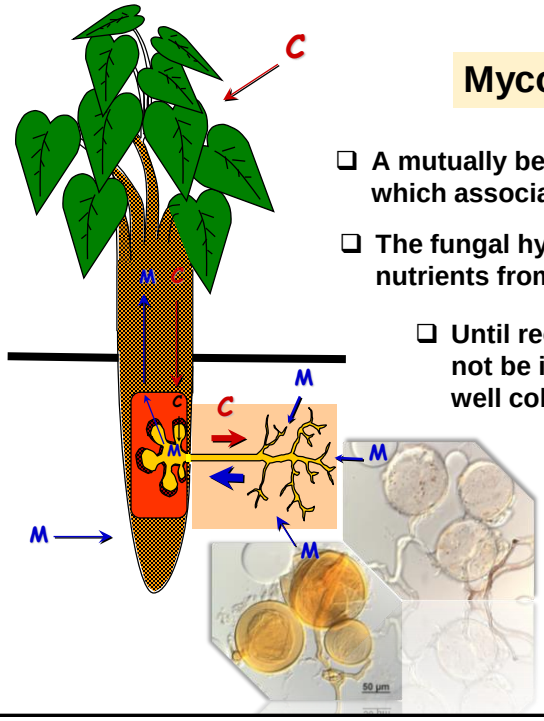
So far seven Ghanaian students and technicians have received training at Embrapa Agrobiologia and six Brazilian Researchers have visited Ghana to learn how to distribute inoculants to hundreds of smallholders

Arbuscular Mycorrhizal Fungi in Agricultural Crops

Instituto Nacional De Ciencias Agricolas - Cuba
Dra. C. Yakelin Rodríguez 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

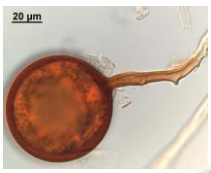


Mycorrhizal Symbioses

- 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

INCA

ADVANCES



Increase (IE %) in yield in response to different species of mycorrhizal fungi inoculated on different root crops in Cuba

Species	Potato	Cassava	Sweet potato	Malanga	Yam
	IE %	IE %	IE %	IE %	IE %
R. intraradices	43. 9 a	48.8 a	397.6 a	110.0 a	47.8 a
R. fasciculatus	31.2 ab	27.4 bc	319.5 b	6.6 bc	39.8 b
F. mosseae	24.7 bc	1.1 d	186.5 c	20.0 b	29.5 c
R. clarus	18.0 bc	38.0 a	7.3 d	3.3 bc	35.4 bc
P. occultum	5.4 c	29.8 bc	3.6 d	18.3 b	22.5 d
A. scrobiculata	1.8 d	20.2 c	0.0 d	-10.0 c	17.7 d
cv %	12.8	7.1	6.9	8.6	3.5

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

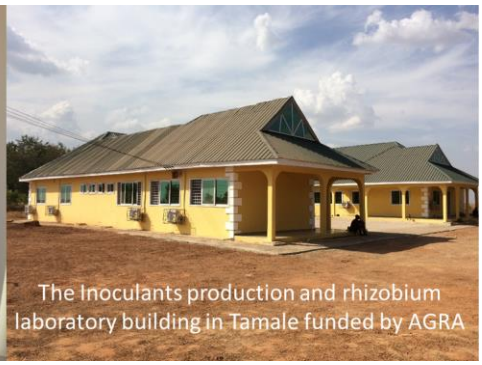
Thank you!

robert.boddey@embrapa.br

Embrapa Ministry of Agriculture, Livestock and Food Supply BRAZILIAN GOVERNMENT BRASIL

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

A visit to the SARI team by Luis Henrique Soares of Embrapa Agrobiologia

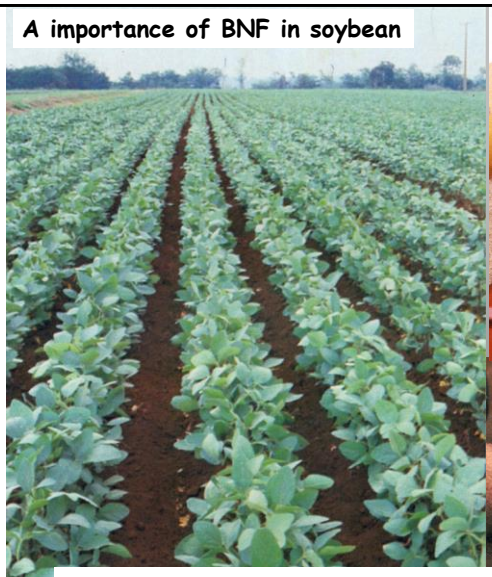


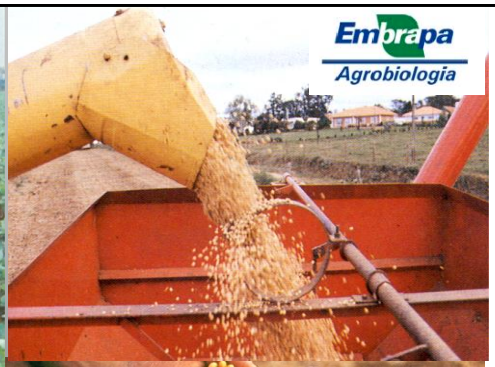
The Inoculants production and rhizobium laboratory building in Tamale funded by AGRA

Embrapa Ministry of Agriculture, Livestock and Food Supply BRAZILIAN GOVERNMENT BRASIL


Uninoculated and no P
Uninoculated + 60 kg P_2O_5/ha
Inoculated and no P
Inoculated + 60 kg P_2O_5/ha

A importance of BNF in soybean





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

24

Infrastructure – Laboratories (19)

- *Nitrogen and Isotopes (15N e 13C)*
- *Soil-Multi-user*
- *Organic Agriculture*
- *Organic matter*
- *Enzymes*
- *Biological control*
- *Soil fauna*
- *BNF Leguminous Trees*
- *Collection of cultures*
- *Microbial Ecology*
- *Microscopy*
- *Mycorrhiza*
- *BNF Grasses*
- *Genetics/Biochemistry*
- *Genome*
- *Molecular Techniques – Multi-user*
- *Inoculant Development*
- *Inoculant Production*



The “John Day” Lab – Isotope-ratio mass spectrometry

Embrapa

Ministry of Agriculture, Livestock and Food Supply

BRAZILIAN GOVERNMENT
BRASIL

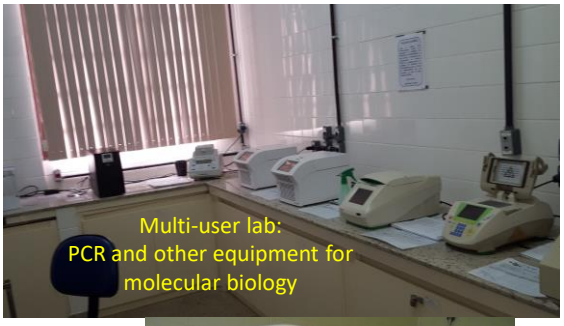
Chromatography Lab – Four automated GCs for GHG analysis

Embrapa

Ministry of Agriculture, Livestock and Food Supply

BRAZILIAN GOVERNMENT
BRASIL

DNA Sequencer



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

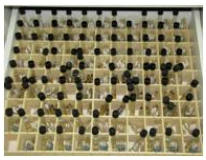
Laser Con-focal microscope

Scanning Electron microscope

Ministry of Agriculture, Livestock and Food Supply

Germplasm bank

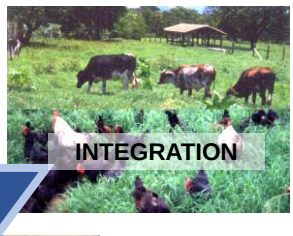
- ***Diazotrophic Bacteria and other Microorganism Culture Collection***
  - Plant-Growth Promoting Rhizobacteria (PGPR) Collection - (Pseudomonas spp. - approximately 200 isolated) united with the N_2-fixing bacteria Collection to improve the structuring of collections, the quality system and the information 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



Embrapa PESAGRO-RIO UFRRJ

Participation in post graduation programs of UFRRJ

Embrapa Ministry of Agriculture, Livestock and Food Supply BRAZILIAN GOVERNMENT BRASIL

International Networking

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**)

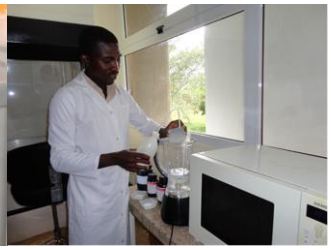
- Project: Enhancing small-holder cowpea legume production using rhizobium inoculants

Network of Experiments for Research and Technology Transfer

Preparing inoculant

Training in Microbiology and Molecular Biology

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

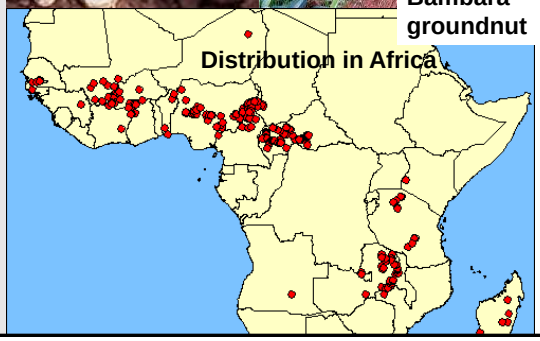


Post project activities

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

Common groundnut

Bambara groundnut



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

Embrapa

Ministry of Agriculture, Livestock and Food Supply

BRAZILIAN GOVERNMENT BRASIL