

Early Generation Seed System Study

Cassava | Brazil (N & NE Regions)

April 2018

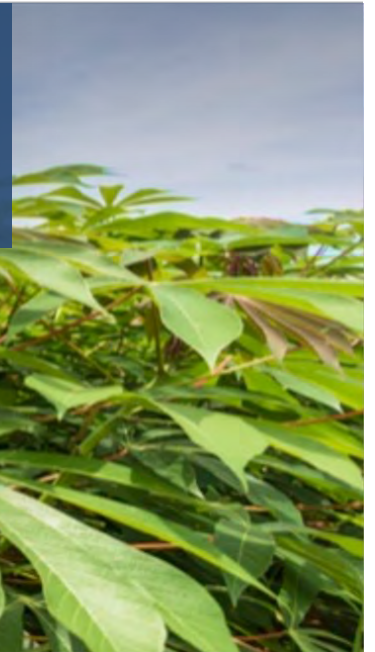


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Acronyms

CSE | Cassava Seed Entrepreneur

EGS | Early Generation Seed

Embrapa | The Brazilian Agricultural Research Corporation

IBC | Instituto Biofabrica de Cacau



Executive Summary

State Owned Research Corporation Enables Brazil's Cassava Seed System

VARIETAL DEVELOPMENT & SEED DEPLOYMENT



Varietal Development

The Embrapa Bahia Research Station for Cassava and Tropical Fruits is focused on tropical crop research and leads the National Cassava Breeding Program. Embrapa releases cassava varieties on a region-specific basis to ensure that they are adapted to Brazil's diverse agro-climatic environments.



Seed Multiplication

The RENIVA Project has partnered with Instituto Biofábrica de Cacau Ilhéus, Bahia State) to mass propagate cassava seed from tissue culture through a lab and a greenhouse stage (on four hectares). Propagated basic seed is then sold in 50-stem bags to cassava seed entrepreneurs and state governments, continued greenhouse and field production.



Certified Seed Production

No formal seed system exists for cassava in Brazil, however, draft legislation has been developed and proposed by Embrapa to standardize the crop's seed standards for cassava seedlings (plantlets produced either by tissue culture or by rapid multiplication, to support CSEs). In the interim, there are no quality control standards or certification processes in place

FARMER PRODUCTION, MARKETING, AND KEY DEMAND SEGMENTS



Farm Production

Brazil has two different types of cassava growers. In the North and North East geographical regions these growers and smallholder family producers farm areas ranging from 0.1 - 10ha with very low technological inputs (yields average are 10-14 ton/ha). On the other hand, in the South East and South Regions, cassava farms are much larger, with land holdings ranging from 20 - 200ha and high technology for agronomic management and yields of 24 ton/ha on average. Nevertheless, both regions now have a high quality seed system which didn't exist at all until 2015, with the advent of the RENIVA Project.



Demand Segments

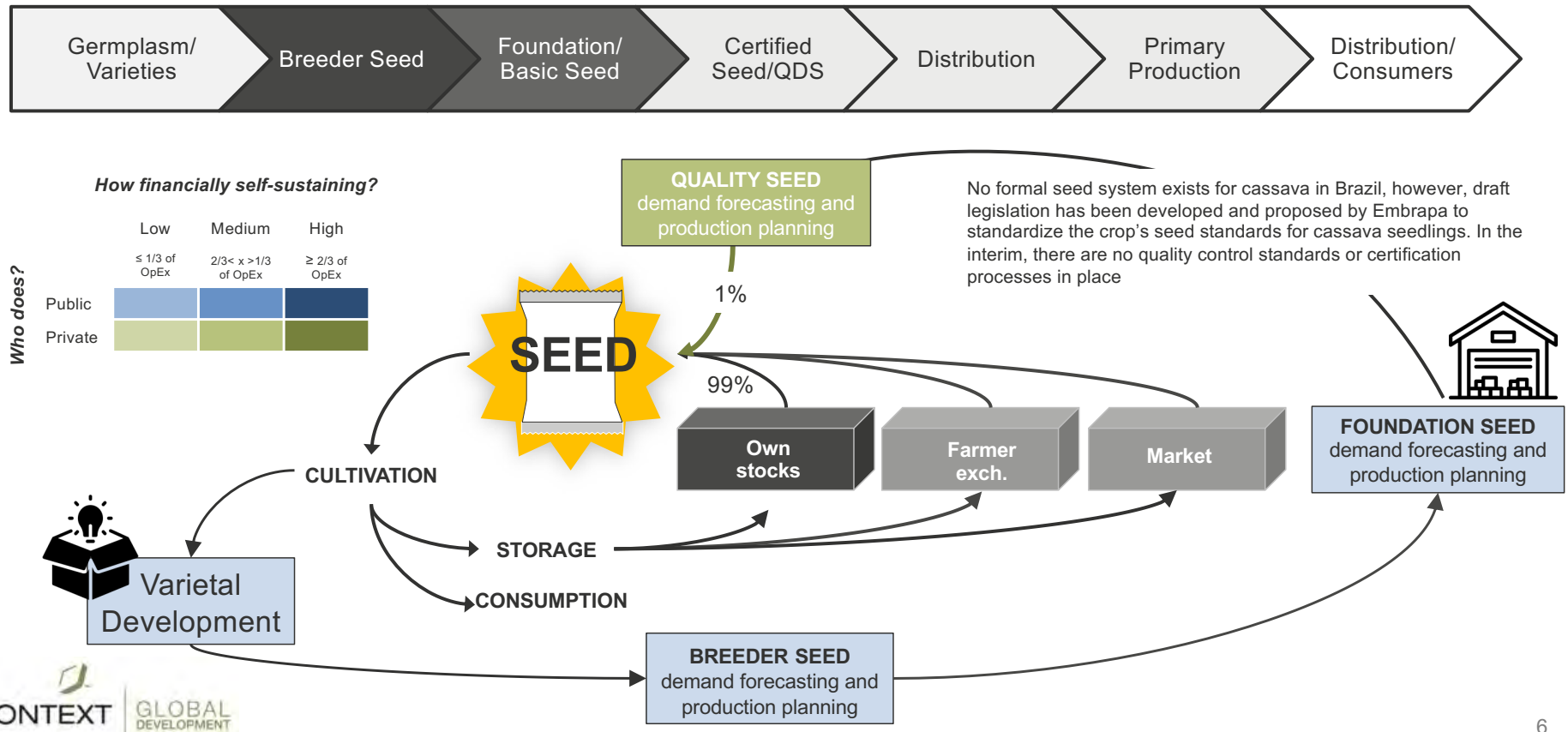
Brazil cassava production is primarily for domestic consumption (+90%). Domestic consumption can be further segmented into four categories: feed (50%), human consumption (33%), other uses (7%), and post-harvest losses (10%).

ENABLING ENVIRONMENT STAKEHOLDERS

[Embrapa Cassava & Fruits](#) | [Instituto Biofabrica de Cacau](#) | [Ministry of Agriculture, Livestock, and Supply](#)

SEED SYSTEM STRUCTURE

In N & NE Brazil Embrapa Relies on Public Sector Institution to Propagate and Supply Quality Stems



Summary of Building Blocks for the Cassava Seed System in Brazil

Emerging Strategies to Lessen Reliance on Public Sector Funding

FINANCIAL SUSTAINABILITY		Public Sector Varietal Development
		Non-Profit Organization Providing Multiplication Research And Scalability
		Select Farmers Are Willing To Pay For Higher Quality Planting Material
		Maniveiros Achieve Profitability While Providing Clean Planting Material To Farmers
		Private Sector Engagement In Promoting Improved Seeds And Best Agricultural Practices






Rapid Multiplication Innovations Scaled Through Not-for-Profit Entity

DEMAND PLANNING & OPERATIONS		Highly Productive Rapid Multiplication System Developed By The RENIVA Project
		Operational Innovations to Address Logistical Challenges
		CSE Innovation In Planting, Multiplication and Operations
		On-farm Demonstration Trials And Clear Product Profiles Of Leading Varieties Help Generate Farmer Demand
		Varietal And MandiPlus Innovation Breakthroughs In Development






Embrapa Advocates Seed System Development and Organizes Actors

ENABLING ENVIRONMENT		Partnership With Instituto Biofabrica de Cacau (IBC)
		Start Up Of Entrepreneurial Maniveiros Was De-risked By The Government
		Embrapa Varieties Are Increasingly Preferred By Farmers
		Government is the Largest Purchaser of Cassava Seed
		Embrapa Personnel Have Significant Experience In Certification






Financial Sustainability

FINANCIAL SUSTAINABILITY		Public Sector Varietal Development	Embrapa relies on federal funding to establish and maintain gene banks, characterize and evaluate varieties, assess disease resistance, analyze genetic diversity, cross-breed, and select the best varieties for release through the RENIVA Project. Since the program began, 54 varieties of cassava seed have been released by Embrapa.
		Non-Profit Organization Providing Multiplication Research And Scalability	Instituto Biofábrica de Cacau (IBC) is largely funded by the Bahia state government and manages the multiplication research in their facilities. IBC works closely with other state governments and largely pursues an approach to deployment whereby the government buys materials and distributes to growers at no cost. In less frequent cases, IBC supplies the stems to maniveiro entrepreneurs at little to no cost.
		Select Growers Are Willing To Pay For Higher Quality Planting Material	Demand for improved seed is being demonstrated at the farm level through the largest and most advanced maniveiro entrepreneur in Pará. While the majority of cassava growers still source their materials at no cost, there is consistent willingness to incorporate improved materials on portions of their field on the basis that disease accumulates in fields and there is benefit in replenishing with clean planting material.
		Maniveiros Achieve Profitability While Providing Clean Planting Material To Growers	Maniveiros received start-up support from Embrapa. Through serving and generating demand through local grower customers, some Maniveiros are able to make a profitable, sustainable businesses from stem multiplication – both of Embrapa varieties and landraces. Successful Maniveiros recognize that their customers will likely want to replenish their plant material every ~4-6 years on at least a portion of their land (usually ~20%) and estimate demand by variety more on intuition than actual orders.
		Private Sector Engagement In Promoting Improved Seeds And Best Agricultural Practices	Private starch players have played a role in receiving Embrapa cassava varieties and multiplying them within their production systems (both company-owned farm production and outgrowers within their catchment area). Additionally, private biofactories are involved in evaluating improved cassava varieties being tested prior to multiplication through the RENIVA system and working with equipment providers to demonstrate benefits of mechanized field activities.

Demand Planning & Operations

DEMAND PLANNING & OPERATIONS		Highly Productive Rapid Multiplication System Developed By The RENIVA Project	The cassava stem propagation process has been optimized through a continual improvement process that increased the multiplication rates of cassava in its tissue culture, plantlet, and stem form. The process developed by IBC – from in vitro to greenhouse – utilizes cost-effective materials and infrastructure organized with efficiency and scalability in mind. Additionally, the location of IBC with the consistency in temperature and humidity of the tropics makes the growing environment for cassava seedlings ideal.
		Operational Innovations to Address Logistical Challenges	The rapid multiplication at IBC is transferred to the field of Maniveiros through a system of precise wrapping and packaging of seedlings. IBC has proven that biomass can be removed prior to packaging without impacting seedling performance. The state government or Maniveiros currently pick up their seeding orders from the facility, so Embrapa is evaluating other mini-cutting techniques to streamline shipment. As IBC increasingly serves a broader number of Maniveiros, there is an opportunity to better structure the ordering and pick-up scheduling system.
		CSE Innovation In Planting, Multiplication and Operations	Embrapa designed a turnkey multi-stage multiplication system for the highest tier Maniveiros (Type I), including a chambered bench, a greenhouse/tunnel, and 1 hectare of irrigated nursery. Rapid multiplication and greenhouse infrastructure at the CSE level is an innovation that allows Maniveiros (Type I) to train fellow Maniveiros (Type II) and to demonstrate the benefits of indexed, disease-free varieties to generate demand. Additional multiplication techniques, such as mini-cuttings, have been developed at IBC are being testing in the field with Maniveiros.
		On-farm Demonstration Trials And Clear Product Profiles Of Leading Varieties Help Generate Grower Demand	Embrapa has supported each varietal launch with clear product profiles to describe their characteristics, suggested uses, agro-ecologies, regions, etc. Three breeders of Embrapa work with growers across the various Brazilian regions and have provided 40-50 on-farm demonstration trials of leading varieties to help generate demand from growers. In southern Brazil, Embrapa partners with cooperatives to help with technical support & distribution.
		Varietal And MandiPlus Innovation Breakthroughs In Development	Indexing diseases (especially frog skin disease), characteristics, and growing conditions was pre-emptively core to the Embrapa RENIVA strategy, even though some major diseases are not a major threat to cassava producers currently. The strength of Embrapa breeding program combined with the potential of the MandiPlus system suggest that future launches of cassava varieties will continue to build desirable attributes.

Enabling Environment

ENABLING ENVIRONMENT		Partnership With Instituto Biofabrica de Cacau (IBC)	Embrapa established a partnership with IBC (a non-profit entity) early on in the RENIVA Project to provide early generation seed multiplication to supply the country of Brazil. This partnership has enabled the RENIVA Project to achieve its objectives of supplying Cassava Seed Entrepreneurs (or Maniveiros) with basic seed of improved varieties from Embrapa.
		Start Up Of Entrepreneurial Maniveiros Was De-risked By The Government	Maniveiros receive starter breeder material from Embrapa free of charge and the Brazilian government has subsidized the infrastructure cost associated with the establishment of decentralized multiplication systems (incl. nursery establishment and irrigation costs). State-level extension services were expected to support growers by facilitating the transfer of varieties and knowledge from Embrapa/IBC to Maniveiros, but due to funding shortfalls, extension services have been severely diminished. In their absence, Maniveiros continue to order basic seed directly from IBC and Embrapa provides as-needed assistance with coordination and training.
		Embrapa Varieties Are Increasingly Preferred By Growers	While exact data of the penetration of cassava varieties is unavailable, there is evidence of increased grower acceptance through the work that Maniveiros are doing on the ground. After all, it is grower demand that enables Maniveiros to construct a business case around stem production. The MandiPlus Project, which is also managed by Embrapa, is helping to break the mentality that cassava planting material has no intrinsic value. And marketing initiatives are being implemented to demonstrate to growers that when planting virus free cuttings, yields may increase between 30 and 40%.
		Government is the Largest Purchaser of Cassava Seed	State governments are the largest buyers of basic seed from IBC and of stems from Maniveiros. State governments treat clean planting material as a public good, and purchase and distribute stems to smallholder growers.
		Embrapa Personnel Have Significant Experience In Certification	Draft legislation has been proposed by Embrapa to standardize the seed standards for cassava seedlings (plantlets produced either by tissue culture or by rapid multiplication, to support Maniveiros). In the interim, there are no quality control standards or certification processes in place to evaluate the genetic purity of the cassava stems being planted.

Summary of EGS System Pain Points

Financial Sustainability

Transition to Commercial Model for Seed Deployment:

Engaging the private sector to take on more leadership and see the business case in developing high quality cassava seed system has been slow and challenging. IBC currently does not have systemic pressure or incentive to shift to a more commercial model due to its relationship with state governments.

Operational and Extension Funding:

Embrapa competes with other major crops for grants; state funding used to support Embrapa programs and extension programs (who worked directly with Maniveiros) but has been reduced significantly.

Innovation, Demand & Operations

Improving Adoption of Embrapa varieties:

While some growers have demonstrated a willingness to pay for plant material with better yield and disease resistance, the strong culture of getting/trading material for free is still dominant among most grower communities.

Seed Supply & Demand Variance (Coordination with CSEs & State Government Requests):

Very difficult to predict demand and there is no formal/central ordering system. Long geographic distances across the country presents logical challenges.

Support and Demonstrations to Growers:

The loss of extensions services from state funding shortages caused fewer support to growers and less predictable/stable demand.

Enabling Environment

Interdependency Creates Risk:

The various players and few sources of public funding make the environment more vulnerable to risks or sudden losses of functions, such as extension programs

Regulatory Uncertainty:

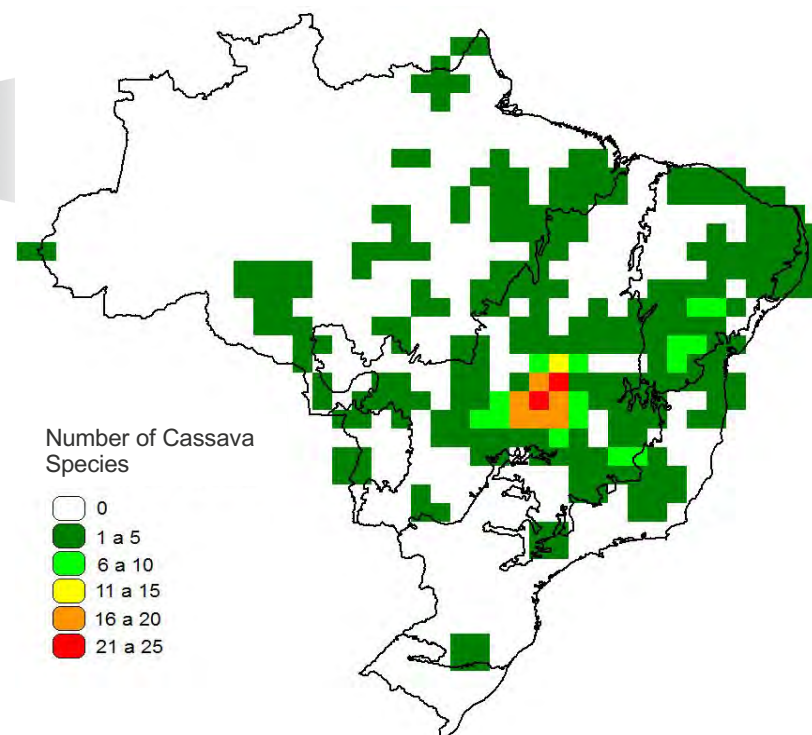
There are currently no regulations specific to cassava seed systems from the Ministry of Agriculture, which only exist for major crops like maize and soy. This could imply risk of poor/diseased plant material reaching the market if testing remains unregulated



Market Dynamics

Brazil was the Third Largest Cassava Producing Country in 2016 and Produced 8% of Global Production, on an Average Yield of 14.9 Tons Per Hectare (FAO Stat)

#	Country	2016 Production Total (tonnes)	% of Total	Yield (hg/ha)
1	Nigeria	57,134,478	21%	91,254
2	Thailand	31,161,000	11%	213,165
3	Brazil	21,082,867	8%	149,922
4	Indonesia	20,744,674	7%	239,133
5	Ghana	17,798,217	6%	189,600
6	DRC	14,677,809	5%	81,483
7	Vietnam	11,045,184	4%	190,468
8	Cambodia	10,206,514	4%	263,302
9	Angola	9,981,245	4%	108,518
10	Mozambique	9,100,000	3%	90,791
11	Tanzania	5,575,304	2%	52,546
12	Cameroon	5,501,749	2%	146,849
13	Malawi	5,088,595	2%	220,230
14	China	4,794,262	2%	164,692
15	Sierra Leone	4,778,393	2%	120,851
16	India	4,554,000	2%	223,235
17	Benin	4,317,642	2%	156,687
18	Rwanda	3,537,566	1%	172,009
19	Côte d'Ivoire	3,210,614	1%	63,466
20	Paraguay	3,166,800	1%	174,000
21	All Others	29,645,655	11%	
	Total	277,102,568	100%	



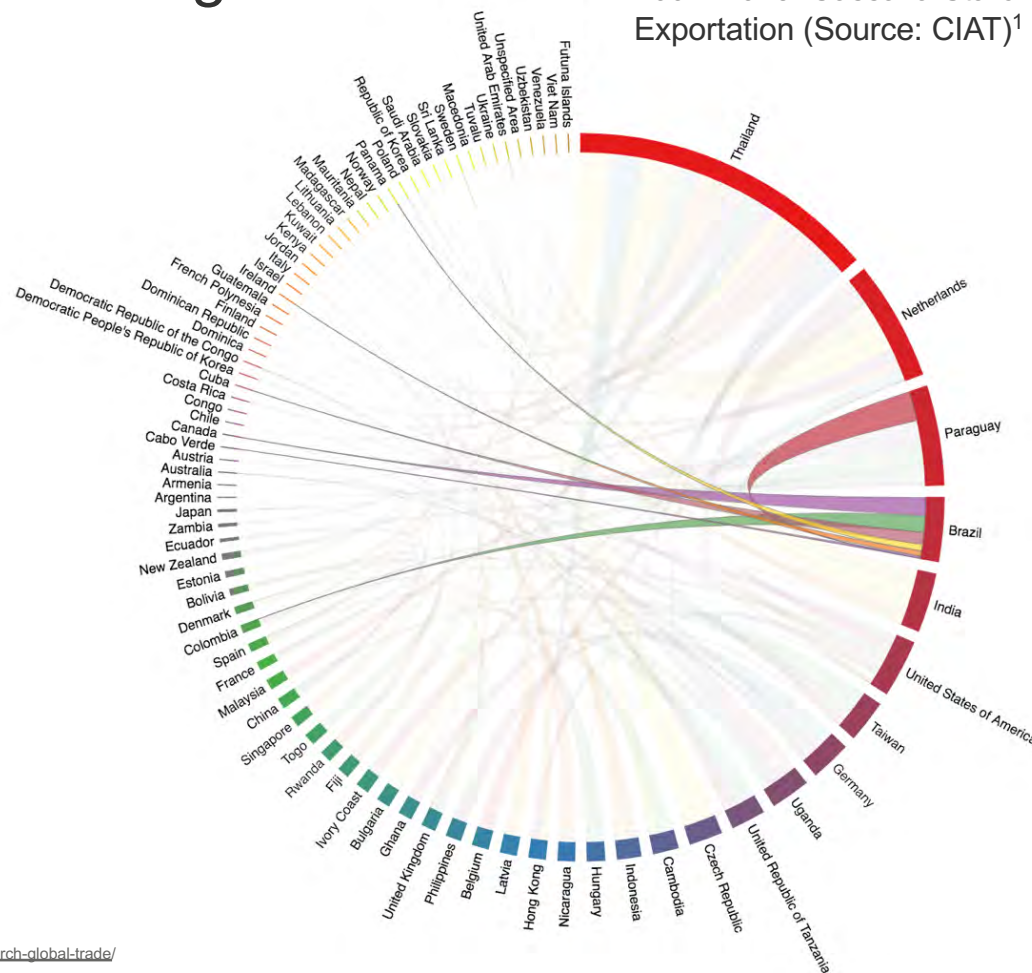
Brazil Is the Fourth Largest Cassava Starch Exporter

2007–2013: Cassava Starch Exportation (Source: CIAT)¹

Brazil is the fourth largest exporter of cassava starch globally behind Thailand, Netherlands, and Paraguay

Brazil's chief export markets are regional, including: Paraguay, Columbia, Cuba, Panama, and Canada

Thailand is the cost leader in the global cassava starch market



Cassava Was the 11th Most Valuable Agricultural Commodity in Brazil in 2016 (FAO Stat)

#	Agricultural Commodity	Total	% of Total
1	Meat indigenous, cattle	\$25,552,696	16%
2	Sugar cane	\$24,171,594	16%
3	Soybeans	\$23,797,890	15%
4	Meat indigenous, chicken	\$16,853,080	11%
5	Maize	\$11,316,429	7%
6	Milk, whole fresh cow	\$10,960,943	7%
7	Meat indigenous, pig	\$5,040,198	3%
8	Rice, paddy	\$3,392,853	2%
9	Oranges	\$3,271,560	2%
10	Coffee, green	\$3,012,581	2%
11	Cassava	\$2,429,132	2%
12	Cotton lint	\$2,018,360	1%
13	Beans, dry	\$1,981,348	1%
14	Bananas	\$1,958,391	1%
15	Eggs, hen, in shell	\$1,858,288	1%

Improvements in crop management practices have enabled Brazil to become a leading exporter of soybeans, meat, sugar, corn, coffee and ethanol¹

Brazil cultivated over 1.4 million hectares of cassava (or manioc) in 2016 (FAOStat)

Over 90% of cassava production is for domestic use, with 45% of overall production estimated for feed²

(1) SOURCE: <https://www.ers.usda.gov/topics/international-markets-us-trade/countries-regions/brazil>

(2) SOURCE: Alberto Duarte Vilarinhos, Research Officer, Embrapa GCP21 Annual Meeting <http://www.gcp21.org/Bellagio/22-AlbertoVilarinhos.pdf>

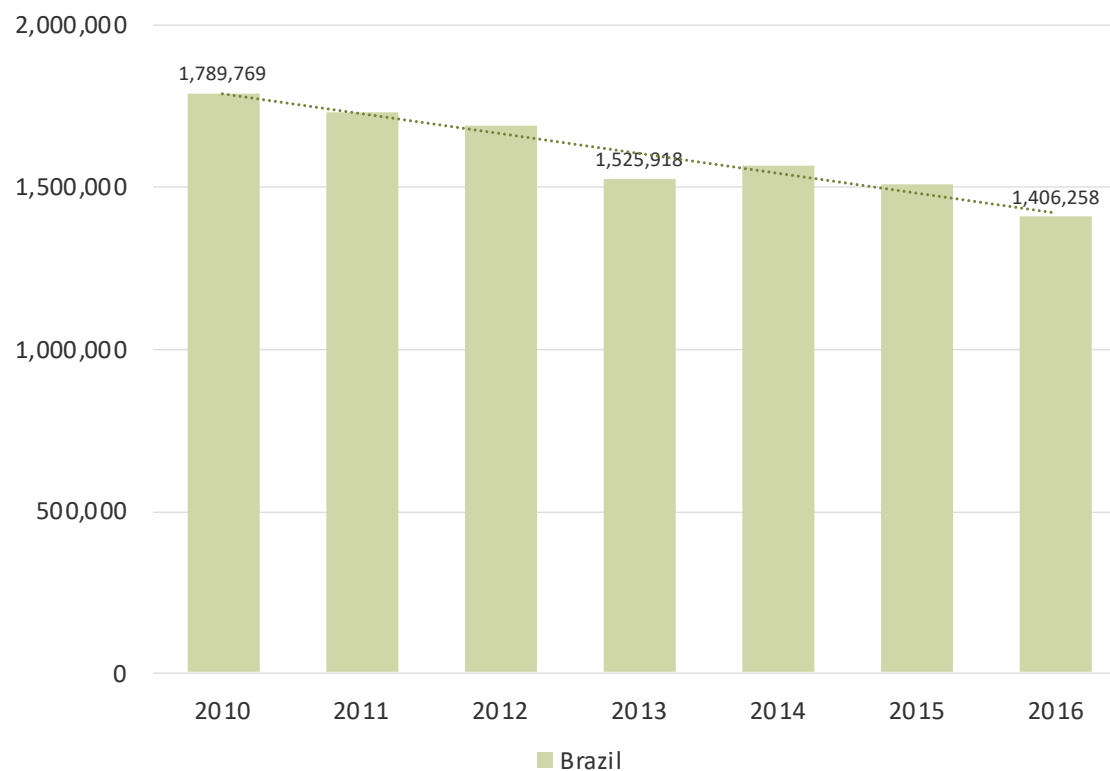
Harvested Hectares in Brazil Declined Over 21% Between 2010 to 2016



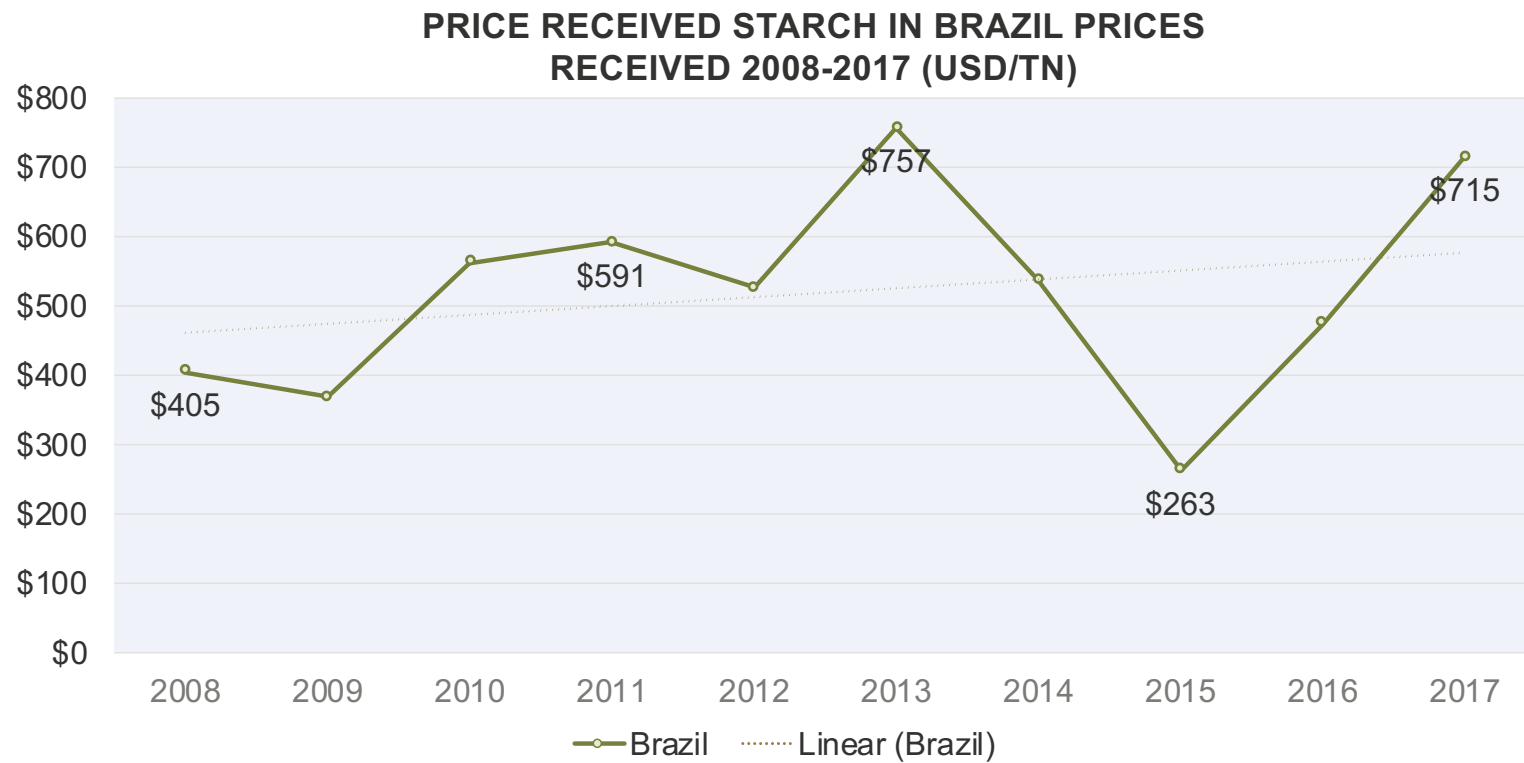
KEY DRIVERS OF DECLINE

- Commodity price volatility
- Lack of regulation of the cassava market
- Competition with other commodities (mainly corn) that have more stable markets

Cassava Area Harvested (ha)

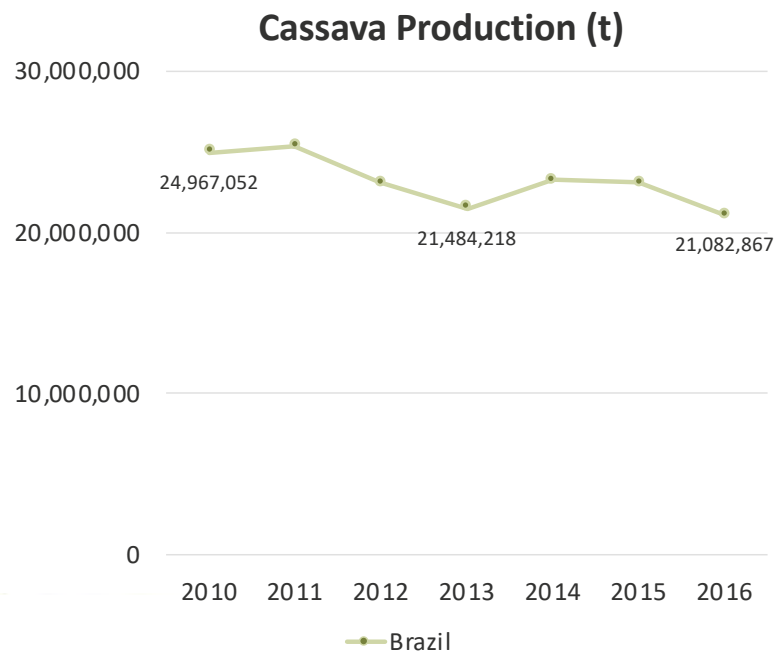


Brazilian Starch Prices Are Highly Variable



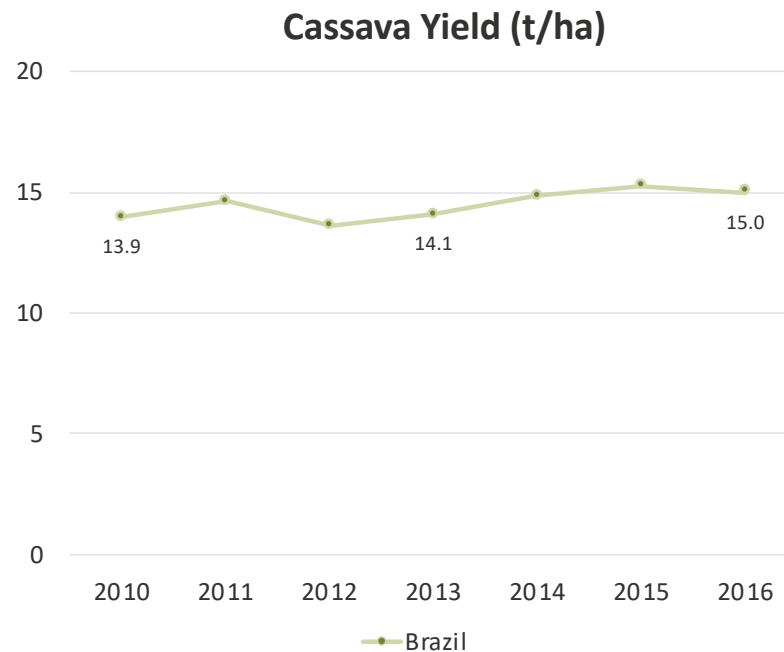
Drop in Cassava Production is Attributable to Lower Harvested Acres, Not Average Yield

PRODUCTION DECLINED BY 15.6%
BETWEEN 2010 AND 2016



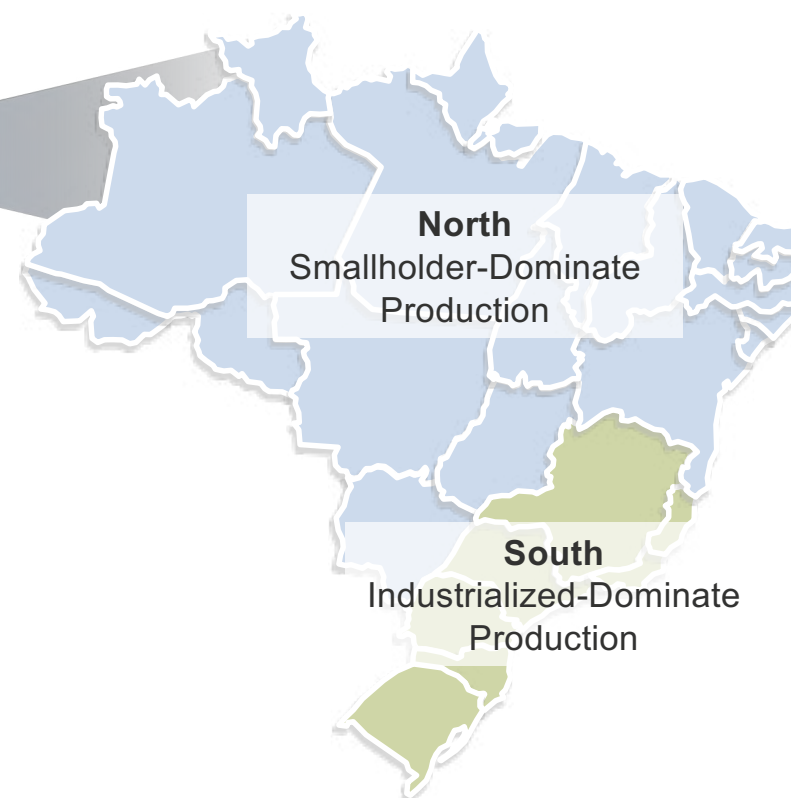
SOURCE: FAOStat (2016)

AVERAGE YIELD INCREASED 7.9%
BETWEEN 2010 AND 2016





Brazil Features Two Dominant Production Systems

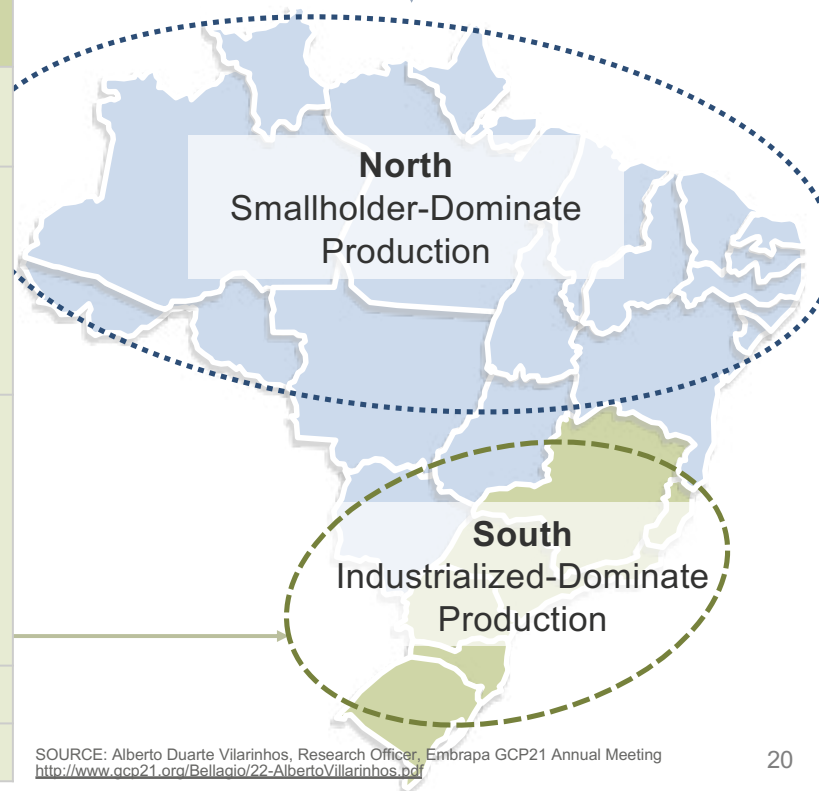
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SOURCE: FAOSTat (2016)

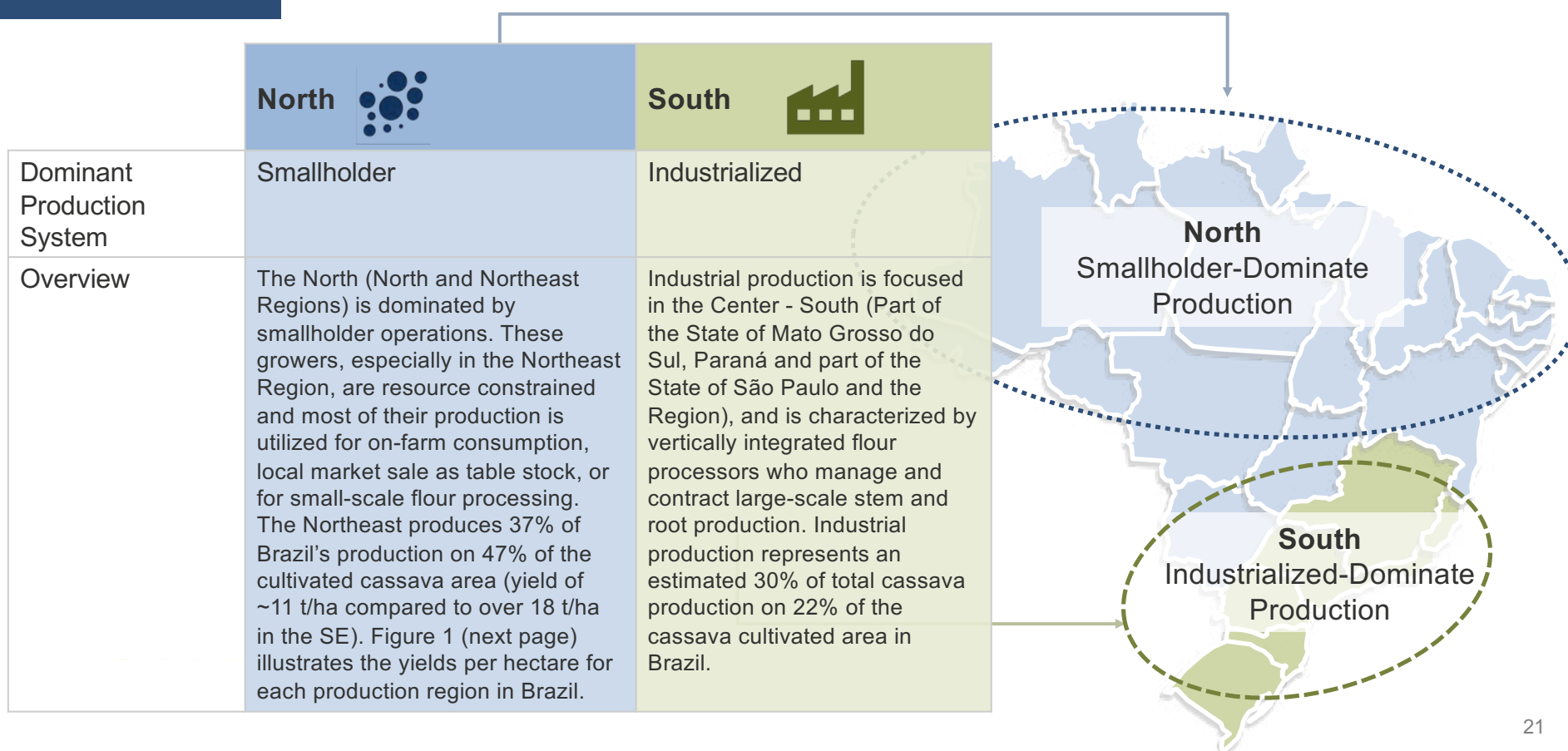
Comparing Cassava Production Systems in Brazil

	North 	South 
Dominant Production System	Smallholder	Industrialized
Characterization	Small grower production (mainly for cassava flour)	Larger scale production for industrial purposes ('farinheiras' and starch factories)
	Family farms, small areas (76% < national yield average)	Prevalence of inputs and mechanization, and larger cultivation areas (30% > 20 ha and 12% > 50 ha)
Cultivated Area (%)	78%	22%
Production (%)	70%	30%



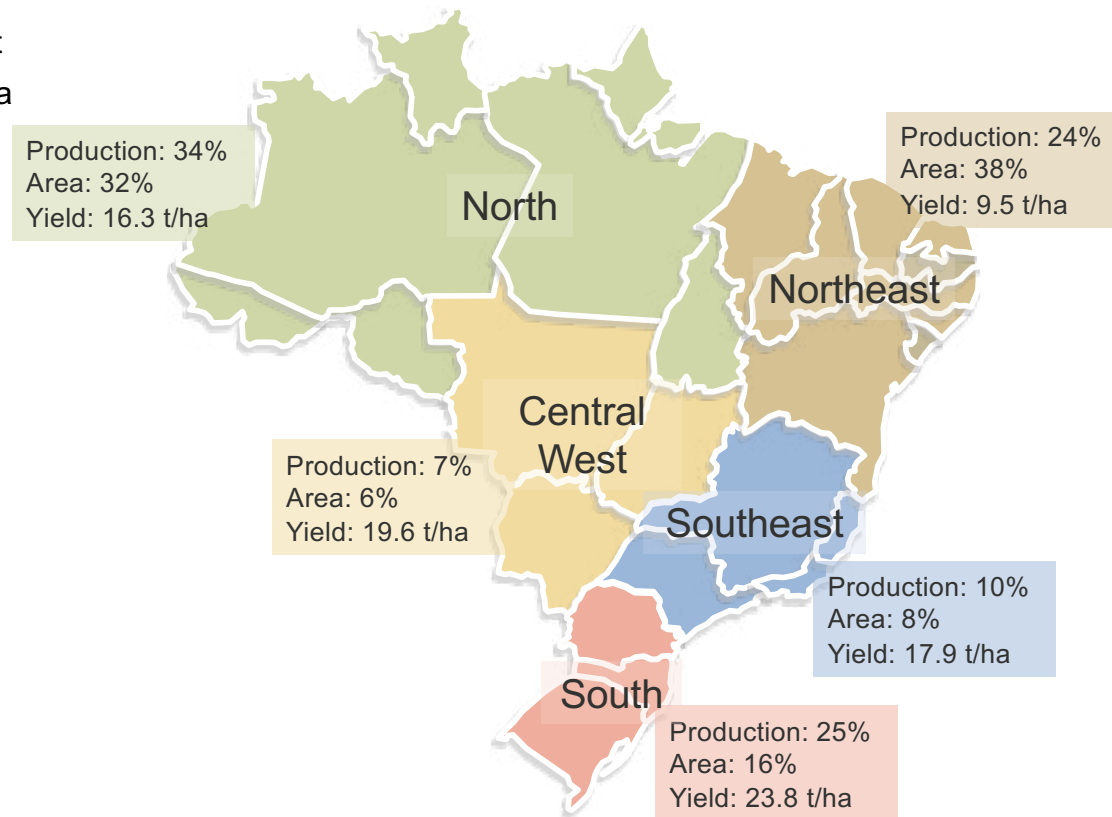
SOURCE: Alberto Duarte Vilarinhos, Research Officer, Embrapa GCP21 Annual Meeting
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Comparing Cassava Production Systems in Brazil

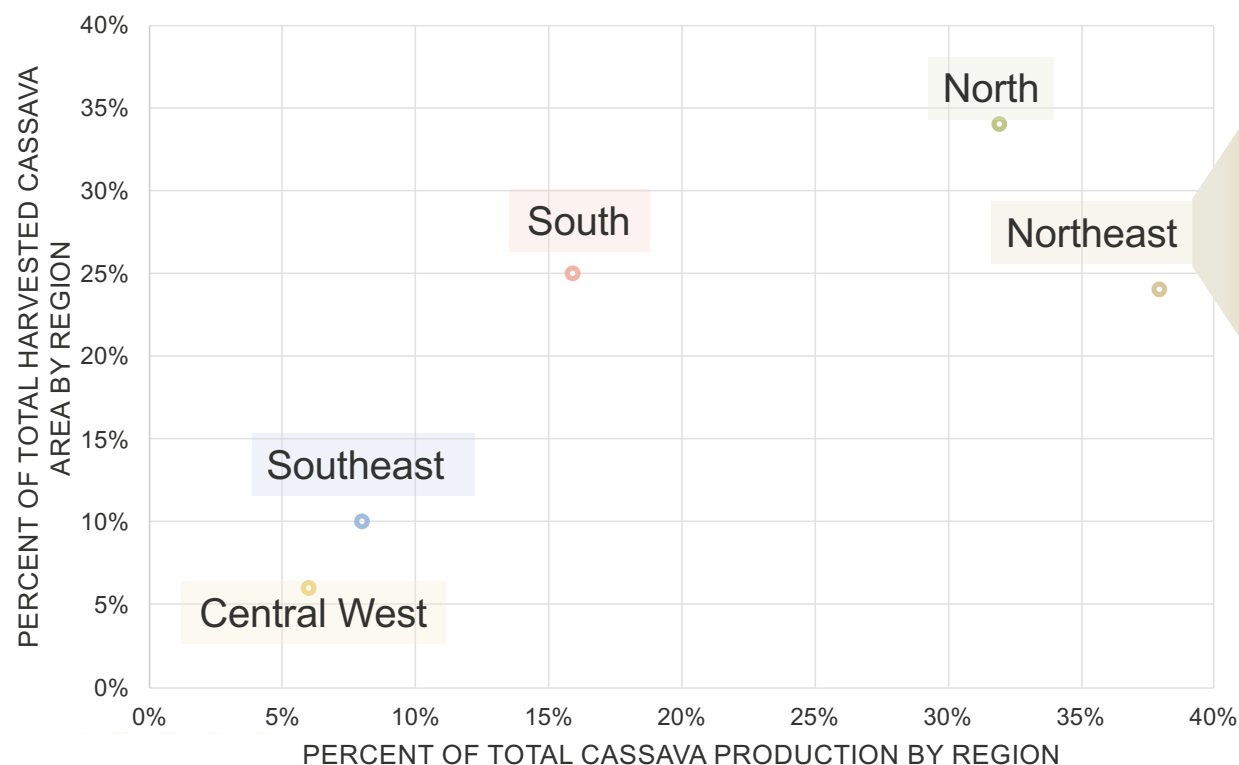


Cassava Production by Region in Brazil in 2015

Production..... 23,059,704 t
Harvested Area1,512,660 ha
Yield.....15.2 t/ha



Cassava Production by Region in Brazil

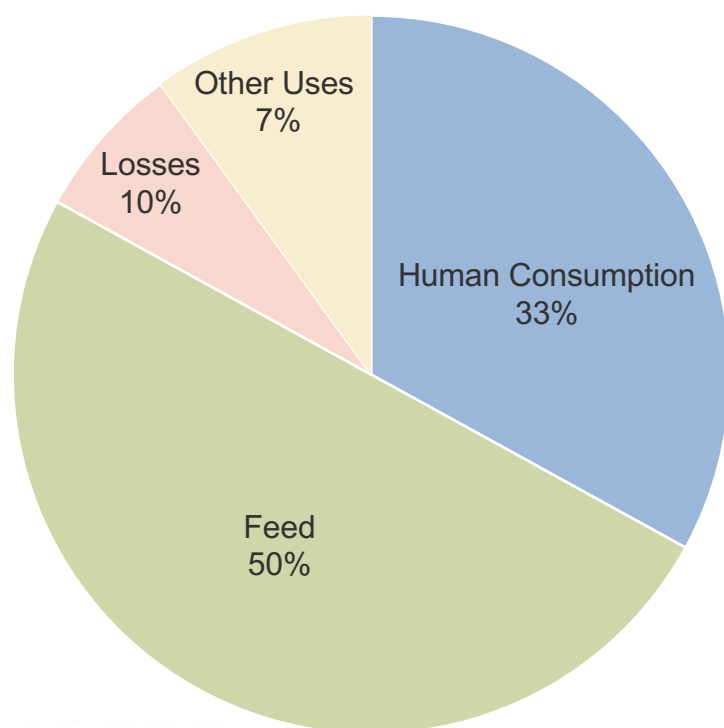


“More than 58% of the Brazilian land area devoted to cassava production is in Northeast, where cassava productivity is 10.7 t/ha, the lowest yield in Brazil. This low yield is probably due to the fact that cassava is grown on fragile and low fertility soils, under uncertain rainfall conditions, and suffers an estimated 50% economic reduction in root yield due to drought, pests, diseases and weeds. Cultivation of cassava varieties with low yield potential, and problems related to technology transfer as well, also contribute to the low productivity levels observed in the region.”

– Grower Participatory Research: The Turning Point for Cassava Development in Northeastern Brazil (1997)²

(2) SOURCE: <http://www.fao.org/tempref/docrep/fao/007/y5271e/y5271e02.pdf>

90%+ of Brazilian Cassava Production is Used Domestically, With 50% of Domestic Consumption Used as Feed



Category	Uses
Feed	Grated roots, hay, silage
Human Consumption	Fried, baked, and boiled roots, flour, starch and derivatives
Other Uses	Biofuel and beverage
Losses	Post-harvest losses



Leadership

RENIVA Project Overview

Problem: Embrapa had developed and released over 54 cassava varieties, but they were not being adopted by growers due to the absence of an efficient transfer and multiplication process.

Intervention: RENIVA¹, which translates from Portuguese as a *Cassava network for multiplication and transference of high quality planting material*, was designed to increase the availability and accessibility of improved seed varieties by serving as an intermediary between new varieties and the market.

The goal of the RENIVA project, which is funded and managed by Embrapa employees, is to enable the commercially sustainable delivery of cassava-seed with improved genetic and phytosanitary qualities within Brazil.

RENIVA's Objectives



1. Establishment of the basis for a continuous multiplication network of cassava cuttings with genetic background and free of virus and other biotic stresses for smallholders located in poor regions of Northeast Brazil;



2. Transfer cassava multiplication technologies to the partners (Rapid Multiplication and Micropropagation);



3. Enable the rescue and mass production of landraces with some risk of suffering genetic erosion



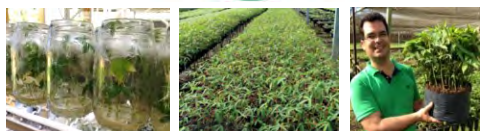
4. Establish a network in which all players may be connected and may have an easy communication channel to promote de cassava culture all over the country.

(1) In Portuguese, 'maniva' is a cassava cutting and 'rede' is network. The name RENIVA is a blend of the two.

RENIVA Project Leadership by Value-Chain Step



**Varietal Development
and Seed Deployment**
(Embrapa Cassava and Fruits)



(TC → Mini-Stems → Mini-Stems)



Stems

CSEs or 'Maniveiros'





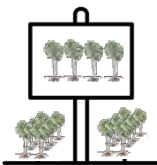


(Mini-Stems → Mini-Stems → Stems)

7% Royalty Collected on Stem Sale Revenue



LEADERSHIP

RENIVA Project Leadership in Brazil

	A	B	C	D	E	F
ORGANIZATION	Embrapa Plant Breeders and Researchers 	RENIVA Project	Instituto Biofábrica de Cacau 	State-Level Extension Services 	Maniveiros 	Embrapa Regional Research Stations 
VALUE CHAIN ROLE	<ul style="list-style-type: none"> Varietal development and release 	<ul style="list-style-type: none"> Basic seed production and distribution of virus-free material to multipliers (biofactories and to CSEs) Technical support to CSEs 	<ul style="list-style-type: none"> Basic seed multiplication in TC and 4 hectares of passive protected screenhouses 	<ul style="list-style-type: none"> When funded from state governmental budgets, provide coordination, technical support, and basic seed distribution for CSEs 	<ul style="list-style-type: none"> Multiply and distribute basic seed (stems) to root growers 	<ul style="list-style-type: none"> Coordination, basic seed distribution, and technical support to state-level extension services and regional CSEs
MAJOR FUNDING SOURCES	<ul style="list-style-type: none"> Government funding Sponsored research Grants 	<ul style="list-style-type: none"> Government funding 	<ul style="list-style-type: none"> Government funding Revenue from cassava seed sales 	<ul style="list-style-type: none"> Government funding 	<ul style="list-style-type: none"> Revenue from cassava stem sales Subsidized input costs (basic seed) 	<ul style="list-style-type: none"> Government funding
FINANCIAL SUSTAINABILITY	PUBLIC SECTOR FUNDED WITH PARTIAL FUNDING FROM PRIVATE SECTOR	PUBLIC SECTOR FUNDED	PUBLIC SECTOR, NOT-FOR-PROFIT, PARTIALLY FUNDED FROM OPERATIONS	PUBLIC SECTOR FUNDED	FUNDED THROUGH OPERATIONS	PUBLIC SECTOR FUNDED

Embrapa – Brazilian Agricultural Research Corporation



Mission

To design research, development and innovation solutions for the sustainability of Brazilian agriculture for the benefit of the Brazilian society.

Institutional Profile

- Established in **1973**
- Linked to Ministry of Agriculture, Livestock and Food Supply



Photo: Embrapa-HQ

- **9.807** employees
- **2.444** researchers:
 - B.Sc. 1%
 - M.Sc. 15%
 - D.Sc./Ph.D. 84%

Embrapa Operates 42 Decentralized Centers of Research and Services

Embrapa – 42 Decentralized Centers of Research and Services

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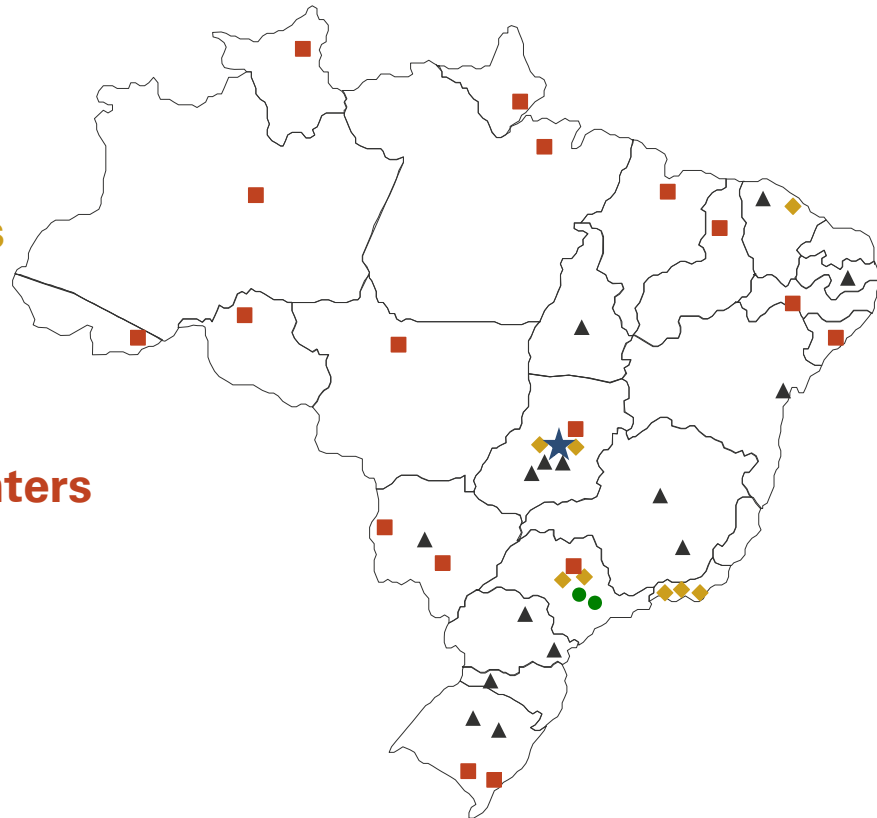
★ Embrapa HQ

◆ 08 Thematic Centers

▲ 15 Product Centers

■ 17 Eco-Regional Centers

● 02 Services Centers



National Center for Cassava and Tropical Fruit Research (Bahia State, Brazil)



MISSION: To provide solutions for the sustainable development of the cassava and tropical fruit crops agribusiness by generation, adaptation and transfer of knowledge and technologies for social benefit



National Center for Cassava and Tropical Fruit Research



- Established in 1975
- 227 Employees
- Total Area: 262 ha
- 71 Researchers

The National Center for Cassava and Tropical Fruit Research is based in Bahia State, Brazil, but is mandated to serve all of Brazil

RENIVA Project Overview



The RENIVA Project's objective is to enable a *seed entrepreneur network for the multiplication and transference of high quality planting material*, and to serve as an intermediary between new varieties and the market.

The goal of the RENIVA project, which is funded and managed by Embrapa, is to enable the commercially sustainable delivery of cassava-seed with improved genetic and phytosanitary qualities within Brazil.

RENIVA Project's key functions include: virus indexing, nuclear seed management, basic seed multiplication (TC to TC, and TC to basic seed plantlets), basic seed demand forecasting, basic seed production contracting, and distribution to off-takers, who could be industry partners (primarily buying tissue culture) or Cassava Seed Entrepreneurs (CSEs). CSEs are typically smallholder cassava multipliers operating with one hectare of irrigated land.

Long-Term Goal: 30% of Brazil's Cassava Planting Area to Be Sourced From Maniveiros'



Biofábrica de Cacau Institute – Technical Partner of the RENIVA Project



“The Biofábrica de Cacau Institute is a Social Organization linked to the Government of the State of Bahia. Its mission is to produce, multiply and distribute to growers genetic material of seedlings of high agronomic value.” - [Instituto Biofábrica de Cacau](#)



OPERATIONAL OVERVIEW

IBC's Laboratory of Plant Micropropagation was planned based on the most refined concepts of modern biotechnology, with the capacity to produce five million seedlings of fruit species per year via in vitro cultivation.

The seedling production unit has a total area of 63 hectares and 20 open field nurseries, which is the largest field nursery in the world for cocoa production. Cassava seedlings are produced in eight greenhouses, spanning 4 hectares.



KEY CASSAVA SEED SYSTEM FUNCTION

Multiply basic plantlets received from Embrapa and distribute to seed entrepreneurs ('Maniveiros') and/or to local support teams (state-level extension services) for distribution to seed entrepreneurs. IBC currently distributes direct to seed entrepreneurs because of funding lapses from state extension services.

Current Distribution Flow: EMBRAPA (RENIVA Project) → IBC → Cassava Seed Entrepreneurs

Former Distribution Flow: EMBRAPA (RENIVA Project) → IBC → Local Support Teams → Cassava Seed Entrepreneurs



CASSAVA SEED PRODUCTION

Since 2014, IBC has donated and sold over one million basic seed to seed entrepreneurs and extension services in the North, and to vertically integrated.

Initially, IBC donated its cassava seed production, but now sells each plantlet for 1.7 reais.

IBC is the only organization in Brazil that is making cuttings for cassava seed entrepreneurs.

State-Level Extension Services



RENIVA PROJECT ROLE

State extension services are another key actor in RENIVA. Extension services are expected to provide technical and coordination support to CSEs within their region in order to assure that phytosanitary standards are being maintained and no virus reinfections occur.

Besides this, extension services they are also responsible for the logistics of basic seed demand forecasting and distribution.



PUBLIC FUNDING VARIABILITY

Recently, a Brazilian state government that RENIVA was collaborating with closed down the extension service company, which had a drastic impact over the large amount of CSEs already undergoing.

The loss of extension personnel was a hit to the burgeoning seed system, as RENIVA has limited contact with the 60 maniveiros that the extension service was formerly working. As a result, there is no coordinating function to connect basic seed supply and demand, and maniveiros must actively call partners, like the largest CSE (Mr. Dutra), or contact Embrapa to source their basic seed (stems).

In response, RENIVA plans to promote a deployment strategy that utilizes large, well-resourced CSEs to contract cassava multiplication to smallholders in the affected area for stem and root production. Under this planned model, extension services would be funded by the private sector, and it is conceivable that large CSEs would partner in cost sharing for the project.

‘Maniveiros’ (Cassava Seed Entrepreneurs)



The RENIVA Project has introduced a new player into the production system called ‘Maniveiros’, which are regional cassava seed entrepreneurs who produce and sell cuttings

Maniveiros Characteristics:

- A smallholder who used to plant cassava to produce roots only
- S/he will now cultivate at least one 1 ha (irrigated) with micropropagated cassava seedlings that are virus-free
- S/he will be paid for the cuttings produced along one year
- Simultaneously s/he will produce seedlings (cuttings and mini cuttings) by rapid multiplication
- S/he will treat seedlings using the MandiPlus technique
- S/he will no longer produce roots, only cuttings and mini-cuttings



Embrapa Eastern Amazon (Belém, Pará) is Providing a Local Support Role to CSEs in the State of Para



RENIVA PROJECT ROLE

Provide a coordination role between state extension services, and support basic seed distribution between IBC and CSEs, and provide capacity building support to extension staff and regional CSEs

- This unit is one of the largest Embrapa research centers: It contains six research centers, 2,500 ha of research land (70 ha in the city), and employs 113 researchers
- The station provides genetic resources and a germplasm bank to the RENIVA system, but it is not providing early generation seed multiplication like is done in Bahia
- The station is working with seed entrepreneur (Dutra) for multiplication, but the basic material is sent here from IBC and Embrapa Cassava & Fruits (Cruz das Almas).
- Basic materials used at this station are varieties that were selected for the region, and this branch is in the process of releasing new varieties specific to this region



SMALLHOLDER FARMERS IN PARA

- Grower-to-grower adoption is the primary way that growers try new varieties
- Tend to be very independent
- Tend to be relatively organized 36



Research & Varietal Development

Cassava Breeding Objectives and Systems



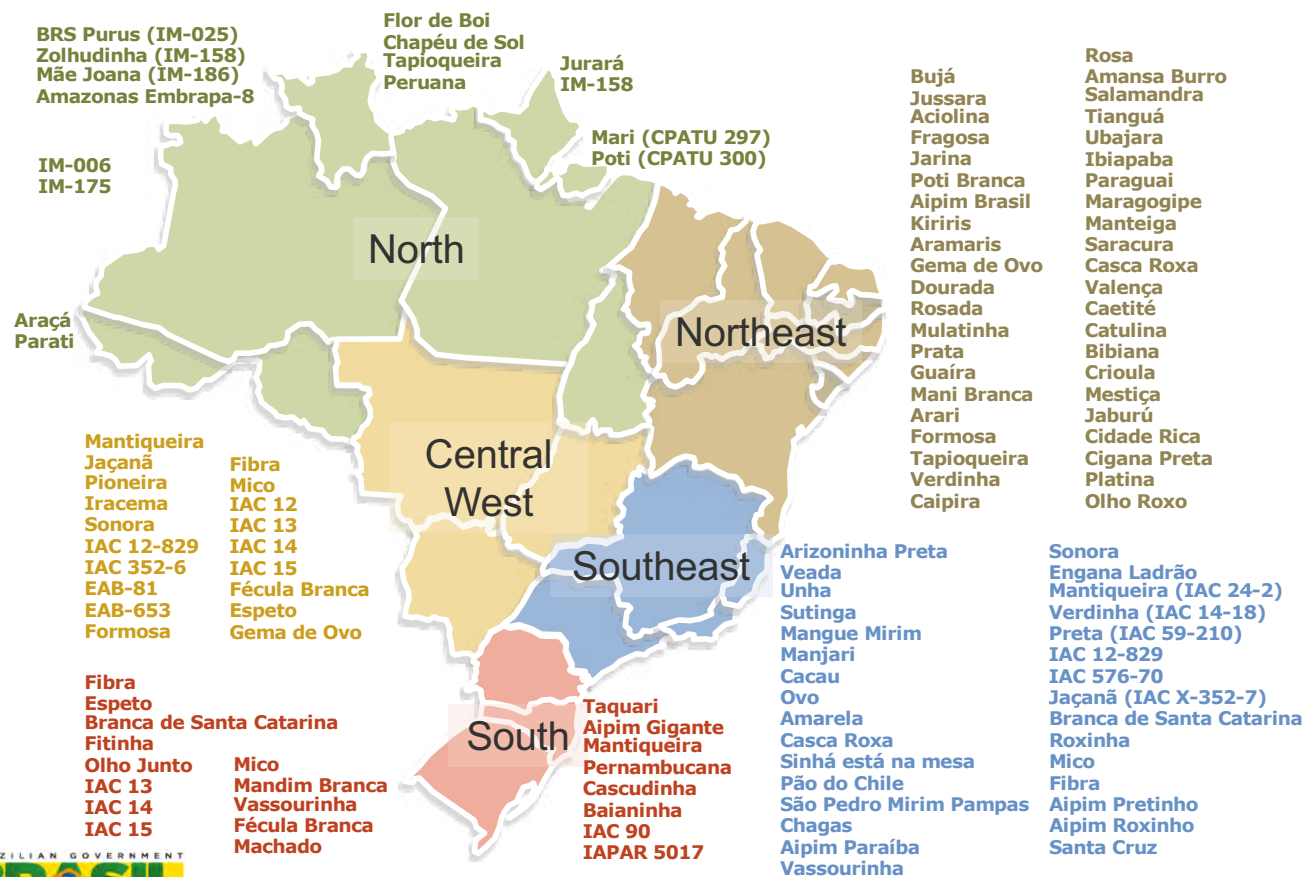
Breeding Goals Depend On The Final Destination (Industrial Use Vs. In Natura)

- **High yield potential** is a constant goal
- **Yield stability** → associated with resistance to biotic factors (drought and soil low fertility) and abiotic (frogskin, bacterial blight, superelongation, witches broom, viruses, root rot, mites, white fly) → the focus varies with the target environment
- **Root quality:**
 - Industrial use requires high dry matter
 - Human consumption → emphasis on cooking and starch characteristics
 - Cooking associated with morphological traits such as skin color, petiole or stem
 - Cyanogenic compounds, proteins and carotenoids
- **Precocity** (*early bulking*)
- **Tolerance to post-harvest physical deterioration (PPD)**

Cassava Varieties that Have Been Released to Different Regions of Brazil

Sources:

Moraes et al. (1980)
Pinho et al. (1986)
Fukuda & Borges (1989)
Fukuda et al. (2002)
Lorenzi et al. (2002)
Takahashi & Gonçalves (2005)
Fukuda & Iglesias (2006)
Fukuda et al. (2008)



Breeding Activities by Stage



Pre-breeding

- Establishment and maintenance of genebanks
- Characterization and evaluation
- Analysis of genetic diversity



Breeding

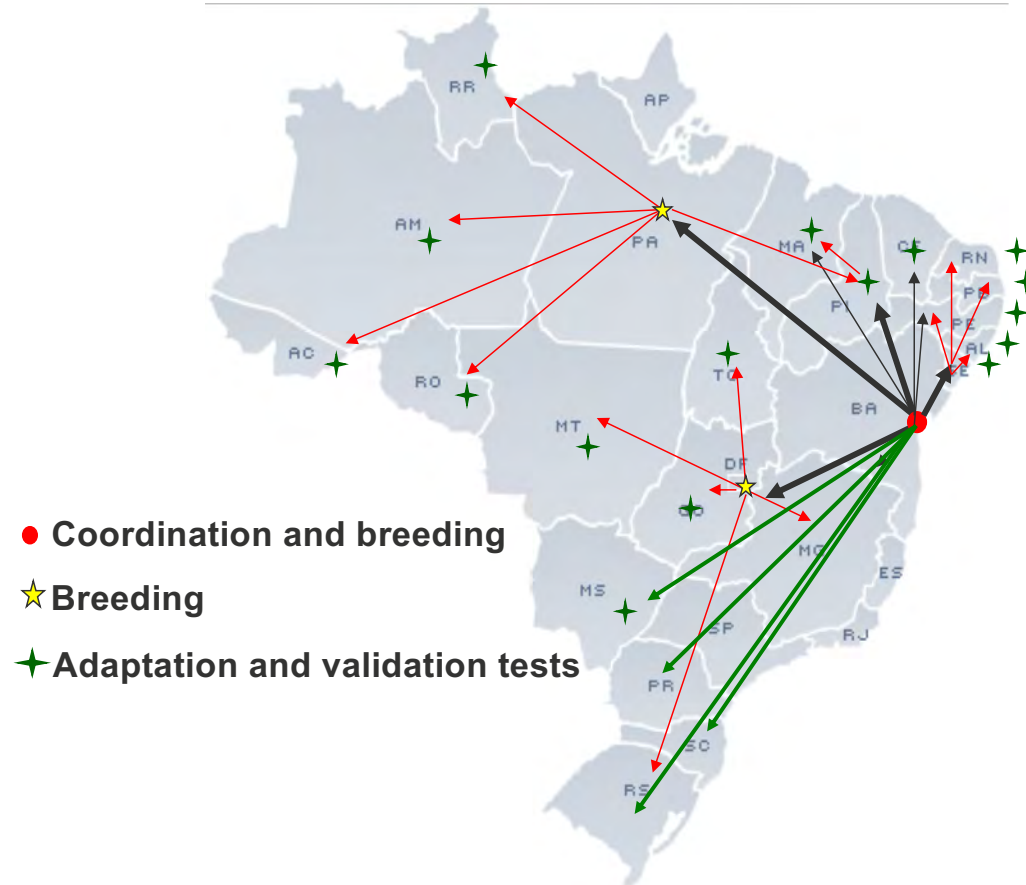
- Crosses between elite parentals
- Breeding Strategies (heritability, correlation, genetic parameters)
- Generation and evaluation of segregating populations
- Genetic gains and selection
- GxE Interaction (adaptability and yield stability)



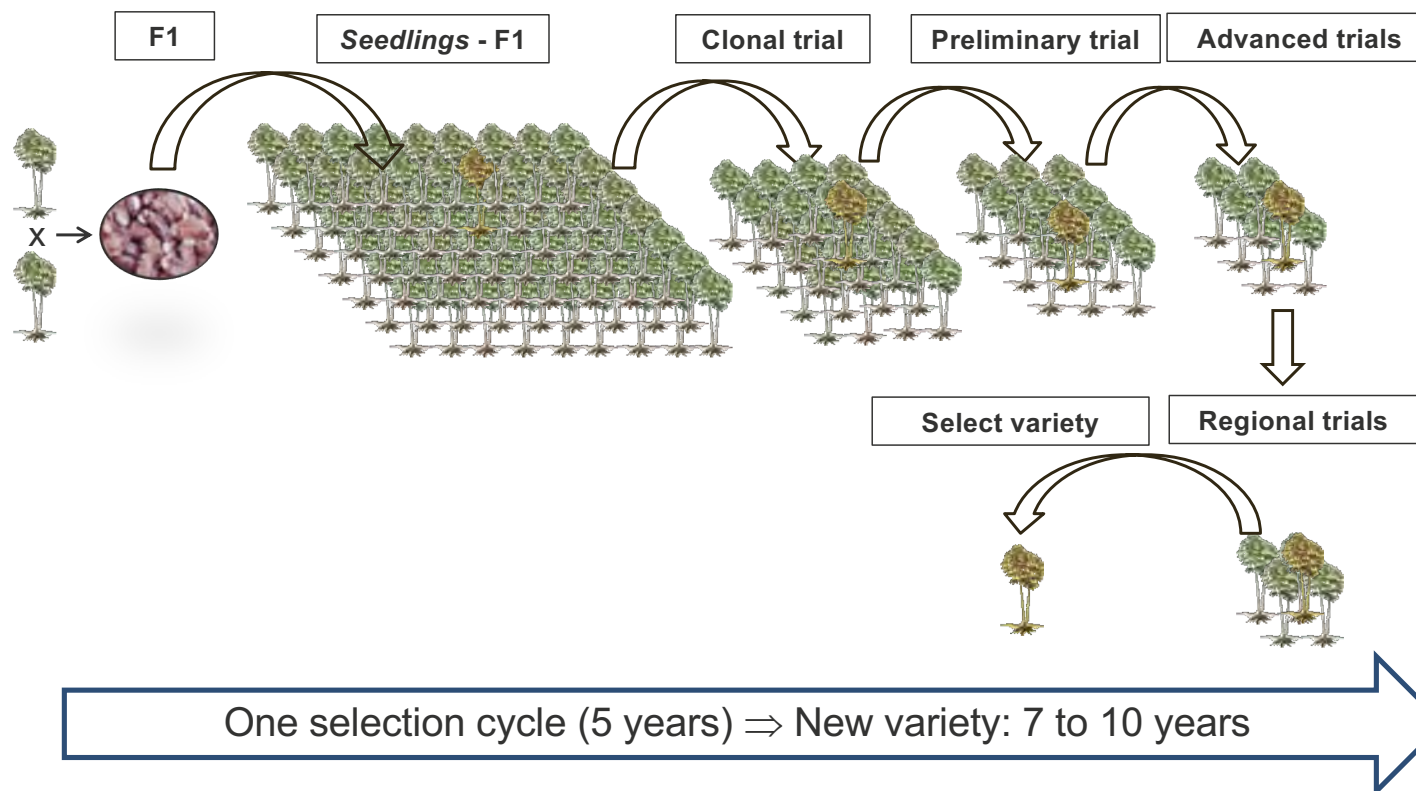
Post-breeding

- Indication of the best varieties
- Registration and/or protection
- Indexing
- Logistics for multiplication and distribution of cuttings

Cross-Country Adaptation and Validation Tests Requires Close Coordination Among Researchers

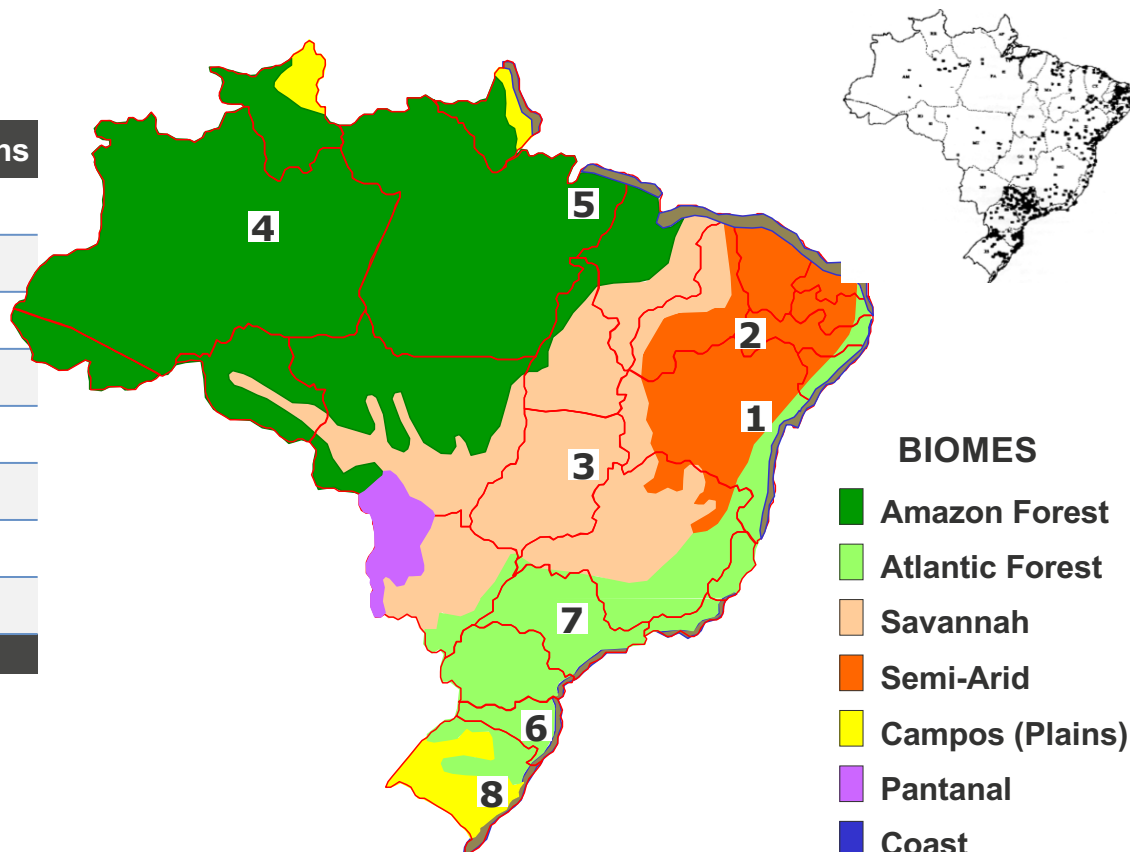


Conventional Varietal Development Process



Cassava Gene Banks

#	Institution	Accessions
1	Embrapa Cassava & Fruits	1550
2	Embrapa Semi-Arid	532
3	Embrapa Savannas	487
4	Embrapa Western Amazon	512
5	Embrapa Eastern Amazon	441
6	EMPASC	600
7	IAC	1000
8	Embrapa Temperate Agriculture	65
TOTAL		5187



Pre-Breeding

Conservation and characterization

FIELD CONSERVATION



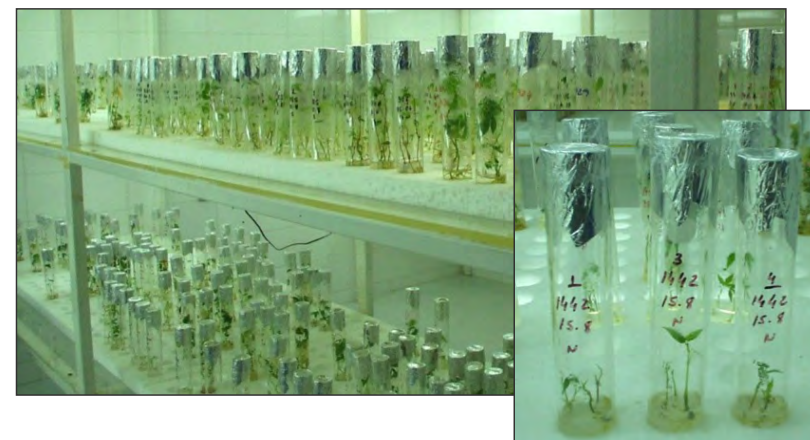
- *16 plants per accession*
- *Annually replanted*



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IN VITRO CONSERVATION



- *To recover lost accessions, and*
- *Maintain duplicates available for distribution of requests via Multilateral System of the IT*

Pre-Breeding

Conservation and characterization

75 morphological and botanical descriptors



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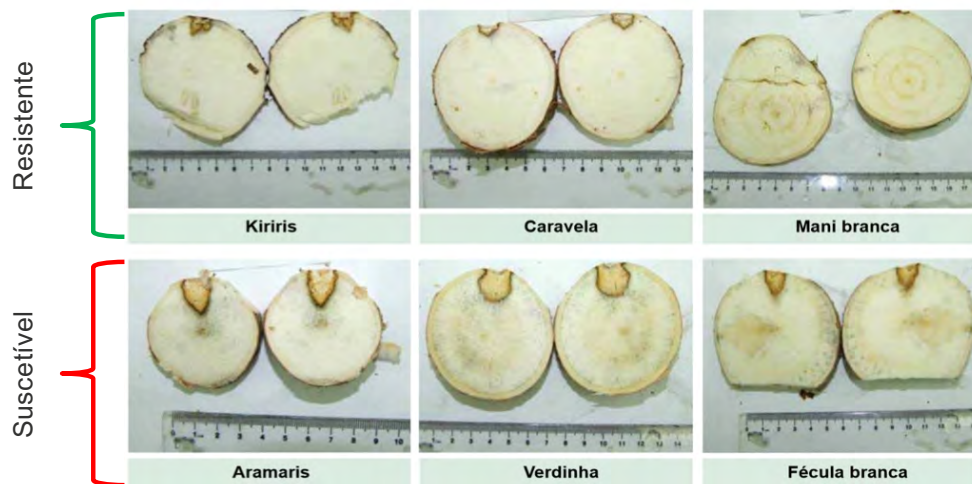


Pre-Breeding

Sources of resistance to Root Rot



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Fotos: Saulo Alves Santos de Oliveira

Measurement of lesions in commercial cassava varieties
inoculated with *Fusarium* sp.

Pre-Breeding

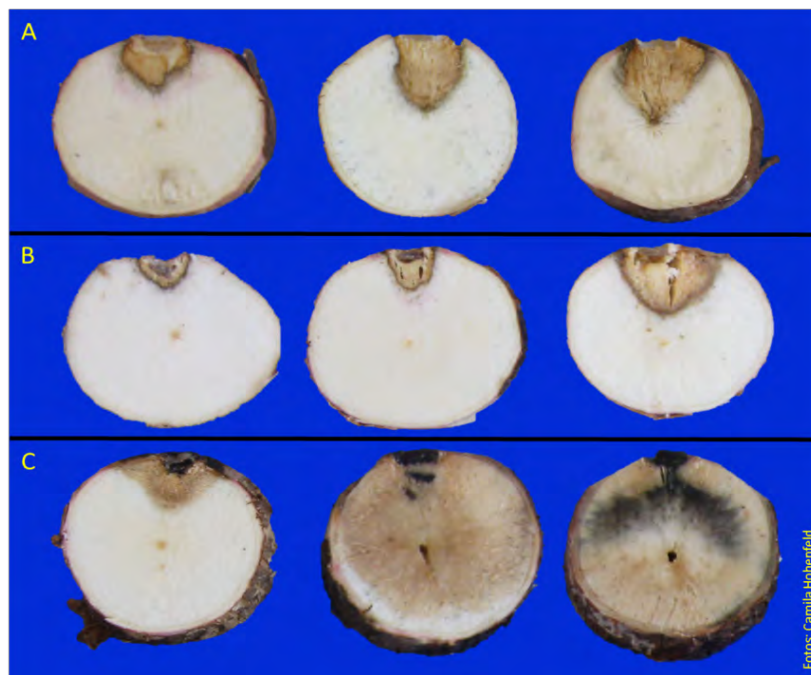
Sources of resistance to Root Rot



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Definition of aggressiveness of isolates of the major diseases



Cassava roots inoculated with (A) *Fusarium* sp. (B) *Phytophthora* sp. e (C) *Scytalidium* sp.

Pre-Breeding

Sources of resistance to shoots diseases



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Photo Credit: Harlien Sandro

Superelongation
(*Sphaceloma manihoticola*)



Photo Credit: S. Oliveira

Bacterial Blight (*Xanthomonas axonopodis* pv. *manihotis*)



Photo Credit: S. Oliveira

Anthracnose (*Colletotrichum gloesporioides*)

Pre-Breeding

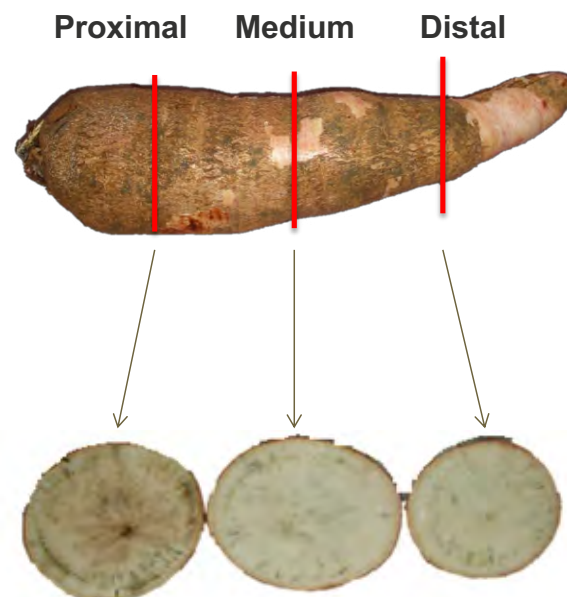
Sources of resistance to PPD – Post Physiological Deterioration



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Screening germplasm for tolerance to PPD



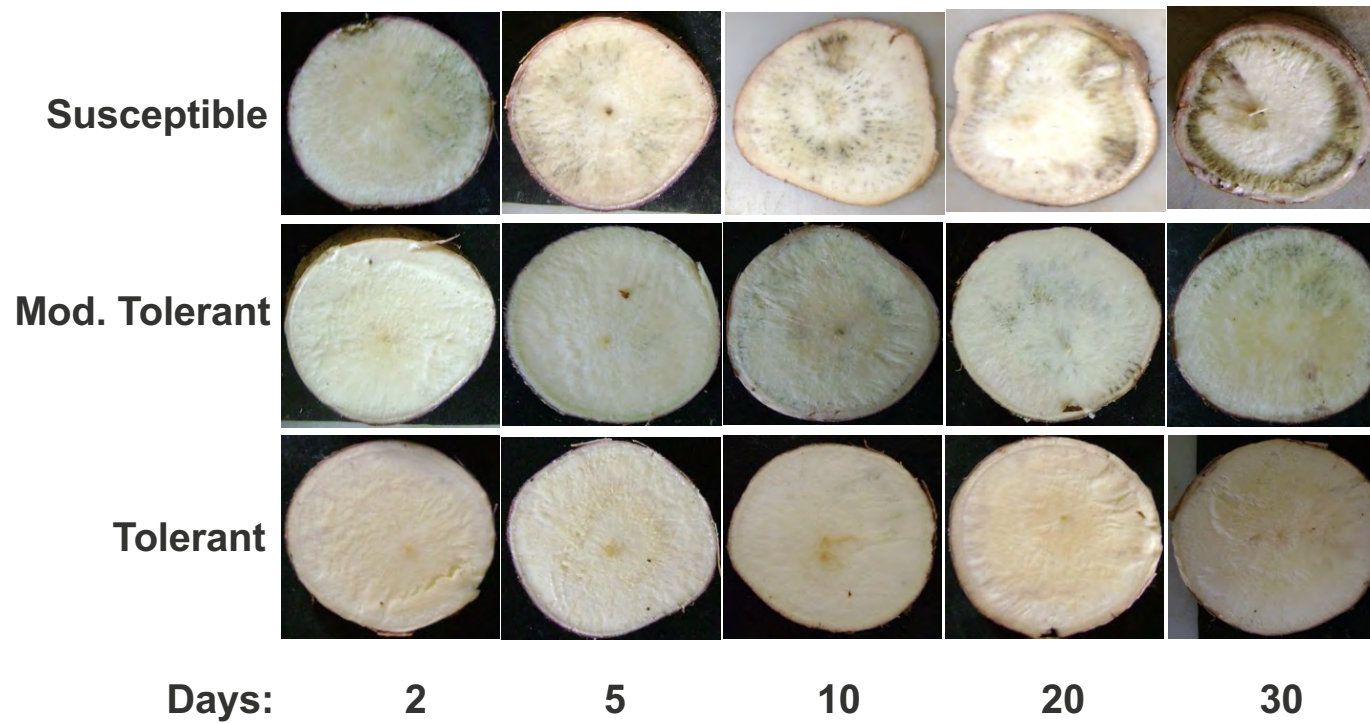
Pre-Breeding



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Sources of resistance to PPD – Post Physiological Deterioration



Pre-Breeding

Sources of resistance to ACMV and CBSD



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ADE 01 PL9	Accessions of <i>Manihot</i> sp. used in the evaluation for resistance to CBSD
ANO 52V PL18	<i>M. anomala</i>
CAEBM 36 P33	<i>M. caerulescens</i>
COM DF-10 PL10	<i>M. longiracemosa</i> (to be published)
CTM 05 P25	<i>Manihot</i> sp. (not identified)
FLA 005-01 PL1	<i>M. esculenta</i> ssp. <i>flabellifolia</i>
FLA 005-07 PL7	<i>M. esculenta</i> ssp. <i>flabellifolia</i>
FLA 005-19 PL19	<i>M. esculenta</i> ssp. <i>flabellifolia</i>
GLA 212 PL11	<i>M. carthaginensis</i> ssp. <i>glaziovii</i>
GLA 590 PL20	<i>M. carthaginensis</i> ssp. <i>glaziovii</i>
GLA 590 PL8	<i>M. carthaginensis</i> ssp. <i>glaziovii</i>
IRW A027-12 PL12	<i>M. irwiin</i>
PER 005 PL16	<i>M. peruviana</i>
PER 02-05 PL5	<i>M. peruviana</i>
POR 004 PL1	<i>M. pornuncia</i>
TOM 001-23 PL31	<i>M. tomentosa</i>

Pre-Breeding

Origin and distribution

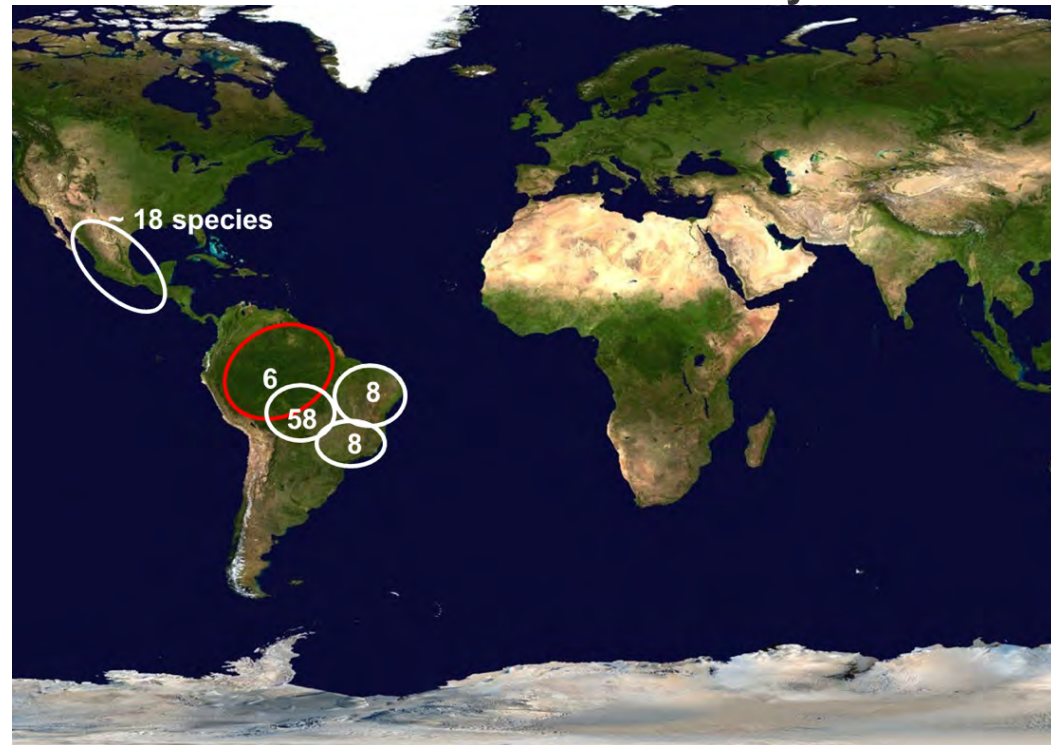


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98 species of *Manihot*
Only one cultivated:
M. esculenta

Areas of cassava diversity

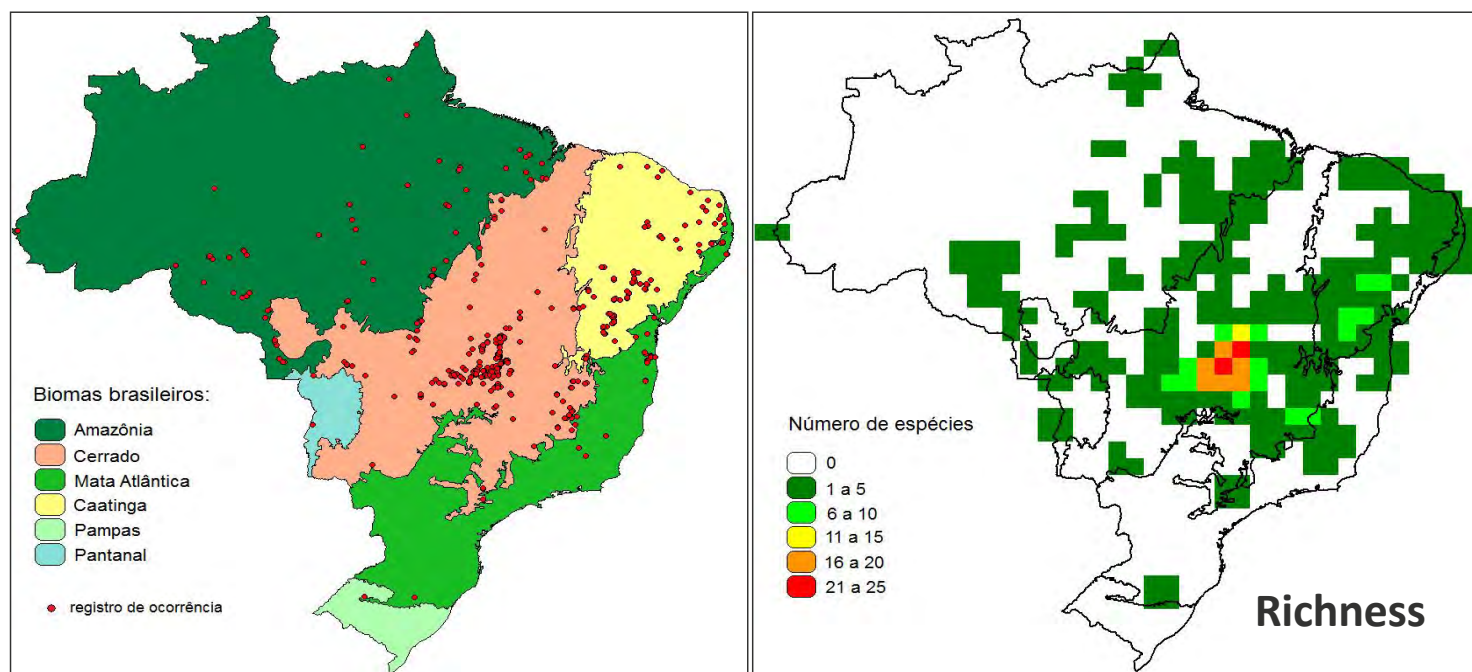


Pre-Breeding

Areas of *Manihot* diversity in Brazil



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75 Brazilian species (~77%)

Pre-Breeding



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Establishment of *Manihot* wild species collection at Embrapa/CNPMF

First planting: Aug/2005



Photo: A.Alves

2012: Total of ~700 accessions of 38 species

Pre-Breeding

Manihot wild species collection at Embrapa/CNPMF



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Photos: A.Alves



Cultivar Catalogues



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MandiPlus is an Embrapa Managed Project that is Evaluating Innovations to Support the Development of an Efficient Stake (Stem) Production System



MandiPlus is co-funded by the Syngenta Foundation and the Bill & Melinda Gates Foundation. Its objective is to establish a highly efficient cassava stake production system through optimizations around planting density, stem treatment, stem size, mechanization.

Enabling Technologies



The slides that follow were presented by Eder Jorge de Oliveira during a Multi-Day Study Tour to Brazil in April, 2018



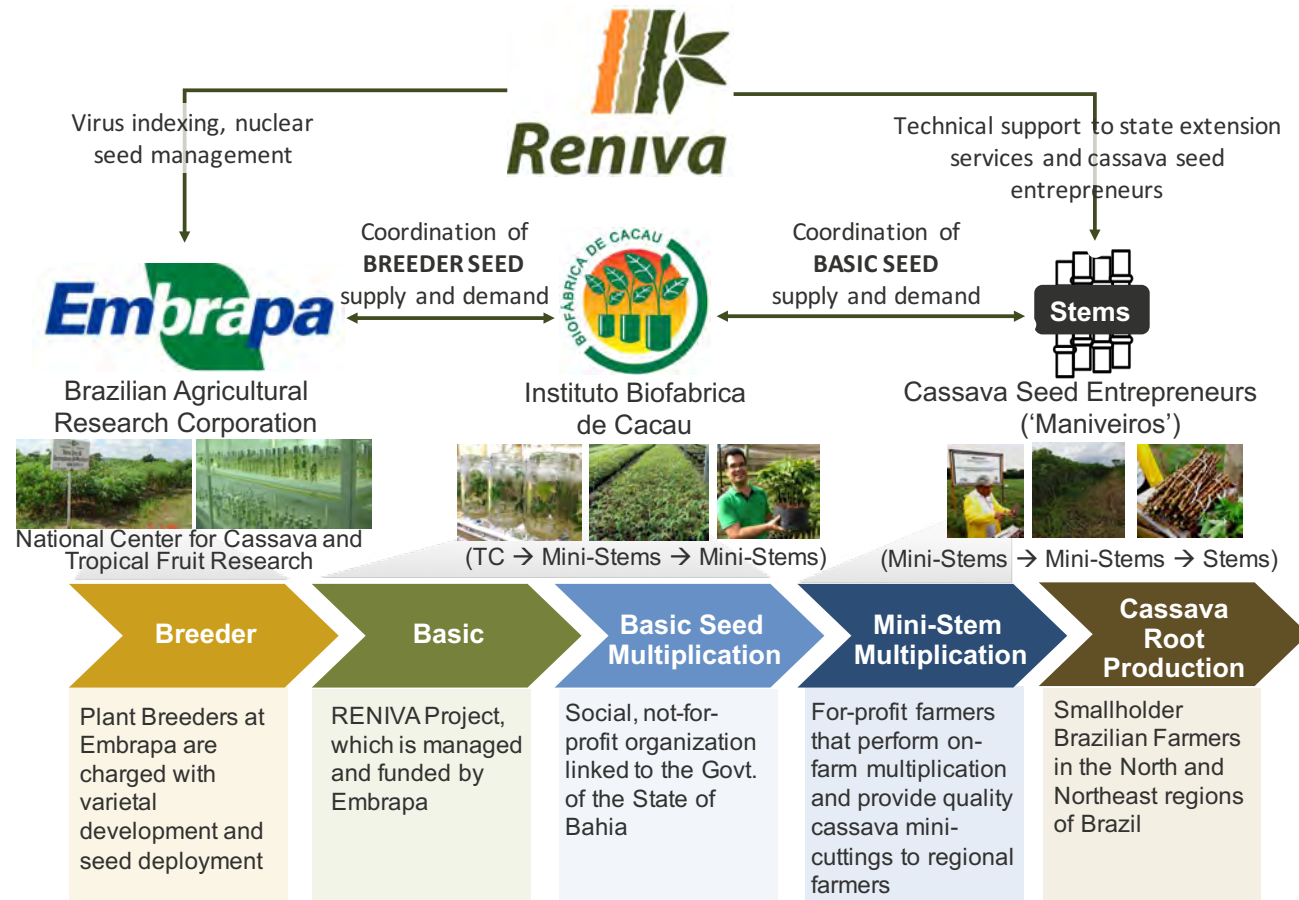
MandiPlus Innovations Are Being Applied Across All Multiplication Stages

		Seed	Responsibility	Cycle (Months)	Potential Multiplication Rate	
					Per step	Cummulative
MandiPlus Project	Year 1	Nuclear G1	Variety Maintained by Research (Embrapa)			
		Pre-basic G2 (C0)	Tissue Culture Lab (IBC)	6	1.1 to 6	90
		Pre-basic G2 (C1)	Greenhouse Multiplication (IBC)	2	2	150
		Pre-basic G2 (C2)		2	2	360
	Year 2	Basic G3 (C1)	Certified Seed Entrepreneurs/Companies	12 (two harvest/year)	85	30,600
	Year 3	Certified G4 (C1)	Certified Seed Entrepreneurs/Companies	12 (two harvest/year)	12.5	382,500
	Year 4	Certified G4 (C2)		12 (two harvest/year)	15	5,737,500
	Year 5	Certified G4 (C3)		12 (two harvest/year)	15	86,062,500
		Commercial Root Production				



Demand Planning & Operations

RENIVA Project Designed to Create a Sustainable Pathway for Improved Seed Varieties to Reach Growers



RENIVA Project Schematic



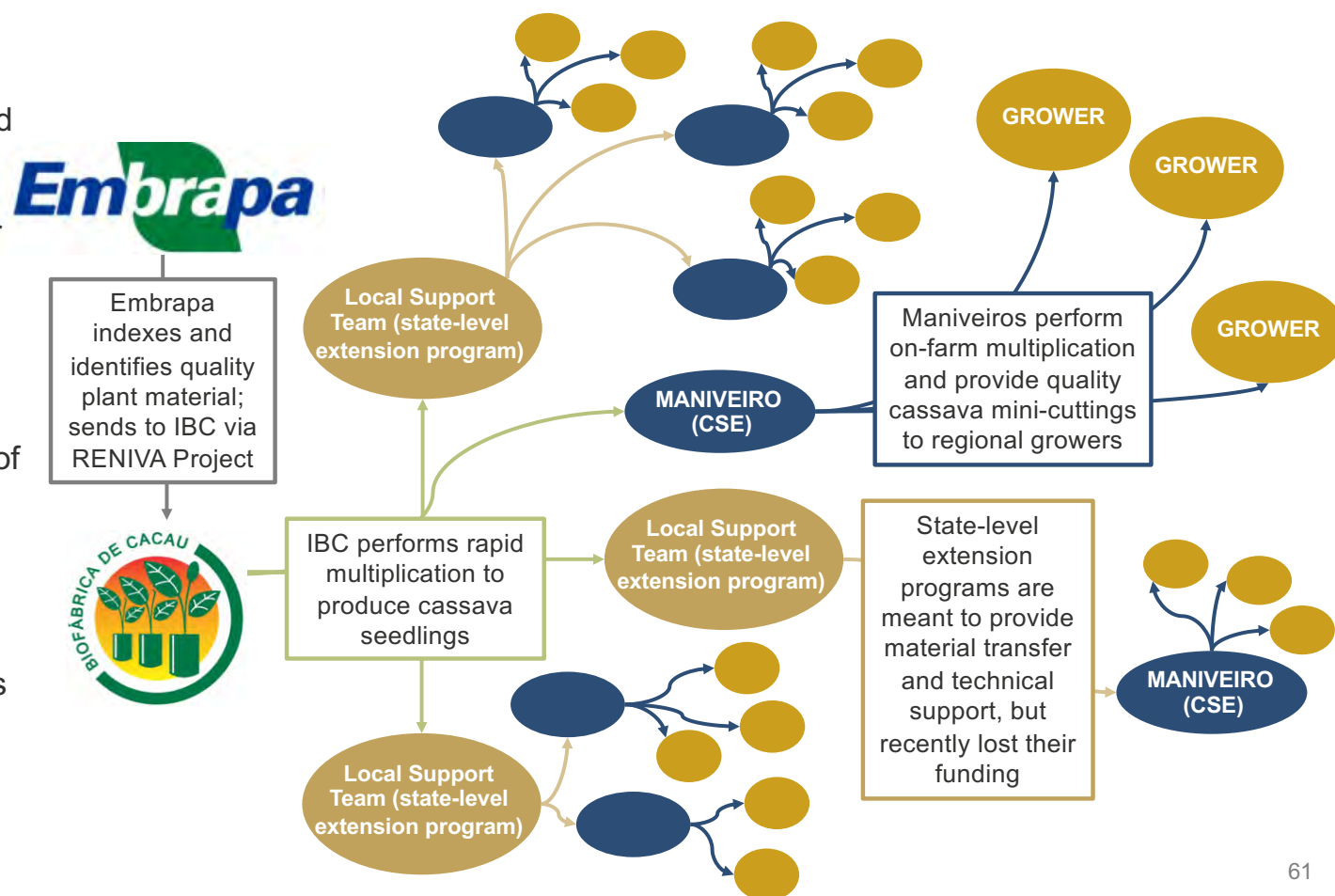
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Embrapa, via its RENIVA Project relies on the Instituto Biofábrica de Cacau (IBC) and its network of Cassava Seed Entrepreneurs (CSEs), which are known as 'Maniveiros', for seed multiplication and distribution.

Biofactories receive breeder seed for tissue culture multiplication and production of basic seed stems, which are distributed to CSEs free of charge, for multiplication on one-hectare plots.

Following multiplication, CSEs distribute their production to cassava growers in their region.



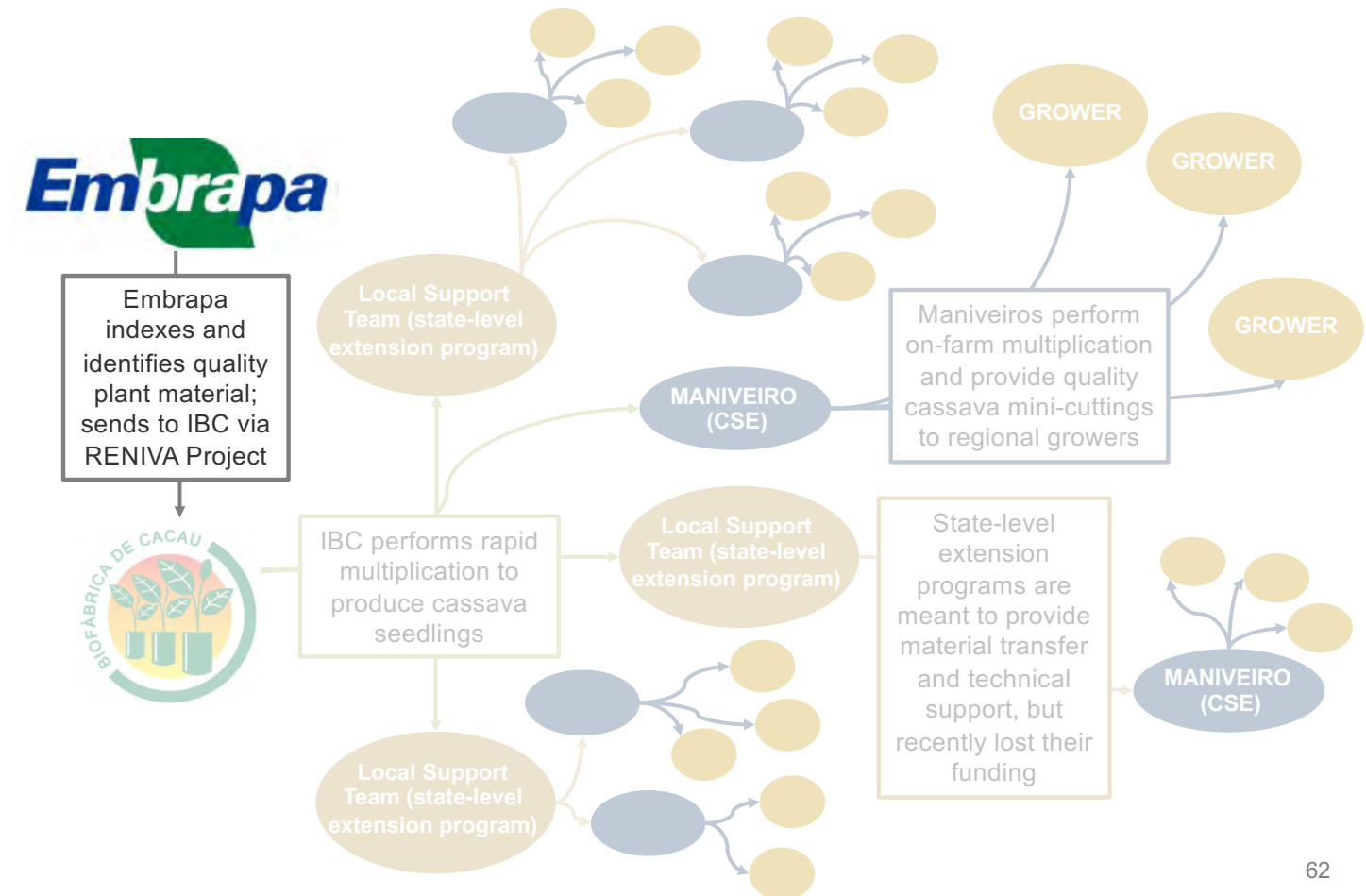
RENIVA Project Schematic



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Embrapa



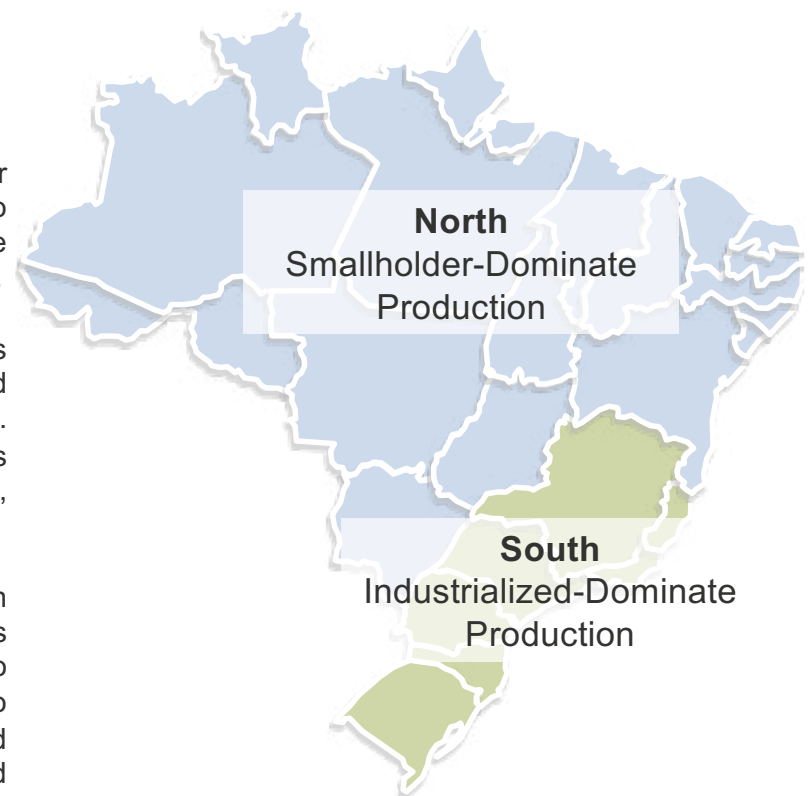
RENIVA's Seed Deployment Strategy Varies by Region



In the South, RENIVA deploys new varieties through private biofactories (two or three) that multiply tissue culture for use by vertically integrated processors to plant their cassava fields, which are typically owned and contracted by the processors. A network of CSEs does not yet exist in the Center South and South.

In the North, RENIVA relies on its network of Cassava Seed Entrepreneurs (CSEs) for seed multiplication and distribution. The CSEs receive basic seed stems from RENIVA, free of charge, for multiplication on one-hectare plots. Following multiplication, the CSEs distribute their production to cassava growers in their region. The economics of CSE production are not currently well defined, but would be studied during a potential in-person visit.

Recently, a Brazilian state government, drastically closed down the extension service company which had a drastic impact over the large amount of CSEs already undergoing. This happened in Bahia. In response, RENIVA plans to promote a deployment strategy that utilizes large, well-resourced CSEs to contract cassava multiplication to smallholders in the affected area for stem and root production. Under this planned model, extension services would be funded by the private sector, and it is conceivable that large CSEs would partner in cost sharing for the project.



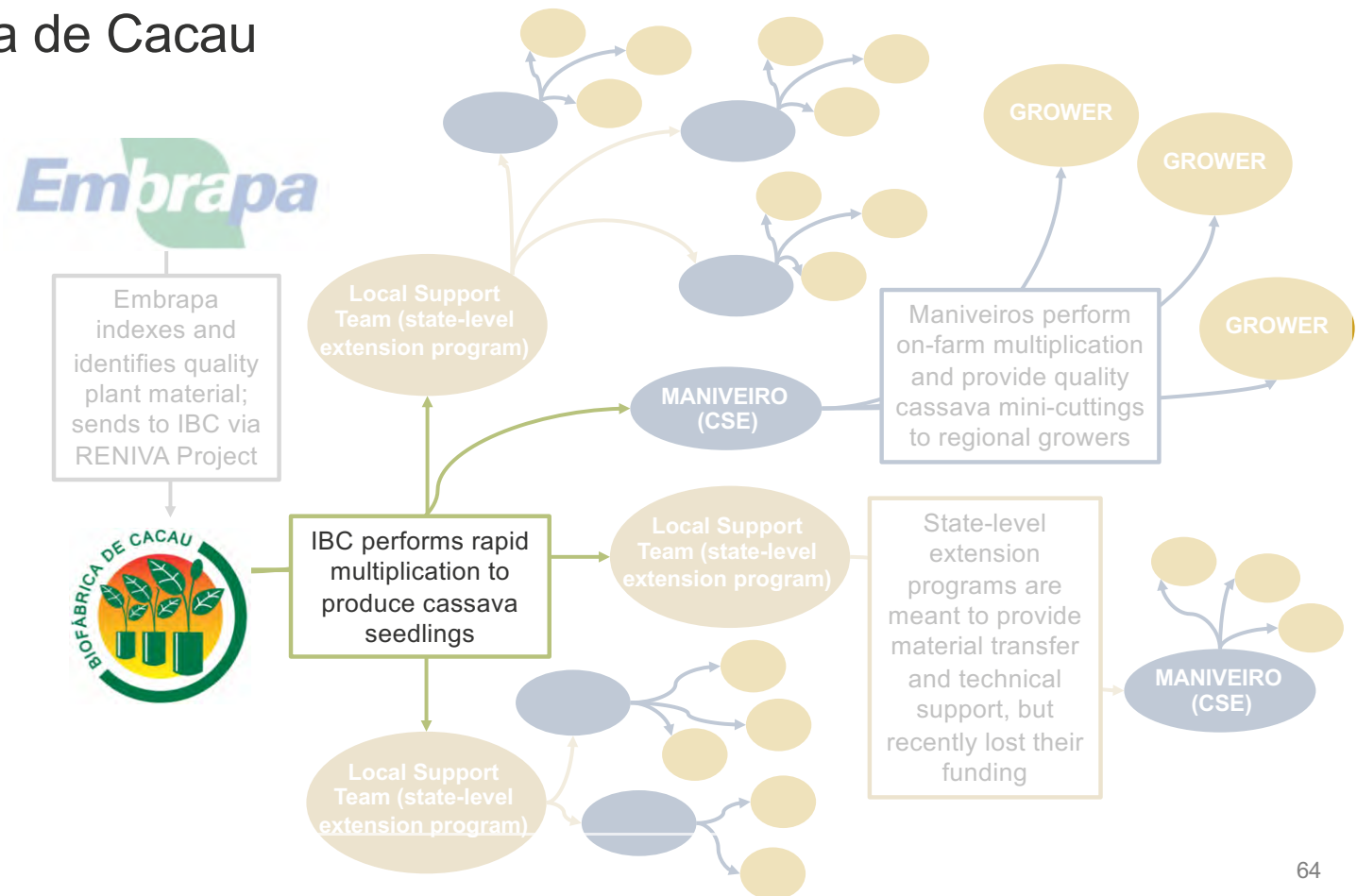
RENIVA Project Schematic



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Instituto Biofabrica de Cacau (IBC)



Deep Dive on IBC's Lab and Greenhouse Cassava Seed Propagation System

SUBCULTURE MULTIPLCIATION

Effective Multiplication Rate of 1:9 over 4-Months

To begin, water is sourced from the river and is sterilized through reverse osmosis. The media is prepared and in a transfer room. The cassava cuttings go into the media.

Phase I: Establishment 35-45 days

Phase one cuttings are developed using artificial light in glass jars

One jar produces three cuttings

Phase II: Multiplication 35-45 days

Propagation of phase two material is accomplished through artificial light in glass jars

Same multiplication rate as phase one: each jar produces three cuttings

Phase III: Rooting 40 days

Seedlings from phase two are transferred to larger jars with 15 seedlings per jar

Root formation (Enraizamento) is supported through a combination of artificial and natural light over 40 days

Phase IV: Acclimatization 60 days

Seedlings from are transferred directly into tubes and moved into greenhouses for 60 days for acclimatization

GREENHOUSE MULTIPLICATION STEP

Effective Multiplication Rate of 1:60,000 over 9-Months

Stems are cut with one bud remaining

First cut is in the first 30 days in the greenhouse

Second cut is in the next 30 days in the greenhouse

It takes each plant 4-5 days to establish roots

Total propagation process takes 8-9 months on average, with a single test tube multiplied out to 60,000 seedlings in one year

TRANSFER TO CUSTOMERS

Plants are sold to state government and to Maniveiros within 45-60 days in 50-plant pots

CSEs or local governments can also come pick up cassava plantlets from the greenhouse

The greenhouse's demand planning is accomplished through grower pre-orders and EMPRAPA recommendations on varietal and volume demand

The Instituto Biofabrica de Cacau is seeking strategic partners to provide technical assistance and build relationship which will provide better understanding of demands

IBC Markets and Sells Cassava Seed of Numerous Varieties

IBC cassava
variety
marketing and
price sheet by
variety

**PRONTAS PARA PLANTIO.
QUALIDADE E MELHOR PREÇO.**

CACAU

Origem Clonal

 Tubetes de 288 cm³ **R\$1,70** •
Tubetes de 56 cm³ **R\$1,20** •

Cultivares: CCN 10, CCN 53, CEPEC 2002, CEPEC 2007, CP 49, CEPEC 2005, IPIRANGA 01, PH 16, PS1319, SJ 02, PH 09

Origem Seminal


 Tubetes de 288 cm³ **R\$1,50** •

Cultivares: CEPEC 2002, C. COMUM, TSH 1188

 **HASTES PARA ENXERTIA**
70 cm **R\$1,00** •

ESSÊNCIAS FLORESTAIS

Origem Seminal

 **Angico Branco**
Tubetes de 288 cm³ **R\$1,40** •

 **Aroeira Vermelha**
Tubetes de 288 cm³ **R\$1,40** •

 **Cedro Rosa**
Tubetes de 288 cm³ **R\$1,40** •

 **Jenipapo**
Tubetes de 288 cm³ **R\$1,40** •

 **Ipê Amarelo**
Tubetes de 288 cm³ **R\$1,40** •

 **Leucena**
Tubetes de 288 cm³ **R\$1,40** •

 **Mogno Africano**
Tubetes de 288 cm³ **R\$5,00** •

 **Mutamba**
Tubetes de 288 cm³ **R\$1,40** •

 **Olho de Pavão**
Tubetes de 288 cm³ **R\$1,40** •

 **Pau-brasil**
Tubetes de 288 cm³ **R\$1,40** •

 **Pau-cigarra**
Tubetes de 288 cm³ **R\$1,40** •

 **Pau d'Arco**
Tubetes de 288 cm³ **R\$1,40** •

 **Quaresmeira**
Tubetes de 288 cm³ **R\$1,40** •

 **Urucum**
Tubetes de 288 cm³ **R\$1,40** •

FRUTEIRAS

Origem Clonal

 **Abacaxi Vitória**
Tubetes de 288 cm³ **R\$1,40** •
(Micropropagação)

 **Banana Willians, Prata e Terra Maranhão**
Tubetes de 180 cm³ **R\$2,00** •
(Micropropagação)

 **Goiaba Paluma**
Tubetes de 288 cm³ **R\$1,40** •

Origem Seminal

 **Açai**
Tubetes de 288 cm³ **R\$1,40** •

 **Cajá**
Tubetes de 288 cm³ **R\$1,40** •

 **Cupuaçu**
Tubetes de 288 cm³ **R\$1,40** •

 **Graviola Morada**
Tubetes de 288 cm³ **R\$1,40** •

MANDIOCA

Origem Clonal (Micropropagação)


 Tubetes de 180 cm³ **R\$1,70** •

Cultivares: Amansa Burro, BRS Caipira, BRS Formosa, BRS Gema de Ovo, BRS Jari, BRS Kiriri, BRS Mari Branca, BRS Mulatinha, BRS Prata, BRS Tapiocqueira, BRS Verdinha, Corrente, Cravelinha, Lagoão, Olho Roxo, Platina, Todo Tempo, Vassourinha.

ORNAMENTAIS

Origem Clonal (Micropropagação)

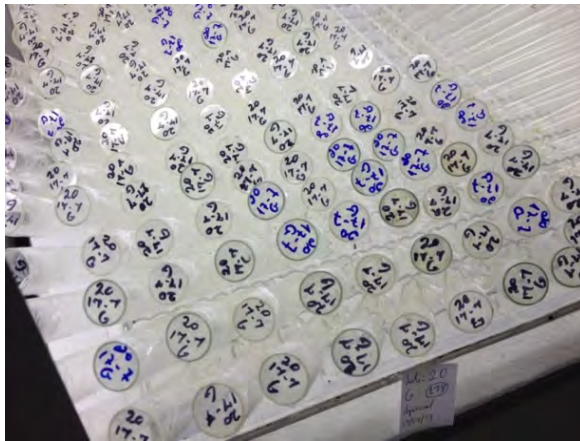
 **Orquídea Denphal Branca ou Roxa**
Vaso de Sapucaieira **R\$30,00** •



KIT SAF - MONTE SEU KIT DE MUDAS
Inovação Biofábrica

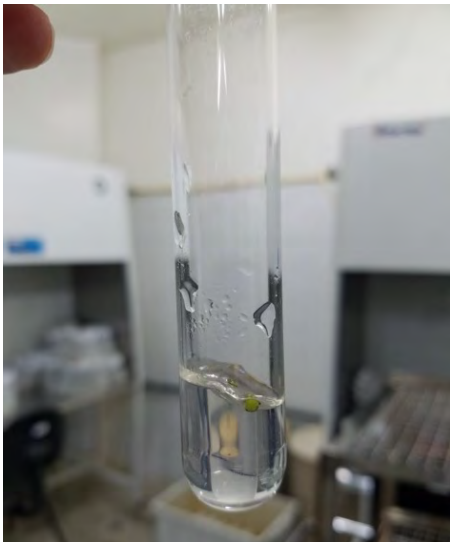
Cassava Multiplication Technology at IBC

IN-VITRO MULTIPLCIATION STEP



Cassava Multiplication Technology at IBC

IN-VITRO MULTIPLCIATION STEP



Phase I – Establishment or Initiation



Phase II – Multiplication



Phase III – Rooting

Greenhouse Multiplication Step at IBC

IBC has 20 such greenhouses, which cost \$80,000 each to construct. Each greenhouse contains 220,000 planting tubes per greenhouse.

Natural light and sprinkler (fogger) type irrigation system is used.

Internal greenhouse temperature remains fairly constant at around 28 degrees Celsius.

GREENHOUSE MULTIPLICATION STEP



Cassava Multiplication Technology at IBC

GREENHOUSE MULTIPLICATION STEP



Greenhouse Multiplication Step at IBC

GREENHOUSE MULTIPLICATION STEP



Root Establishment of Multiplied Basic Seed



semente de mandioca a partir de mudas micropropagadas.

50-Plant Pot for Distribution to CSEs and Government Buyers

Instituto Biofábrica de Cacau (IBC)'s Production Stages in Pictures

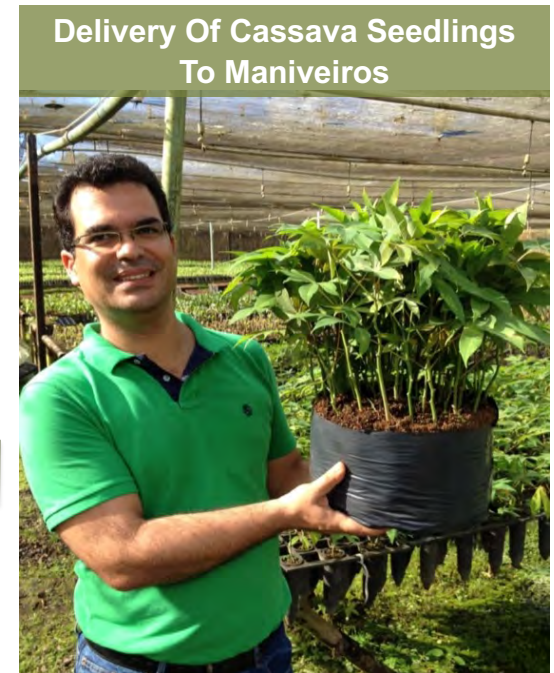
Tissue Culture Multiplication



Rooted Cassava Seedlings



Delivery Of Cassava Seedlings To Maniveiros

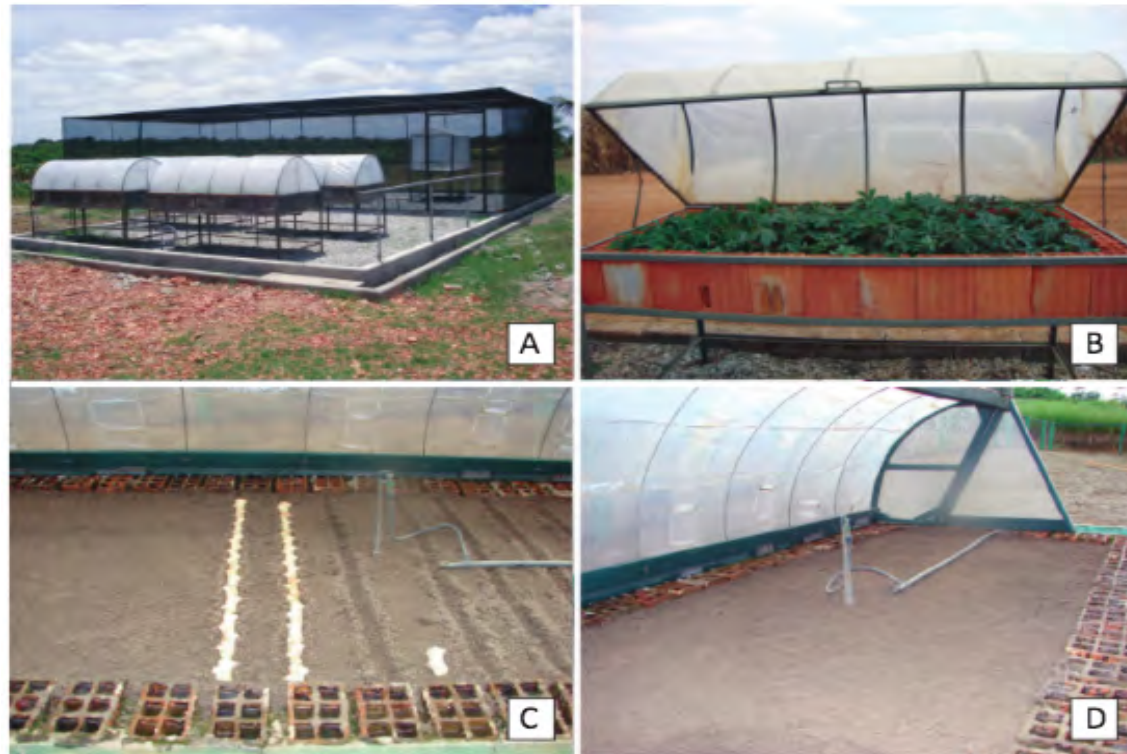


Photoautotrophic Tissue Culture



Rapid Multiplication Technology

To aid in seedling multiplication efforts, the RENIVA project has innovated on a technology developed by CIAT in the 1980s.



(A) For the production of cassava seedlings. (Photo: Nicolau Schaun)
(B, C, and D) Multiplication chambers with irrigation for the initial planting of cassava
(Photos: José Raimundo Ferreira Filho)

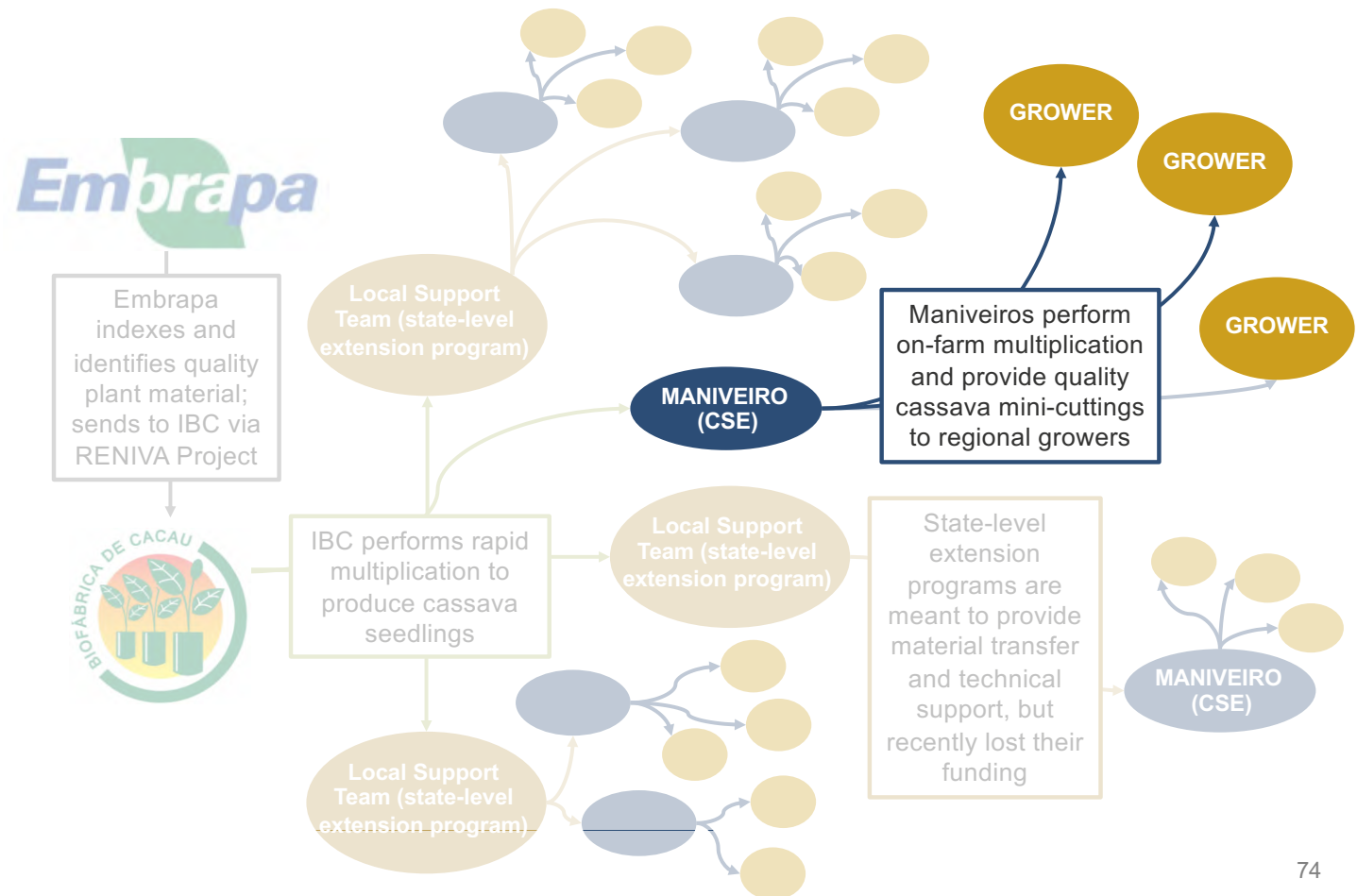
RENIVA Project Schematic



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Maniveiros



Maniveiros are Segmented into Two Categories Based on Their Area Under Seed Production

Type I

- Large Area (>10 ha)
- Maintainer of genotypes
- Tests for viruses
- Trains other CSEs
- Assisted by Extension Service
- Certified
- Produces cuttings and seedlings from Embrapa and Landraces

Type II

- Smaller Area (<10 ha)
- Trained by Type I CSEs
- Produces cuttings and seedlings from Type I genetics
- Assisted by extension service

Type I Maniveiro Profile: Benedito Dutra

Farm Leadership: Benedito Dutra



- Age 52, Comes from a smallholder farm family
- Agronomist by training with a specialization in environmental management
- Worked with Embrapa on the seed project for the last 12 years

Farm Management & Operations



- Located in Tracuateua, PA
- 6 employees, including 2 brothers of Dutra
- Total area = 370 hectares; Cassava area = 60 hectares (remaining area is used to grow cowpea)
- High level of mechanization throughout the season

The Vision of Dutra Farms

Another 20 years working with the RENIVA project, growing to 300 hectares of seed production with the possibility to feed 750M people

Continue to develop strategic partnerships with Type I Maniveiros, totaling a 500-1000 hectares of seed production

Younger brother of Dutra take over the farm when he retires in 10 years

Dutra's Business Model Relies on Free Material from Embrapa and On-Farm Demand Generation

Embrapa provides the planting material for free



Dutra generates stem demand and trains other Maniveiros through demonstration days



Dutra harvests and sells both stems (3 times per plant) and roots (on the 3rd time)



- Embrapa and Dutra have a **well-established relationship**;
- New quality varieties are **given** to Dutra (He started with 20 cuttings from Embrapa and has now produced 60 million cuttings)
- Dutra has the **technical knowledge** to grow and **multiply** quality material on his operations (uses positive selection within the improved varieties)
- Propagation rate is **1:15**, sometimes up to **1:20**

- Dutra reserves 4 days per month for events open to visitors, including growers, government institutions, etc. where he **shares the operations of his farm**
- He pays for lunch and each guest is **given 20 free cassava cuttings**
- Through this community engagement, Dutra gets a sense of **which varieties are in highest demand** and **optimizes his planting density/multiplication rate** to reflect demand

- Dutra **sells cuttings** for ~R\$1 per stem; **Embrapa does not receive a royalty** on planting material that Dutra sells, but it is under consideration
- Clients include: **government (most common), large and small producers, grower associations and other Maniveiros**
- Dutra assumes that customers who purchase disease-resistance varieties will want to buy new material every **4-5 years**, but he does not assume repeat purchases
- **Dutra earns >5x more on stem sales than root sales**

Operational Overview of Dutra's Business



BUSINESS MODEL

- Dutra makes 5x more on stems than roots. Earns 5 to 20 times more on all cuttings (3 per plant) than on roots
- Embrapa variety is the most popular. Dutra has a sense of demand and has room to make mistakes because the multiplication rate is so fast



SALES RELATIONSHIP W/ GROWERS

- Dutra started with 20 cuttings, and has produced an estimated 60 million cuttings. He uses 10% of his best plants for cloning even among the improved varieties, and he encourages his customers to do the same (anyone who visits receives 20 free cuttings)
- Customers buy up to 2 varieties, and may come back to refresh their seed stock after 5 years, but Dutra does not assume that customers will re-purchase mini-cuttings from him
- The average smallholder grower purchases 500 cuttings, and are able to multiply them to 1 acre within 3 years



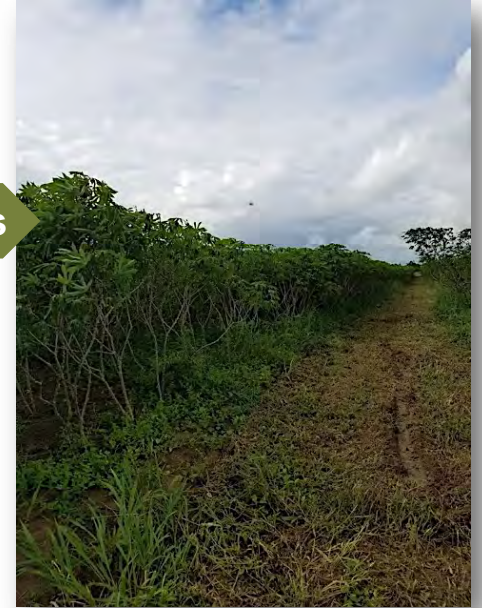
SALES RELATIONSHIP W/ GOVERNMENT

- Dutra has two sales channels: state government and direct to producers. Under the former, the state government buys stems from him and then they distribute to ~1,000 producers annually. Dutra sells direct to just 20 growers annually, but he forecasts that his direct business will expand exponentially in the coming years due to grower demand

Dutra's Stem & Root Production

Agro-ecological Conditions

- In this region, there are 7-8 months of rain (Jan-Aug = 2500mm)
- Soil is sandy; topography is 3-5% which allows for better drainage and less risk of root rot.



Varietal Selection

- 12 cultivars total
 - 4-5 indexed cultivars provided by Embrapa
 - 8 landrace varieties that were identified by Dutra independently (some landraces have natural resistance to root rot and/or high starch content (>30%))
 - Dutra has the capacity to sample plants of landraces, to be virus tested as a result of training provided by Embrapa.

Dutra's Stem & Root Production

Planting / Production

- Completely mechanized
- 20,000-30,000 plants/ha for long non-branching. 10,000 plants/ha for branching
- 250 kilos fertilizer per ha



Propagation / Harvest



STEMS

- Usually 3 stem cuttings per season (every 6 months) with increasing number of stems with each cutting
- Harvest is manual at ~4 ha per day; positive selection on the top 10% of plants
- 60-80% survival if planted within 10 days



ROOTS

- Yield 20-30 tons per ha
- Harvests every ~18 months (little/no threat of root rot or insect pests)
- Completely mechanized

Dutra Responds to Cultural Resistance By Recommending Gradual Incorporation Of Quality Material

DUTRA CURRENTLY SELLS
DIRECT TO ~20 GROWERS



The majority of Dutra's sales are to the **state government**, which then distributes planting material to growers; however, his direct grower sales are growing rapidly



According to Dutra, the main challenge of this business is the **cultural adversity to changing and/or buying material**, especially since cassava has been grown in Brazil for generations with little change in practices



DUTRA'S
RECOMMENDATION TO
GROWERS:

Replace 5-10% of area to plant improved material; this typically implies about 500 cuttings

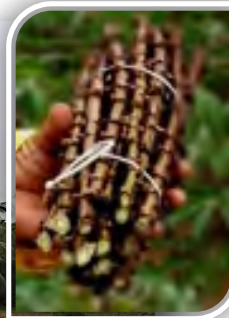
Allow plant to grow for ~16 months
total for 1:30 multiplication rate

Harvest stems at
~9 months

Harvest stems +
roots at ~7 months

In 3 years, the entire area is
covered with improved material

The Mini-Cutting Plot Is The Newest Experimentation Between IBC And Dutra



Mini cuttings are 1/10 the weight of traditional cuttings and can produce up to 1:50 multiplication rate per year

Planted in very high density (40,000-100,000 plants/ha) because they are not intended for root production

Only part of his operation that is not mechanized

Mini cutting plot is 4 months old; not yet being used at scale








Dutra (center) describing his mini-cutting technique to Herminio Souza Rocha (left) and Helton Fleck de Silveira (right) of the RENIVA Project

Photo Credit: Dr. James Legg



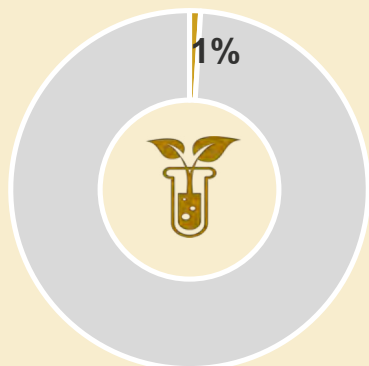
Financial Sustainability

Financial Sustainability

FINANCIAL SUSTAINABILITY		Public Sector Varietal Development	Embrapa relies on federal funding to establish and maintain gene banks, characterize and evaluate varieties, assess disease resistance, analyze genetic diversity, cross-breed, and select the best varieties for release through the RENIVA Project. Since the program began, 54 varieties of cassava seed have been released by Embrapa.
		Non-Profit Organization Providing Multiplication Research And Scalability	Instituto Biofábrica de Cacau (IBC) is largely funded by the Bahia state government and manages the multiplication research in their facilities. IBC works closely with other state governments and largely pursues an approach to deployment whereby the government buys materials and distributes to growers at no cost. In less frequent cases, IBC supplies the stems to maniveiro entrepreneurs at little to no cost.
		Select Growers Are Willing To Pay For Higher Quality Planting Material	Demand for improved seed is being demonstrated at the farm level through the largest and most advanced maniveiro entrepreneur in Pará. While the majority of cassava growers still source their materials at no cost, there is consistent willingness to incorporate improved materials on portions of their field on the basis that disease accumulates in fields and there is benefit in replenishing with clean planting material.
		Maniveiros Achieve Profitability While Providing Clean Planting Material To Growers	Maniveiros received start-up support from Embrapa. Through serving and generating demand through local grower customers, some Maniveiros are able to make a profitable, sustainable businesses from stem multiplication – both of Embrapa varieties and landraces. Successful Maniveiros recognize that their customers will likely want to replenish their plant material every ~4-6 years on at least a portion of their land (usually ~20%) and estimate demand by variety more on intuition than actual orders.
		Private Sector Engagement In Promoting Improved Seeds And Best Agricultural Practices	Private starch players have played a role in receiving Embrapa cassava varieties and multiplying them within their production systems (both company-owned farm production and outgrowers within their catchment area). Additionally, private biofactories are involved in evaluating improved cassava varieties being tested prior to multiplication through the RENIVA system and working with equipment providers to demonstrate benefits of mechanized field activities.

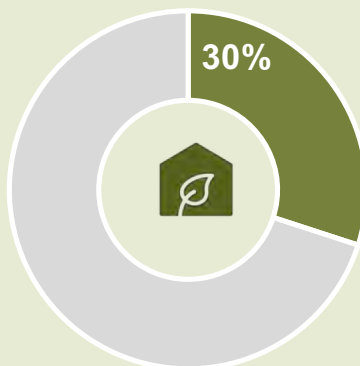
Financial Sustainability by EGS Value-Chain Step

Varietal Development & Breeder Seed Management



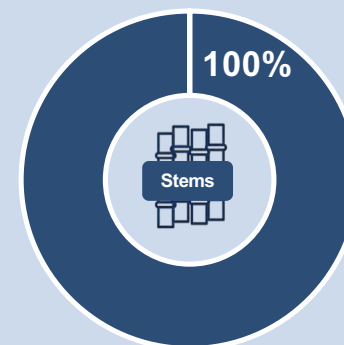
Public Sector Funds Varietal Development

Basic Seed Production



Public Sector Subsidizes 70% of Basic Seed Production Costs, and Sells Production to State Governments, Biofactories, and CSEs

Quality Declared Seed?






Maniveiros Fund their Operating Costs Through Mini-Stem Sales



Enabling Environment

Enabling Environment

ENABLING ENVIRONMENT		Partnership With Instituto Biofabrica de Cacau (IBC)	Embrapa established a partnership with IBC (a non-profit entity) early on in the RENIVA Project to provide early generation seed multiplication to supply the country of Brazil. This partnership has enabled the RENIVA Project to achieve its objectives of supplying Cassava Seed Entrepreneurs (or Maniveiros) with basic seed of improved varieties from Embrapa.
		Start Up Of Entrepreneurial Maniveiros Was De-risked By The Government	Maniveiros receive starter breeder material from Embrapa free of charge and the Brazilian government has subsidized the infrastructure cost associated with the establishment of decentralized multiplication systems (incl. nursery establishment and irrigation costs). State-level extension services were expected to support growers by facilitating the transfer of varieties and knowledge from Embrapa/IBC to Maniveiros, but due to funding shortfalls, extension services have been severely diminished. In their absence, Maniveiros continue to order basic seed directly from IBC and Embrapa provides as-needed assistance with coordination and training.
		Embrapa Varieties Are Increasingly Preferred By Growers	While exact data of the penetration of cassava varieties is unavailable, there is evidence of increased grower acceptance through the work that Maniveiros are doing on the ground. After all, it is grower demand that enables Maniveiros to construct a business case around stem production. The MandiPlus Project, which is also managed by Embrapa, is helping to break the mentality that cassava planting material has no intrinsic value. And marketing initiatives are being implemented to demonstrate to growers that when planting virus free cuttings, yields may increase between 30 and 40%.
		Government is the Largest Purchaser of Cassava Seed	State governments are the largest buyers of basic seed from IBC and of stems from Maniveiros. State governments treat clean planting material as a public good, and purchase and distribute stems to smallholder growers.
		Embrapa Personnel Have Significant Experience In Certification	Draft legislation has been proposed by Embrapa to standardize the seed standards for cassava seedlings (plantlets produced either by tissue culture or by rapid multiplication, to support Maniveiros). In the interim, there are no quality control standards or certification processes in place to evaluate the genetic purity of the cassava stems being planted.

A Formal Cassava Seed System Does Not Presently Exist in Brazil



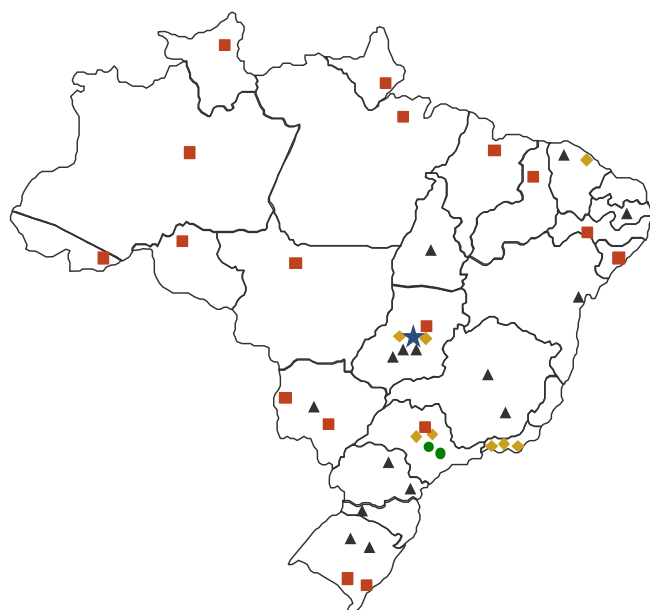
No formal seed system exists for cassava in Brazil, however, draft legislation has been developed and proposed by Embrapa to standardize the crop's seed standards for cassava seedlings (plantlets produced either by tissue culture or by rapid multiplication, to support CSEs). In the interim, there are no quality control standards or certification processes in place to evaluate the genetic purity of the cassava stems being planted. Below is a translated excerpt from Embrapa, which describes the necessity of this effort:



One of the objectives is that this will take effect under future legislation for the production of cassava propagation materials at the federal level, through a specific standardization of the Ministry of Livestock and Food Supply. This will enable the Cassava Seed Entrepreneurs (CSE) to establish themselves in the certified cassava seed production business, contributing to the sustainability of the Brazilian crop and providing an improvement in the quality due to the thousands of families who base their nutritional and financial sustenance in this important culture.

Brazilian Agricultural Research System Overview

42 Embrapa Centers



70 Agricultural Universities





17 State Research Networks



Private Sector: Brazil has also an active and growing private sector, which supplies technologies and technical assistance mainly in farm inputs and food processing

SOURCE: Presentation at the Cassava Value Chains Workshop, CIAT, Cali, Colombia (Published on Sept 15, 2016)

Research System Actors

ACTOR	FUNCTION
<p>OEPAS</p>  <p>State Agencies of Agricultural Research</p>	<p>The role of the OEPAS is to meet state agricultural demands, whose solutions depend on technological research, developed by R&D&I centers such as Embrapa and other federal institutions</p>
<p>Consepa</p>  <p>The National Council of State Agencies for Agricultural Research</p>	<p>Civil non-profit association, under private law. The Council is made up of the State Agencies of Agricultural Research (Oepas) and is in charge of:</p> <ol style="list-style-type: none"> 1) Institutional strengthening of the Oepas 2) Identify the problems and offer recommendations so that these organizations can fully correspond to their role as promoters of the Brazilian agriculture through the research activities

thank you



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ACKNOWLEDGEMENTS

Thank you for your time and support in the development of the EMBRAPA EGS Profile!

Stakeholders Consulted

Name	Position	Organization
Lanns Alves de Almeida Filho	General Director	Instituto Biofabrica de Cacau in Brazil
Herminio Souza Rocha	Supervisor, Technology Transfer Office and RENIVA Project Leader	EMBRAPA / RENIVA Project Leader
Aldo Vilar Trindade	Assistant Director, Technology Transfer Office	EMBRAPA
Alfredo Alves	Plant Physiologist and International Affairs Team Leader	EMBRAPA
Helton Fleck de Silveira	RENIVA Project Leader	EMBRAPA
Eder Jorge de Oliveira	Breeder/Researcher, MandiPlus Project Lead	EMBRAPA
Saulo Alves Oliveira	Plant Pathologist/Researcher, MandiPlus Project	EMBRAPA
Dr. Carlos Estevão	Research Center Head	National Center For Cassava and Tropical Fruit Research Center (at Cruz das Almas)

Definitions

Breeder seed: Breeder seed is produced by or under the direction of the plant breeder who selected the variety. During breeder seed production, the breeder or an official representative of the breeder selects individual plants to harvest, based on the phenotype of the plants. Breeder seed is produced under the highest level of genetic control to ensure the seed is genetically pure and accurately represents the variety characteristics identified by the breeder during variety selection.

Basic seed (or Foundation seed): Basic seed is the descendent of breeder or pre-basic seed and is produced under conditions that ensure maintaining genetic purity and identity. When foundation seed is produced by an individual or organization other than the plant breeder, there must be a detailed and accurate description of the variety the foundation seed producer can use as a guide for eliminating impurities ("off types") during production.

Early generation seed: There is no scholarly definition of EGS which has attracted widespread usage in the literature. What the definitions in use share in common is a focus on breeder seed and basic seed but almost always in a context that is much wider and more complex than the mention of these two steps would imply.

Formal seed system: The formal seed system is a deliberately constructed system that involves a chain of activities leading to genetically improved products: certified seed of verified varieties. The chain starts with plant breeding or variety development program that includes a formal release and maintenance system. Guiding principles in the formal system are to maintain varietal identity and purity and to produce seed of optimal physical, physiological, and sanitary quality. Certified seed marketing and distribution take place through a limited number of officially recognized seed outlets, usually for financial sale. The central premise of the formal system is that there is a clear distinction between "seed" and "grain." This distinction is less clear in the informal system.

Informal seed system: The informal system also referred to as a local seed system, is based on farmer-saved seed or QDS. Varieties in the informal system may be variants of improved varieties originally sourced from the formal system, or they may be landrace varieties developed over time through farmer selection. There is less emphasis on variety identity, genetic purity, or quality seed. The same general steps or processes take place in the local system as in the formal sector (variety choice, variety testing, introduction, seed multiplication, selection, dissemination, and storage), but they take place as integral parts of farmers' production systems rather than as discrete activities. While some farmers treat "seed" as special, there is not always necessarily a distinction between "seed" and "grain." The steps do not flow in a linear sequence and are not always monitored or controlled by government policies and regulations. Rather, they are guided by local technical knowledge and standards and by local social structures and norms.

Improved versus landrace/local varieties: Improved varieties are the product of formal breeding programs that have gone through testing and a formal release process. A landrace is a local variety of a domesticated plant species which has developed over time largely through adaptation to the natural and cultural environment in which it is found. It differs from an improved variety which has been selectively bred to conform to a particular standard of characteristics.

RENIVA Project: RENIVA¹, which translates from Portuguese as a *Cassava network for multiplication and transference of high quality planting material*, is a project designed to increase the availability and accessibility of improved seed varieties by serving as an intermediary between new varieties and the market.

MandiPlus Project: Project funded by the Syngenta Foundation and the Bill & Melinda Gates Foundation for the purpose of developing an optimized cassava stake production system

Maniveiros or Cassava Seed Entrepreneurs (CSEs): technical growers selected by Embrapa and state-level extension services who propagate 'basic' stems of virus-free Embrapa and landrace varieties received directly from Instituto Biofábrica de Cacau and/or from their state extension. CSEs sell propagated stems to local growers for cassava root cultivation.

(1) In Portuguese, 'maniva' is a cassava cutting and 'rede' is network. The name RENIVA is a blend of the two.

Cassava Production Methods in Brazil

SINGLE ROWS MONO AND INTERCROPPED



DOUBLE ROWS – MONO AND INTERCROPPED



Cassava Production Methods in Brazil – Planting

SMALL SCALE PRODUCTION SUBSISTENCE FARMING



LARGE SCALE PRODUCTION INDUSTRY



Land Preparation



Planting



Herbicide Treatment

Cassava Production Methods in Brazil – Harvesting

LARGE SCALE PRODUCTION INDUSTRY



Cassava Production Methods in Brazil – Processing

LARGE SCALE PRODUCTION STARCH INDUSTRY



Main Cassava Constraints in Brazil

BIOTIC STRESSES

PESTS

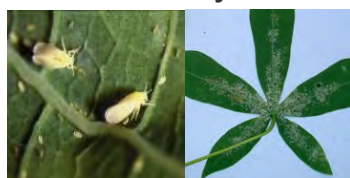
Cassava Green Mites (CGM)



Hornworm



Whitefly



Mealybug (MB)



Photos: A.Alves; A.Bellotti; M. Dita

DISEASES

Cassava Vein Mosaic Virus (CsCMV)



Photos: Eder Oliveira

Cassava Common Mosaic Virus



Frogskin Disease



ABIOTIC STRESSES

Drought and Poor Soils



Photo: Revista Veja



Photo: A.Alves

Postharvest Physiological Deterioration (PPD)



- PPD initiates within 24 – 48 hours after harvest
- Roots become unfit for food and market
- Price discounts and economic losses

BRS Aramaris

(starch and root rot resistance)



Root yield 29.6 t/ha DM 34%

BRS Formosa

(starch and bacteriosis resistant)



Root yield 43 t/ha

BRS Ararí

(starch and semi-arid)



Root yield 14.6 t/ha DM 38.8%



Ministry of Agriculture,
Livestock and Food Supply



BRS Mani Branca

(starch and semi-arid)



Root yield 27.6 t/ha DM 35.2%

BRS Rosada

(fresh consumption, high lycopene)



Root yield 33.8 t/ha DM 25.6%



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BRS Kiriris

(starch and root rot resistance)



Root yield 33.8 t/ha DM 30.0%

BRS Gema de Ovo

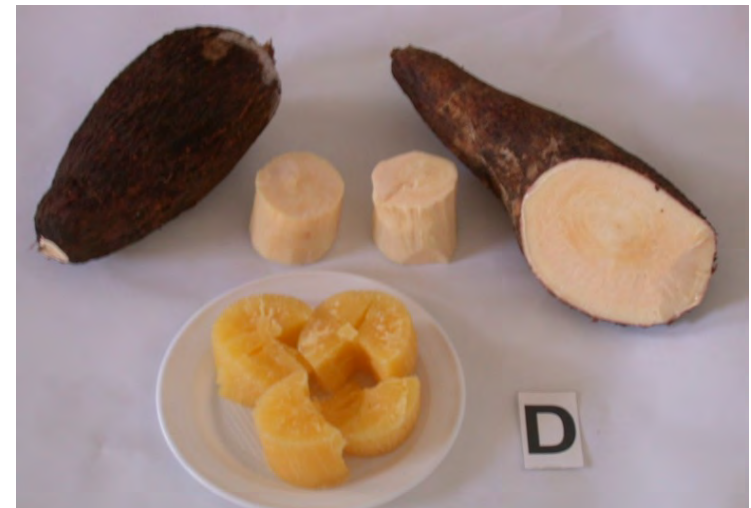
(fresh consumption, high carotene)



Root yield 28.3 t/ha DM 40.1%

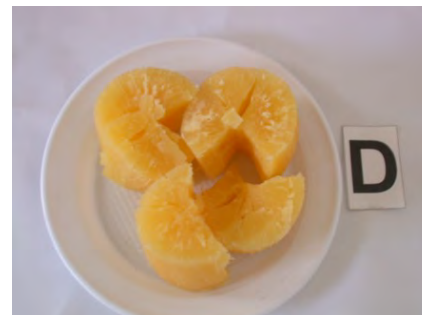
BRS Dourada

(fresh consumption and high carotene)



Root yield 33.8 t/ha DM 40.6%

Varieties BRS Rosada, BRS Dourada, BRS Gema de Ovo (rich in lycopene or carotene)



BRS Mulatinha

(starch and semi-arid)



Root yield 24.6 t/ha DM 36.5%



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BRS Prata

(starch and semi-arid)



Root yield 31.7 t/ha DM 36.3%

BRS Guaíra

(starch and semi-arid)



Root yield 31.4 t/ha DM 36%



Ministry of Agriculture,
Livestock and Food Supply



Aipim Brasil

(starch and semi-arid)



Root yield 15 t/ha DM 25%