CONTEXT | GLOBAL DEVELOPMENT

Early Generation Seed Case Studies

Brazil Banana

June 2019

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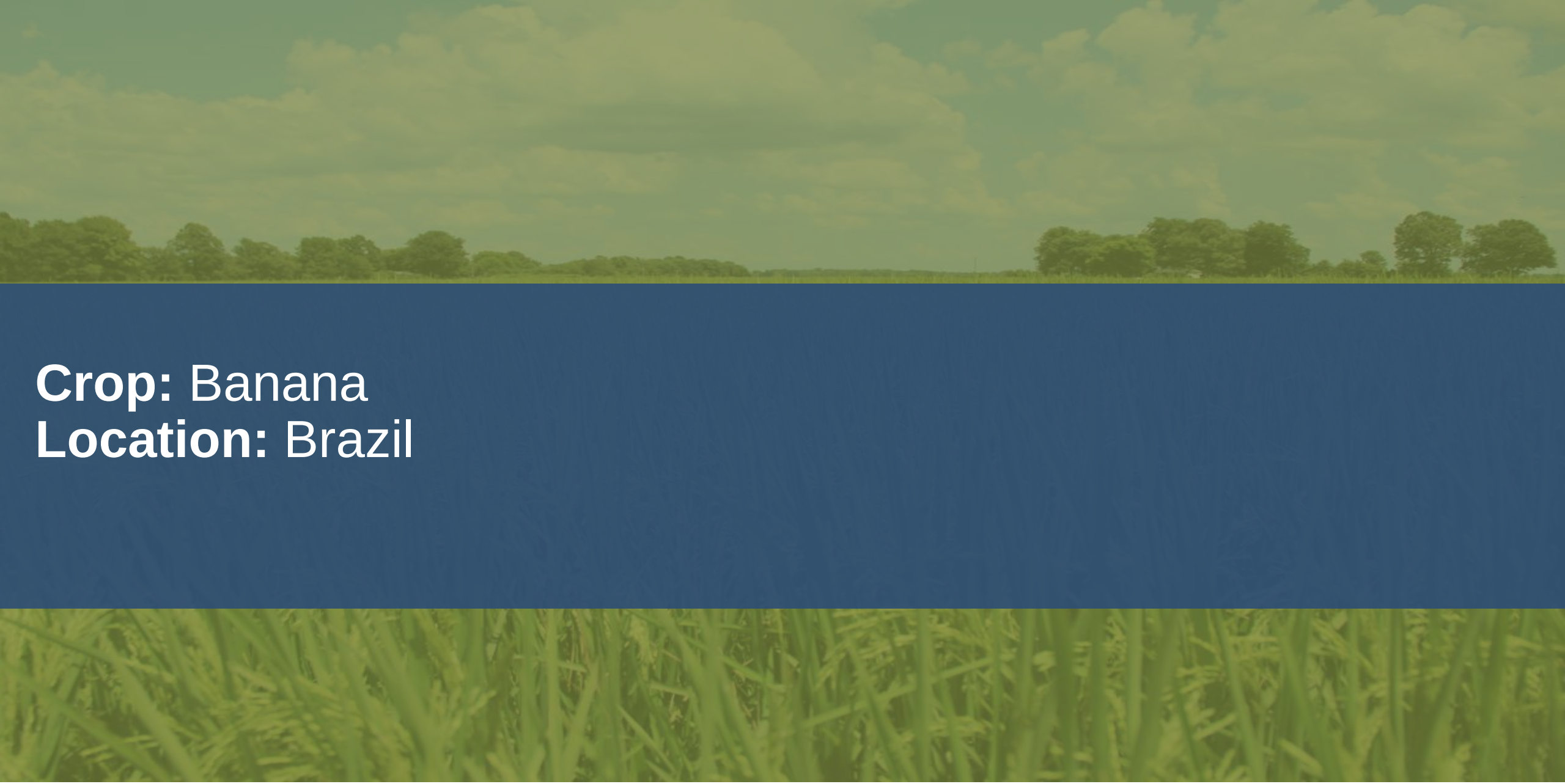
Brazil Banana Case Study

Appendix

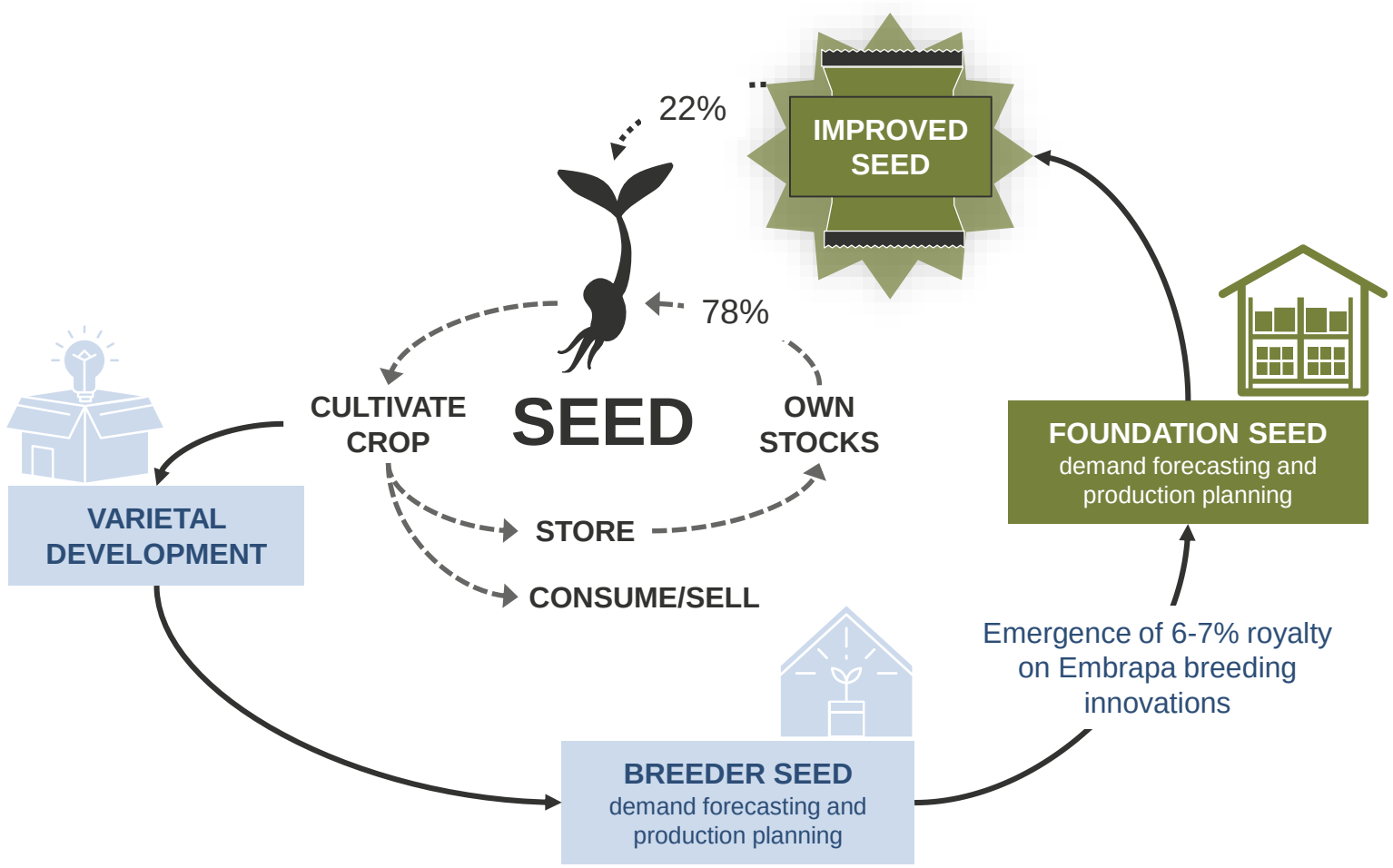
CONTEXT | GLOBAL DEVELOPMENT



Crop: Banana
Location: Brazil

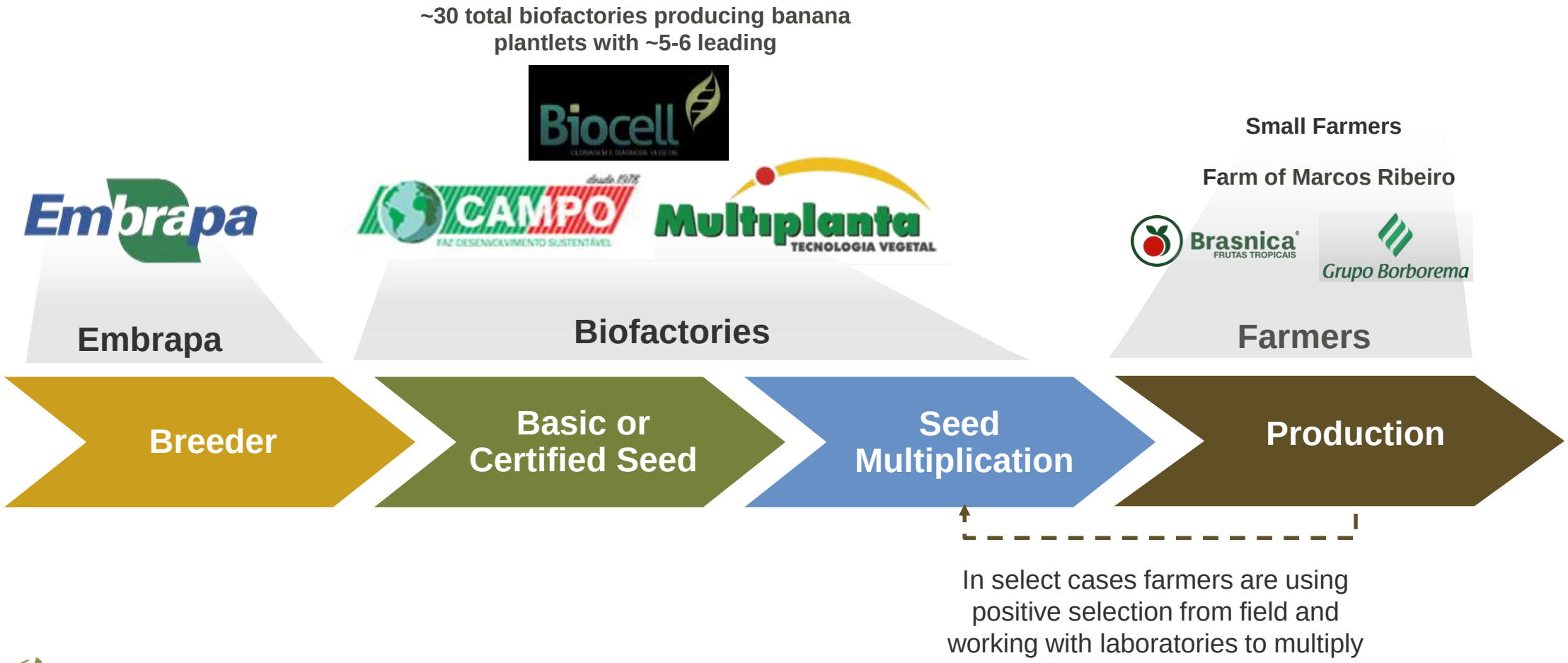
CONTEXT | GLOBAL DEVELOPMENT

Embrapa Seeds Commercial Biofactories With Breeder Seed of Publicly Released Varieties



Ex. Idaho Potatoes

Biofactories Scaled Slowly and Steadily as Operational Issues Were Better Understood and Addressed



CONTEXT | GLOBAL DEVELOPMENT

Organizational Value Chain Leadership Summary

ORGANIZATION	Brazilian Agricultural Research Corporation	Brazilian Regional Seedling Distributors	Federal Ministry of Agriculture and Livestock	Farmer Associations	State Government Organizations
	Embrapa	Campo/ Biocell / Multiplanta / others	MAPA	Abanorte, Asbanco, Abavar, Frutas Oeste Bahia	IDAM *(Instituto de Desenvolvimento Agropecuario e Florestal Sustentavel do Estado do Amazonas)*
VALUE CHAIN ROLE	– Varietal Development (Brazilian Banana Breeding program) – Maintain Germplasm Active Bank – Support MAPA legislation processes	– Certified clean seedling sales and distribution	– Develop legislation of micropropegated seed systems – Perform regular quality audits at biofactories	– Support farmers commercially (guaranteed price for banana fruits) – In some cases, facilitate the purchase of TC plantlets through pooled orders to biofactories	– Pool orders for small farmers in the north of Brazil
MAJOR FUNDING SOURCES	– Government funding – Sponsored research – Grants – PPPs	– Funded through seedling sales – Privately owned	– Government funding	– Share of farmer member's production revenues; farmer member fees	– Government funding
FINANCIAL SUSTAINABILITY	– Subsidized by public – Receive 6% royalties for registered banana hybrids	– Self-sustaining through revenues of seedling sales	– Subsidized by public	– Funded by farmer membership and production revenues	– Subsidized by public

KEY SUCCESS FACTORS

Summary of EGS System Success Factors

FINANCIAL SUSTAINABILITY

- Large, capitalized farmers and irrigation projects enabled initial and continued demand for quality tissue culture (TC) materials at reasonable price
- Cost reduction strategies supported by data-driven management practices at biofactories ensure a acceptable price for both large and small farmers
- Industry norm in place to share risk of plantlet production through structured contracts with sufficient lead time and staggered payments
- Proactive overproduction and over-fulfillment of farmer orders mitigate the anticipated risks of loss due to mutation or contamination
- Emergence of 6-7% royalty on Embrapa breeding innovations

DEMAND PLANNING & OPERATIONS

- Growing domestic banana fruit market (with predictable varietal demand & market timing) has given farmers enough experience to reasonably predict demand
- Biofactories able to meet demand because of stable varietal preference and advance farmer order norms
- Best practices are understood to minimize somaclonal variation and contamination to meet both regulatory requirements and individual biofactory QC standards
- Biofactories scaled slowly and steadily as operational issues were better understood and addressed
- Operational structure of major labs is well defined, with technical staff incentivized to achieve efficiency and quality
- Large farmers paying for multiplication of positively selected materials expands market potential

ENABLING ENVIRONMENT

- Government investment in large production regions and irrigation infrastructure created opportunities for farmer to own and operate land
- National regulations have introduced minimum genetic variation and disease standards for biofactories
- Diverse buyers represent a wide customer base for biofactories and makes TC materials accessible to small farmers
- Farmer associations with both large and small farmer membership offer guaranteed market prices
- Embrapa and biofactories provide materials to support successful transfer of TC materials to farm, and a participatory breeding program is in place for evaluating upcoming varieties

KEY SUCCESS FACTORS

Financial Sustainability

Large, capitalized farmers and irrigation projects enabled initial and continued demand for quality tissue culture (TC) materials at reasonable price	Throughout the 1980s, Brazilian government invested in large-scale irrigation systems to support the development of farmland, leading to attractive growing regions for banana. Beginning in the early 1990s, large, commercial farmers supported the evolution of the banana plantlet demand and enabled biofactories to be successful through large orders of planting materials. This volume allowed labs to have viable business models against their initial costs, but also to scale and improve efficiency enough to eventually support smaller orders from smaller farmers. Today, biofactories have consistent, clear value proposition messaging for farmers about TC planting materials, and the value is generally understood (despite occasional perceived issues of quality or reliability of orders).
Cost reduction strategies supported by data-driven management practices at biofactories ensure a acceptable price for both large and small farmers	Biofactories are privately owned and operated. Successful biofactories strive to continuously optimize their plantlet production costs, which has resulted in plantlets being affordably priced for farmers. Observed cost optimization strategies include 1) development of highly trained, incentivized and retained staff; 2) detailed analysis of fixed and variable costs such as planting jars (plastic vs. glass) and LED lightbulbs; 3) selection of quality substrate, greenhouse screens, chemicals, media, etc. to minimize losses. As a result of these and other measures, TC material price has remained flat or increased slightly over time, representing only 10-20% of total farmer production costs.
Industry norm in place to share risk of plantlet production through structured contracts with sufficient lead time and staggered payments	In addition to a relatively stable demand year-over-year, an industry standard exists for contractual agreements between biofactories and farmers. Such contracts are initiated between 4 and 12 months in advance, enabling sufficient lead time for biofactories to produce the necessary plantlets. Typically farmers pay for 30-50% of order when it is placed, and the remaining payment is made after delivery of the materials in 3 or more installments. This practice shares the risk between the two parties and allows flexible financial arrangements based on farmer circumstances.
Proactive overproduction and over-fulfillment of farmer orders mitigate the anticipated risks of loss due to mutation or contamination	Biofactories proactively initiate ~20% more plantlets than what the farmer orders; by the end of the micropropagation cycle, 3-5% of additional materials are sent to farmers. Biofactories assume there will be loss within the micropropagation process as a result of contamination and mutations. They also assume that there will be minimal material that is not viable after delivery to farmers, either as a result of transportation loss or mutations that are only detectable after further plant growth, so extra materials are commonly sent.
Emergence of 6-7% royalty on Embrapa breeding innovations	The varieties developed by Embrapa are subject to a 6-7% royalty if registered; an example of this includes BRS Platina, which is multiplied by Multiplanta biofactory. The royalty fee is embedded into the farmer price and not specified as a separate surcharge. The royalties are paid back to Embrapa and support the broader organization, including the breeding program, for further varietal development. For the Embrapa varieties that are not protected, such as BRS Princesa, the plantlets are reproduced and sold without royalty obligations.

KEY SUCCESS FACTORS

Demand Planning and Operations

Growing domestic banana fruit market (with predictable varietal demand & market timing) has given farmers enough experience to reasonably predict demand	At the core, farmers and biofactories have been responding to market demand that has been steadily increasing over the past two decades. The predominantly domestic consumption of bananas (only 2% exported) represents stable preferences of varietal taste and peak market windows. Pricing is also well established by variety, with class differentiation offering a premium for higher-value properties by variety. With relatively feasible transportation by truck and plane to major banana consumption markets (populated cities), farmers can select varieties based on agronomic fit / performance in their respective regions vs. according to specific regional consumer demands.
Biofactories able to meet demand because of stable varietal preference and advance farmer order norms	Large farmers consistently replant 10-20% of their area with TC materials annually, resulting in consistent demand to biofactories. Each biofactory maintains its own clonal gardens that ensure ample supply of mother plants by variety, with consistent proportions of each demanded year over year. As farmer orders are placed at least 4 months in advance, biofactories have sufficient time to adjust their operations according to expected volumes.
Best practices are understood to minimize somaclonal variation and contamination to meet both regulatory requirements and individual biofactory QC standards	Regulatory standards require that TC materials sold to farmers are free from disease contamination and have minimal genetic variation. These standards are met through limiting multiplication cycles and growth regulators and establishing daily morphological evaluations by staff to identify contamination (media plantlets, lab & growth chambers) and mutations (larger greenhouse plants). Additionally, 0.2% of biofactory materials must be sent to virus indexing labs for testing. Customer concerns and complaints, when they occur, are managed through response channels beginning with initial office administrators and escalated to top management as needed.
Biofactories scaled slowly and steadily as operational issues were better understood and addressed	Today's largest biofactories started small and kept building slowly as organizational knowledge and capabilities grew. Managers knew that maintaining quality and customer satisfaction was critical before more volume growth could be realized. The years of experience and expertise is what large biofactories consider their key differentiator and value proposition against small, new biofactories. Nevertheless, in recent years some major farmers have turned towards smaller/newer labs due to the flexibility they represent and the perception that large operations are at risk of being too large to maintain quality.
Operational structure of major labs is well defined, with technical staff incentivized to achieve efficiency and quality	Routine daily or weekly production reviews by biofactory management determines whether order fulfilment is on-track, and roles across the organizations are well defined (laboratory and greenhouse activities separately managed and staffed). For major labs (Biocell, Multiplanta), turnover is low with some key managers having 20+ year tenures with the companies. Incentives at multiplication and rooting stages are offered to technicians on a per-plant basis.
Large farmers paying for multiplication of positively selected materials expands market potential	A few large progressive farmers are employing positive selection as a technique to have higher control over the characteristics and qualities of their banana production. This process involves selecting the favorable plants in the field and sending those materials to biofactories for multiplication via tissue culture (instead of sourcing from lab's clonal libraries). While the success of this technique is yet to be proven, it could represent a win-win in that farmers receive materials that are more ideal for their discrete production region/practices and biofactories can offer a custom, differentiated product in which they can charge a premium for multiplication services. Currently between 20-25% of replanted banana material is sourced from TC labs; this method of TC multiplication from farmers' positive selection has the potential to grow the TC sourced proportion of replanted material against conventional sucker proportion.

KEY SUCCESS FACTORS

Enabling Environment

Government investment in large production regions and irrigation infrastructure created opportunities for farmer to own and operate land	Projeto Famoso was a government-funded agricultural land development project in the 1980s originally intended for grains, but evolved into primarily banana production region. As a result of up-front government investment in the irrigation system, the land was viable for production and economic gains. Over time, the ownership shifted to private farmers with varying amounts of land who maintain the land and irrigation schemes through association fees.
National regulations have introduced minimum genetic variation and disease standards for biofactories	Disease pressure at various historic points have re-established trust in TC material and made more active government regulation a necessity within the industry. Through these regulations, all TC materials are required to be tested for diseases and meet minimum quality and genetic variation standards. Additionally, three classifications of planting materials were legally defined and provide the framework for multiplication/testing rigor and genetic origin. Given historic issues with previous disease outbreaks, there is now an industry-wide commitment to address the threat of TR4, a fungal disease that is prevalent in virtually all other major banana producing countries.
Diverse buyers represent a wide customer base for biofactories and makes TC materials accessible to small farmers	While large farmers play a critical role in the overall demand equation, they do not represent the “typical” Brazilian banana farmer (most banana producers have 15 ha or less). Biofactories offer a range of plantlet sizes and rooting options to meet the demands of farmers with varying circumstances or infrastructure, making the TC plantlet market accessible to small farmers in addition to large. Additionally, in Amazonas state, a government organization (IDAM) supports small farmers by pooling TC plantlet orders.
Farmer associations with both large and small farmer membership offer guaranteed market prices	Farmer associations provide commercial price guarantees to farmer members and play a facilitation role in regions where irrigation infrastructure or other community resources are key to production success. These associations are supported through member fees and small surcharges on banana production sold to end markets. In some select cases, associations also support the pooling of orders for TC materials, but this is not their core offering and it usually does not involve smaller farmers.
Embrapa and biofactories provide materials to support successful transfer of TC materials to farm, and a participatory breeding program is in place for evaluating upcoming varieties	Farmers are supported through easily-accessible materials from both Embrapa and biofactories regarding best agronomic practices for transferring TC materials to field environments. In some cases, biofactories visit farmers to ensure successful transfer of materials to the field and/or resolve issues related to unsuccessful planting. Select large farmers are also invited to participate in an early-stage participatory breeding program, in which they receive limited amounts of newly developed Embrapa varieties to evaluate in-field (agronomically) and in markets (taste / reception of end customers). This engagement from Embrapa makes TC materials more accessible for all farmers and ensures new varieties can be successful for both farmers and Embrapa.

PAIN POINTS

EGS Seed System Pain Points

Financial Sustainability

Farmer payments for TC planting materials are nearly always staggered in at least 2 installments to address farmer cashflow limitations

In recent years, farmer trust in TC material has decreased due to perceived or real quality issues in the genetic stability of plantlets. This dissatisfaction in TC materials has caused some farmers to return to conventional planting methods and/or positive selection on a small portion of their farms

Demand Planning & Operations

Decrease in banana demand in recent years has decreased prices and strained both farmers and biofactories

Risks of contamination of planting materials is high; leading biofactories have developed rigorous standards to prevent and test for diseases

Somaclonal variation is a prevalent challenge throughout multiplication process; biofactories customarily send an extra 3% of materials to farmers to accommodate anticipated variation, however, farmers report up to ~20% variation in materials received. By national law, biofactories are allowed to have a maximum of 2.5% of somaclonal variation.

Enabling Environment

Government regulation, verification, and quality assurance oversight are more advanced than in many systems, but in practice, regulatory resource constraints and limited genetic testing from biofactories result in farmer dissatisfaction. There is inspection carried out by Ministry of Agriculture over biofactories but not with high frequency.

Brazil Banana EGS System Timeline

Late 1970s

Bioplanta Biofabrica was formed
- Financed by cigarette company Souza Cruz
- Sophisticated labs and scientists, but unsuccessful at maintaining genetic stability
- Farmers received plantlets with up to 60% variation, felt scammed and wanted to sue but no legislation in place to be able to
- Lasting negative impact on farmer receptivity of tissue culture (TC) material
- Several former employees of Bioplanta went on to create their own labs which are now successful

1998

Black Sigatoka Fungus hit Brazil
- Fungus spread rapidly across several banana varieties, primarily located in the north of Brazil
- CAMPO Biofactory generated one million plantlets in a year's time to salvage production in that region

2010s+

Prevalence of on-farm positive selection
- Because of distrust and dissatisfaction with clonal library TC materials, some large farmers are moving back to conventional planting methods and/or practicing positive selection for TC multiplication

1970s | 1980s | 1990s | 2000s | 2010s

1990s

Re-emergence of TC banana biofactories
- Large farmer demand / infrastructure and the growing demand of bananas by the market created a new opportunity for biofactories to establish quality protocols in banana plantlet production

2000s

Brazilian legislation developed through Ministry of Agriculture and Livestock (MAPA)
- Established basic guidelines to be followed for the production, commercialization and use of planting material
- Established more quality control for banana plantlets to ensure mother plants are tested for viruses (Banana Streak Virus & Cucumber Mosaic Virus)

2019+

2019+: Risk of TR4 outbreak in Brazil may introduce new demand for resistant Embrapa varieties

CONTEXT | GLOBAL DEVELOPMENT

Market Dynamics

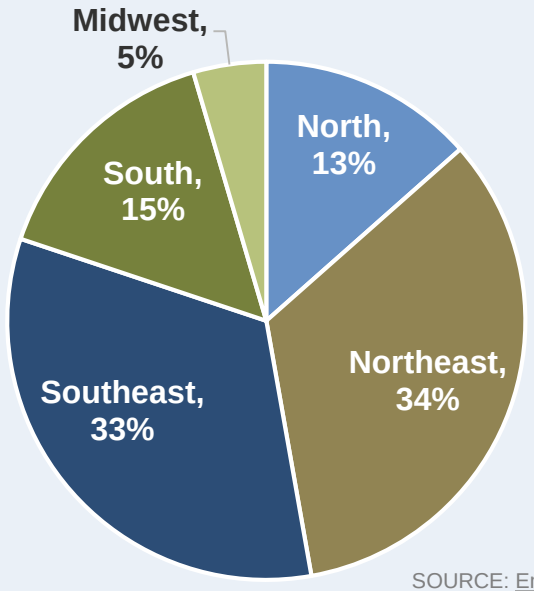
India Dominates Banana Production; Brazil Produces 6% of Global Production

Brazil Ranked 4th Globally for Banana Production in 2016

#	Country	2016 Production Total (tons)	% of Total
1	India	29,124,000	26%
2	China (incl. Taiwan)	13,324,337	12%
3	Indonesia	7,007,125	6%
4	**Brazil**	**6,764,324**	**6%**
5	Ecuador	6,529,676	6%
6	Philippines	5,829,142	5%
7	Angola	3,858,066	3%
8	Guatemala	3,775,150	3%
9	Tanzania	3,559,639	3%
10	Rwanda	3,037,962	3%
11	Costa Rica	2,409,543	2%
12	Others	28,318,900	25%
	Total	113,537,864	100%

SOURCE: FAOSTAT

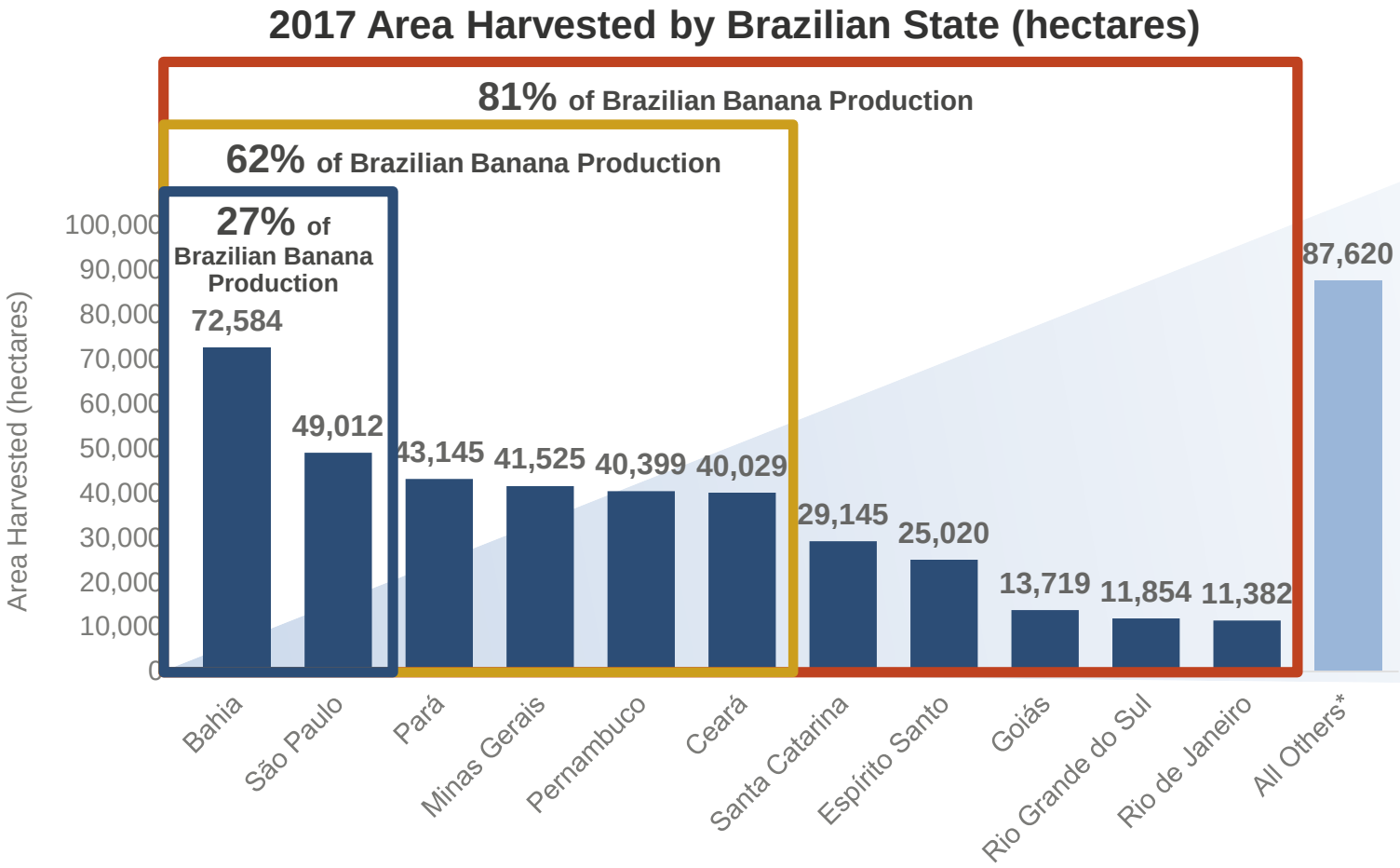
Bananas are produced throughout Brazil, but highest in Southeast and Northeast



SOURCE: Embrapa Database

CONTEXT | GLOBAL DEVELOPMENT

Top Brazilian Banana Production Regions



Total area harvested = ~475,000 ha

~300,000 ha formally produced; remainder is smallholder, backyard, informal production

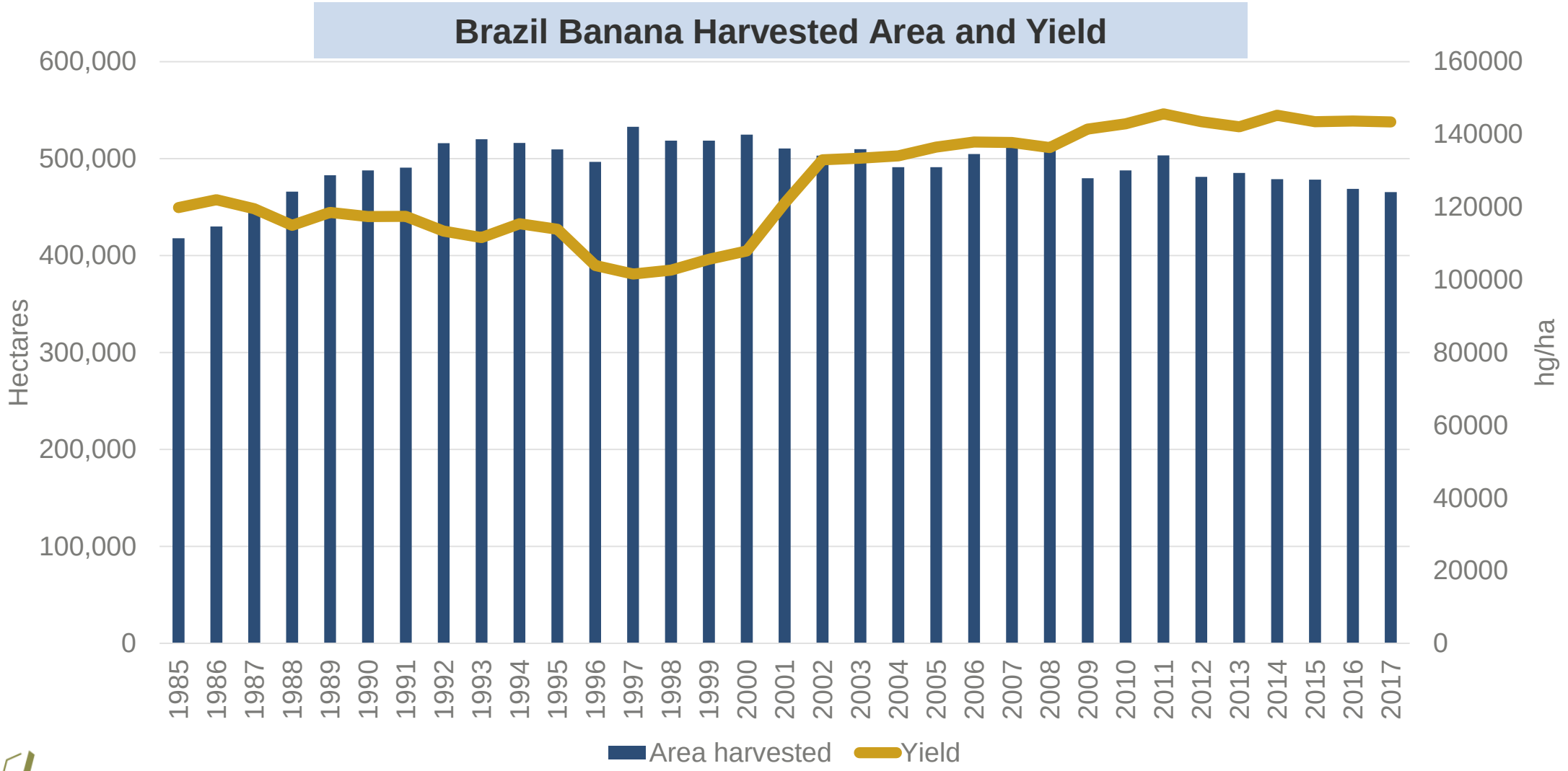
States harvesting more than 10,000 hectares in 2017

States harvesting less than 10,000 hectares in 2017

SOURCE: Embrapa Database

*Includes states with less than 10,000 harvested hectares

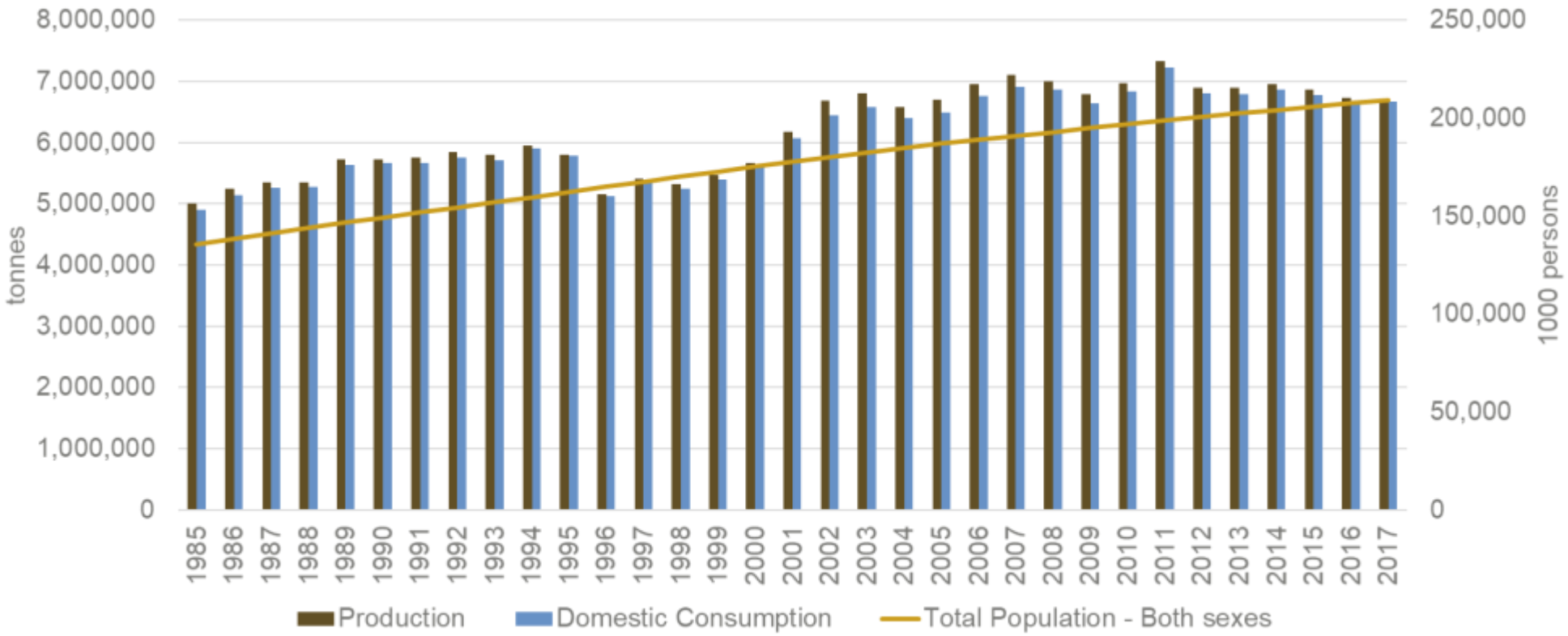
Banana Yield Continues to Improve; Harvested Area peaked in 1997



FAOSTAT

Domestic Demand has Increased Over Time with Population Growth; Very Little Banana Export

Brazil Population and Banana Production & Consumption



Historically, less than 2% of Brazilian bananas are exported each year due to:

Production and Quality Issues:
Including post-harvest handling, transportation issues, and issues with flesh color from colder weather, high labor costs

Varietal Preference:
Cavendish is the world's most popular variety and Brazil mostly produces other varieties which are not demanded by the U.S. (the world's largest banana importer)

CONTEXT | GLOBAL DEVELOPMENT

FAOSTAT; HF Brasil, BananaLink

Most Common Brazilian Banana Varieties

	PRATA	PACOVAN	CAVENDISH	BR PRINCESA *(Developed by Embrapa)*
% Brazilian Production	~50%	<10%	~40%	<10%
Market Window *(best time to sell)*	Jan-Mar	N/A	Jun-Aug	N/A
Average Yields	~35 MT / ha	~20-25 MT / ha	~70 MT / ha	~30 MT / ha
Typical Market Price (2018)	R$1.12/KG or ~US$294/MT	R$30-70 / one hundred bananas	R$0.76/KG or ~US$199/MT	R$0.35/KG
Most Common Cultivars / Other Notes	Most common cultivars – Prata Ana (Natural variation; recommended by Embrapa in early 1980s) • Stable production YOY • Highly synchronized – Prata Gorutuba • Originally was more resistant to Panama disease, but has had increasing damage from the disease recently • Production starts very low and increases over time – Prata Catarina • Production starts very high and decreases over time All Prata cultivars sold for same price to end market; separated by 1st and 2nd quality class Produced & consumed throughout Brazil	Largely produced and consumed in smallholder farms in the North (Pernambuco, Rio Grande do Norte, etc.)	Supplied by Brazil TC labs as well as from Costa Rica Produced throughout Brazil but largely consumed in the South (Sao Paulo, Santa Catarina) or exported (small percent)	Require about 40% of nutrients and about 60% of water as compared to Prata and Cavendish Produced & consumed throughout Brazil

CONTEXT | GLOBAL DEVELOPMENT

Hortifruti/Cepea; Farmer Interviews; Embrapa

Main Banana Diseases/Challenges in Brazil

FUNGI

FUSARIUM WILT RACE 1 (PANAMA DISEASE)

BLACK SIGATOKA

FUSARIUM WILT RACE 4

NOT YET IN BRAZIL, BUT EXPECTED TO BE A FUTURE THREAT; EMBRAPA BREEDERS ALREADY TESTING A RESISTANT VARIETY

VIRUSES

- Cucumber Mosaic Virus
- Banana Streak Virus

PESTS

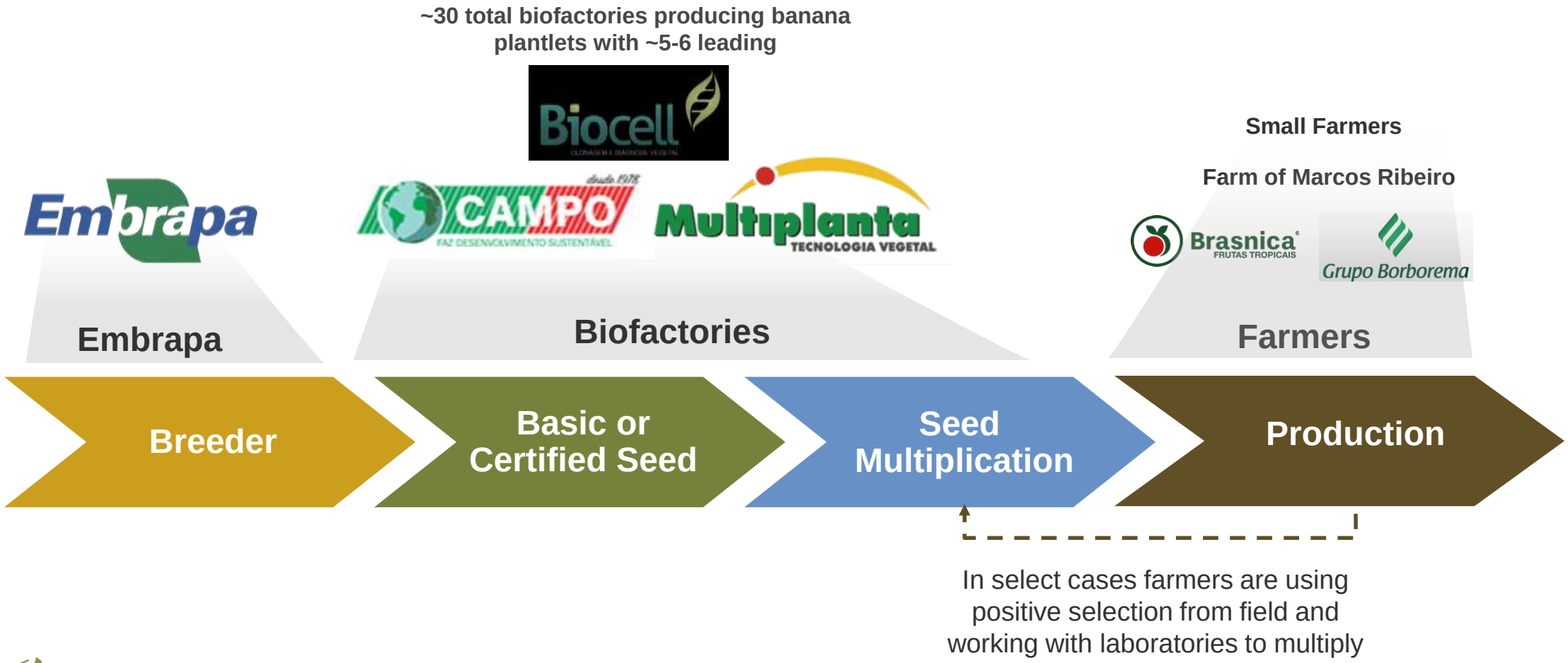
- Cosmopolites soridus
- Nematodes

CONTEXT | GLOBAL DEVELOPMENT

Photos – Herminio Souza Rocha & Fernando Haddad

Leadership

Organizational Leadership by Value-Chain Step



LEADERSHIP

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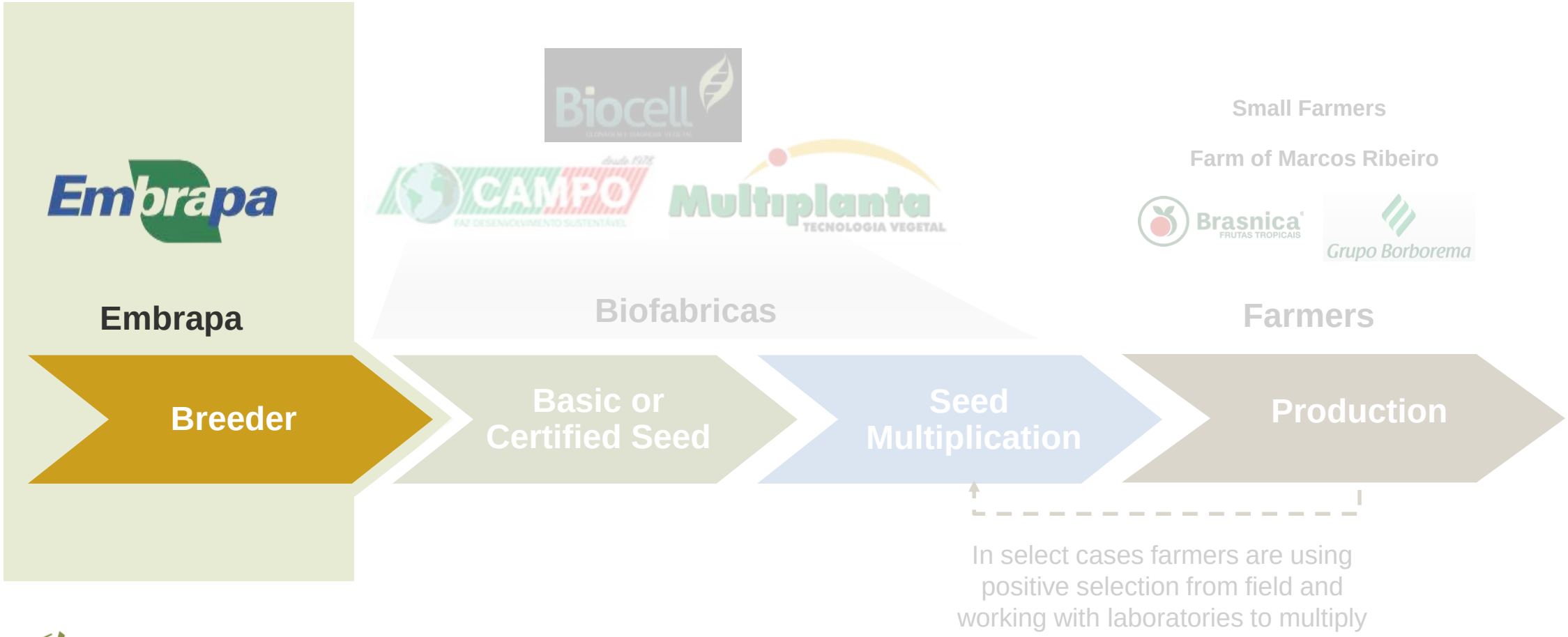
Organizational Leadership by Value-Chain Step



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.

Photo: Embrapa-HQ

INSTITUTIONAL PROFILE

Established in **1973**

Linked to Ministry of Agriculture, Livestock and Food Supply

9.807 employees

2.444 researchers

B.Sc.	M.Sc.	D.Sc./Ph.D.
1%	**15%**	**84%**

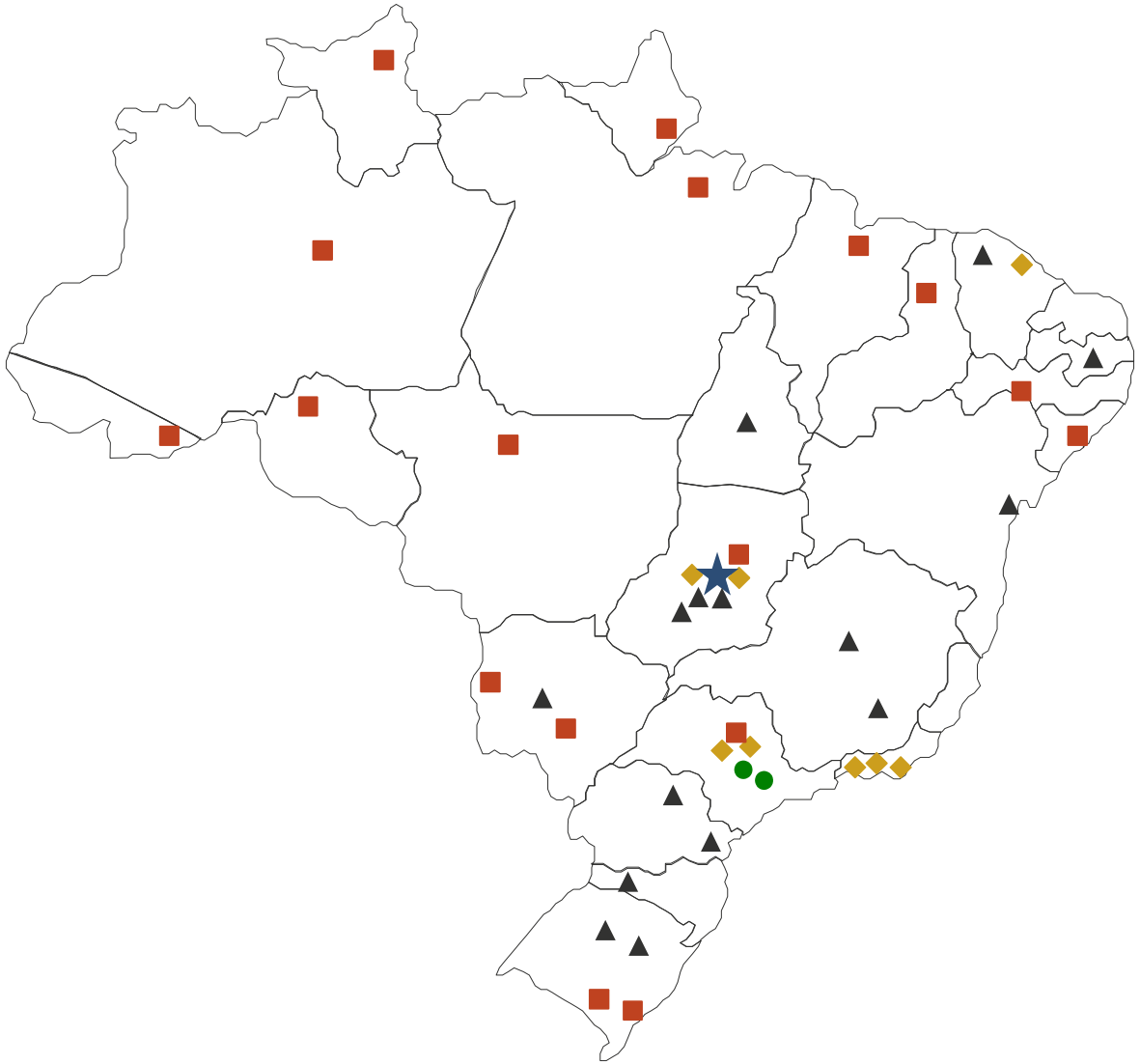
Embrapa Operates 42 Decentralized Centers of Research and Services

RH data from DGP: 31-Mar-2013

LEADERSHIP

Embrapa – 42 Decentralized Centers of Research and Services

- Embrapa HQ
- 08 Thematic Centers
- 15 Product Centers
- 17 Eco-Regional Centers
- 02 Services Centers



LEADERSHIP

Embrapa – 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

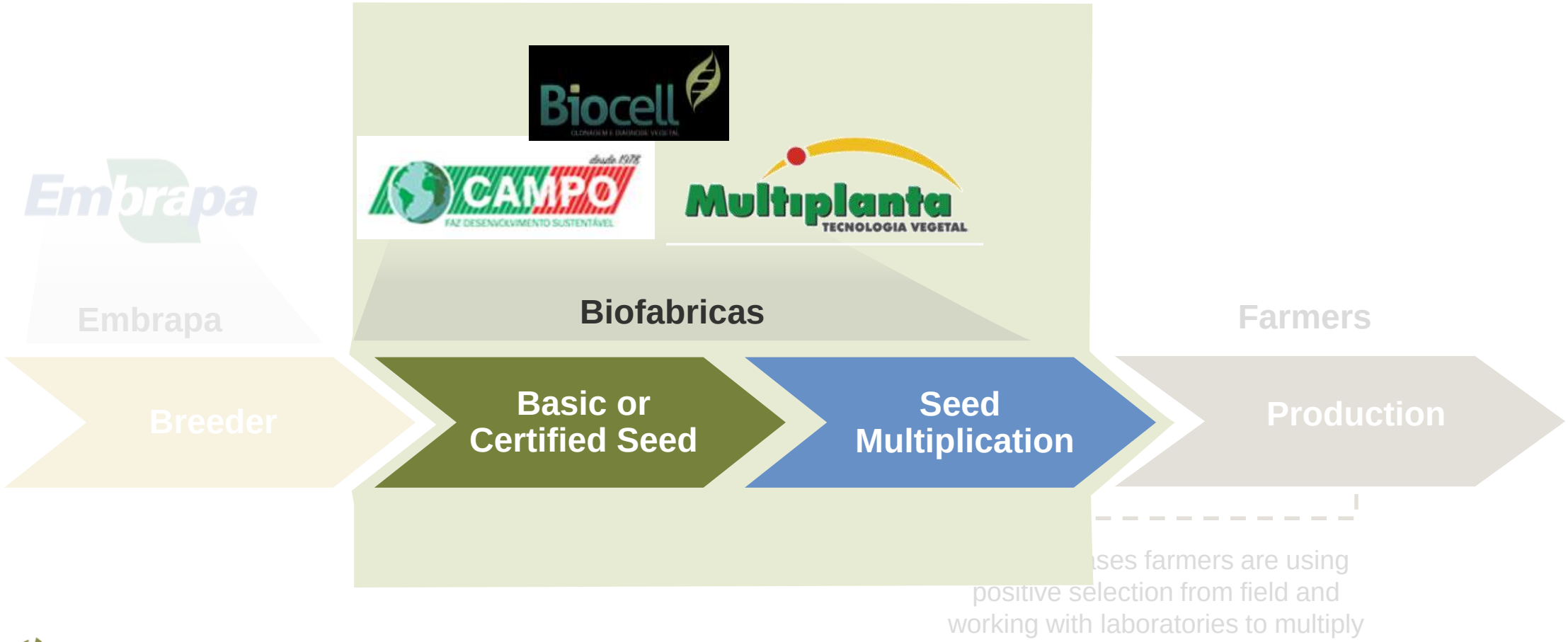
National Center for Cassava and Tropical Fruit Research

Established in **1975**	Total Area: 262 ha	**227** employees	**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

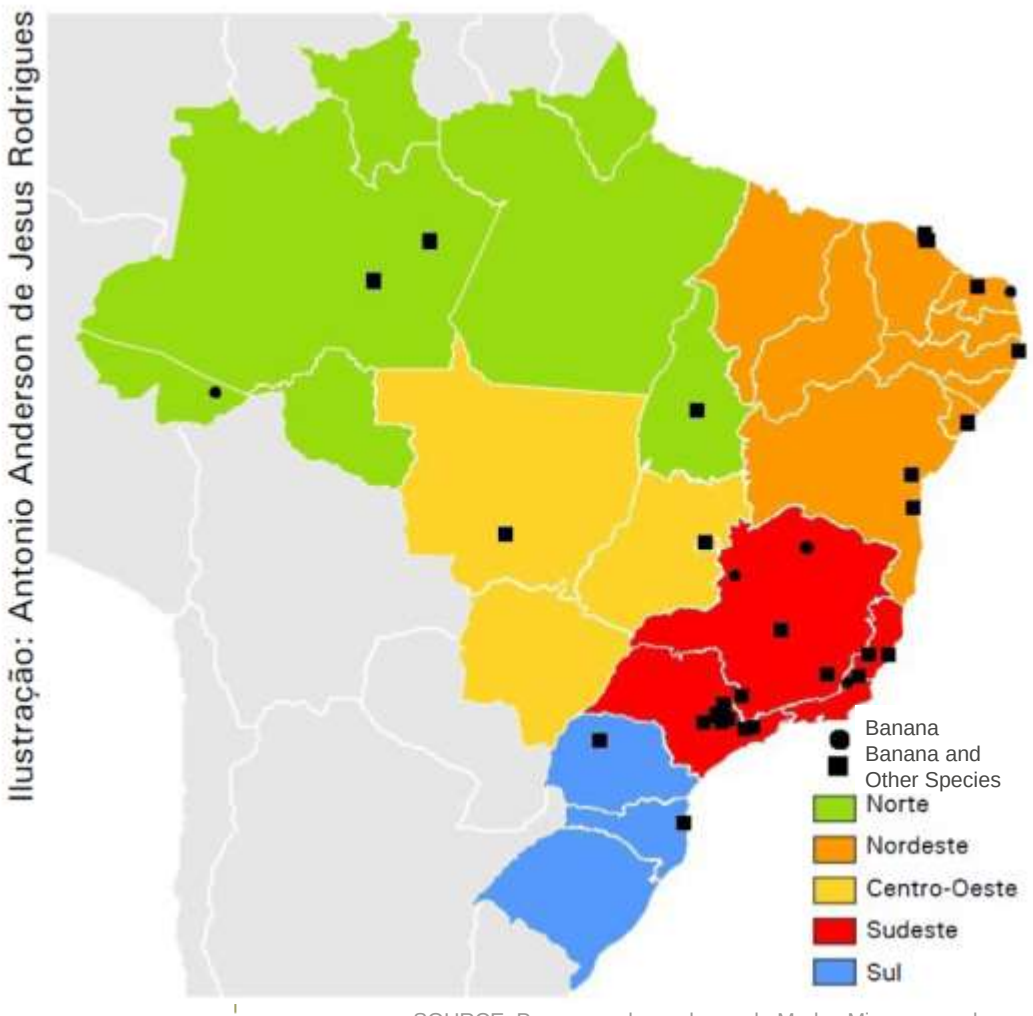
SOURCE: SGP/CNPMF, Oc.2014

Organizational Leadership by Value-Chain Step



Banana Biofactories Provide Clean Seedlings Throughout the Country

Brazilian Banana Biofactory Locations



The number of **BANANA BIOFACTORIES INCREASED BY 112.5%** from 2008 to 2016. Volume rose from 16 banana biofactories to 34 in 2016.

Only **FIVE BIOFACTORIES** produce **BANANA SEEDLINGS EXCLUSIVELY. 29** of the banana biofactories also **PRODUCE OTHER SPECIES.**

Brazil produced around **7.5 MILLION SEEDLINGS BY TISSUE CULTURE** in 2010; today, an estimated **10-12 MILLION TC SEEDLINGS** are produced

SOURCE: Panorama da producao de Mudas Micropropagdas no Brasil (2008-2015); received from Embrapa contact

Major Biofactories Producing Banana Plantlets in Brazil

BIOFACTORY	LOCATION	FOUNDING YEAR	ESTIMATED # BANANA PLANTLETS PRODUCED ANNUALLY	FARMER PRECEPTIONS*
Biocell	Sete Lagoas-Minas Gerais	2000	3.5M	Generally higher priced plants, some problems with variation in more recent orders.
CAMPO	Cruz das Almas-Bahia	1991	0.6M	Positive perception – good quality, good price.
Multiplanta TECNOLOGIA VEGETAL	Andradas-Minas Gerais	1991	3.0M	Generally higher priced plants, some problems with variation and timely delivery. Material generally high quality.
FLORA biotecnologia mudas micropropagadas	Itajai-Santa Catarina	2008	0.7M	N/A
biofabricadecacau.org.br	Ilheus-Bahia	1997	<0.5M	N/A
Biocacau	Amador, Eusebio-Ceara	2008	<0.5M	N/A
sbw DO BRASIL	Holambra-Sao Paulo	2005	<0.5M	N/A
COSTA RICA	Multiple biofactories (Cavendish only)	N/A	N/A (multiple biofactories)	Considered better material than Brazil; pay R$3.80/plantlet + transportation. In beginning, up to 50% of materials lost during transportation (dehydration); Now don't lose anything.

*Qualitative assessment from limited number of farmer interviews; N/A indicates that a farmer customer of that biofactory was not interviewed

TC Plantlets are Estimated to Make Up at least ~20-25% of Replanted Banana Area Annually

Estimated # TC Plantlets produced & sold per year	**11,000,000**
Ha Banana in Brazil	465,000
# Plantlets/Ha	**1600**
Avg Duration of Plant (yrs)	**15**
% Plants replaced annually	7%
Ha replanted annually	31,000
TOTAL # Plants needed to replant annually *(Conventional + TC)*	49,600,000
% Replanting by TC plantlets	~22%
% Replanting by Conventional/Saved Seeds	~78%

Estimate based on bottom-up sum of major banana biofactories

Estimates based on industry expert opinions

Supplied by biofactories (low estimate)

Replanted on farm through conventional methods

CONTEXT | GLOBAL DEVELOPMENT

Micropropagation Technique Overview

Phase 1: Initiation

The lateral buds from root suckers are sterilized and placed into culture media

Extract portion of leaf to be virus indexed with molecular tools (usually by public universities, some private companies, which also need MAPA certification)

High % of contamination

Phase 2: Multiplication

Genetic stability kept through controlled number of multiplication cycles and controlled concentration of growth regulators

Lower % contamination

Biorreactors – previously common tool to increase multiplication, but today limited use because high instance of contamination

Phase 3: Rooting

Prepare plants for rooting through reducing cytokinin concentration, using a double layer of medium, and using ethylene inhibitors

Shift from heterotrophic to autotrophic conditions – stress plants before moving to aid in acclimatization in natural conditions

Phase 4: Acclimatization

Shift plants from culture medium into artificial substrate

High humidity initially, then gradually reduce

Sampling for virus indexing

CONTEXT | GLOBAL DEVELOPMENT

CAMPO

Campo Biotecnologia Vegetal Ltda, a national company with private capital, was created in 1991 in Paracatu-MG with the mission of offering Brazilian farmers high quality seedlings that meet the competitive quality standards of the national and international market; thus contributing to sustainable agriculture from the social, economic and environmental point of view through the application of the tools of modern biotechnology.

Location:
Cruz das Almas-Bahia

Cruz das Almas-Bahia

Entered partnership with Embrapa and Bahian Agricultural Development Company (EBDA) in 1998 to create the biofabrica in Cruz das Almas

100% of Cruz das Almas plantlet production is banana; sell to farmers throughout the country

Manaus-Amazonas

In 2001, created CAMPO da Amazonia in Manaus-Amazonas to meet demand for disease resistant bananas in the Northern region. It is an acclimatization facility that sells banana plantlets that are ready for field planting.

http://www.campo.com.br/biotecnologia/en/quem-somos/

CONTEXT | GLOBAL DEVELOPMENT

CAMPO Visit – Macropropagation Demonstration – not done often by labs or farmers

1. Extract suckers (can be done without destroying original plant or bunch)
2. Check for disease/pest symptoms, plant with knob facing down
3. First plant will not product good bunch; used as mother plant only
4. At 6-7 months old (before producing bunch), take off suckers, ensure no disease, wash with chloride
5. Upon rooting in ~60 days, kill meristem which induces later buds, then kill lateral buds to induce second lateral buds
6. Can produce 50-100 plantlets in 1 year

Process is similar to PIBS (Plants Issus de Bourgeons Secondaires), a rapid multiplication technique applied to plantain

PROS

- Does not require sterile conditions
- Easier to maintain than biofactory

CONS

- More susceptible to disseminating pests and diseases vs. TC materials
- High infrastructure / facilities / labor / expertise required
- Inconsistent / potentially low propagation factors

WHY IT IS NOT COMMONLY USED IN BRAZIL

The technical labor and intensity to do macropropagation in the growing region has not been able to substantiate a benefit as comparted to the affordable and well-established micropropagated TC options

Multiplanta

Marcio de Assis, Owner & Administrator

Location: Andradas-Minas Gerais

Established in **1991**

~45 employees (including 2 lab supervisors, 1 greenhouse supervisor, and 2 office administrators)

6 hectares, 17,000 m^2 of green-houses

~65% of plantlet production is banana; other crops include strawberry, potato and eucalyptus

2003

Law 10711

Defines THREE classes of plantlets
(All three are common; non-certified does not represent poor quality)

1 Non-certified without genetic origin
Clones collected from field – Technical report required to prove it is virus free

2 Non certified with genetic origin
Cones provided by Empraba

3 Certified
Certified and documented according to standards of MAPA, free to be marketed to all Brazilian states and abroad

Multiplanta is the only biofactory that produces Class 3 Certified banana plantlets

Marcio considers this classification as a business decision to avoid conflict and eliminate risks; some incremental costs but never considered eliminating

CONTEXT | GLOBAL DEVELOPMENT

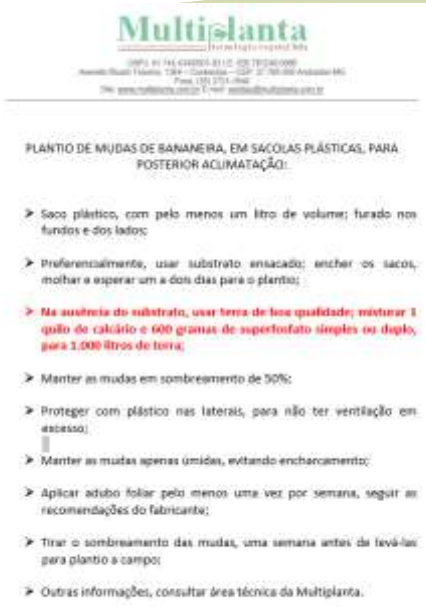
“No Excuses” Philosophy

Laboratories have enough experience to resolve production/quality issues and should no longer have technological shortcomings

- Errors (late delivery, incorrect orders, mutations, etc.) are a result of human oversight, not lack of capabilities or technology
- Clear incentives must be provided to staff to ensure efficiency and quality; Maximum of 7 multiplication cycles

Farmers have access to multiple sources of support from both Multiplanta & Emprapa

- Embrapa routinely publishes articles and information on how to successfully transfer TC to field
- Multiplanta also provides instructions to farmers, and for the complaints received (5-10% orders), most issues are agronomic, not technological



Multiplanta

PLANTIO DE MUDAS DE BANANEIRA, EM SACOLAS PLÁSTICAS, PARA POSTERIOR ACLIMATAÇÃO:

- Saco plástico, com pelo menos um litro de volume; furado nos fundos e dos lados;
- Preferencialmente, usar substrato ensacado; encher os sacos, molhar e esperar um a dois dias para o plantio;
- Na ausência do substrato, usar terra de boa qualidade; misturar 1 quilo de calcário e 600 gramas de superfosfato simples ou duplo, para 1.000 litros de terra;
- Manter as mudas em sombreamento de 50%;
- Proteger com plástico nas laterais, para não ter ventilação em excesso;
- Manter as mudas apenas úmidas, evitando encharcamento;
- Aplicar adubo foliar pelo menos uma vez por semana, seguir as recomendações do fabricante;
- Tirar o sombreamento das mudas, uma semana antes de levá-las para plantio a campo;
- Outras informações, consultar área técnica da Multiplanta.

Documentos 214

Boas práticas agrícolas de campo no cultivo da bananeira

Embrapa

- A muda seja retirada apenas após a colheita da planta mãe;
- A muda retirada esteja do lado oposto ao filho selecionado do bananal.

CONTEXT | GLOBAL DEVELOPMENT

Multiplanta

LARGE PLANTLETS	SMALL PLANTLETS
Field ready, less durable transportation	Not field ready, more durable transportation
~60% business	~40% business
3% additional plantlets sent to farmers	5% additional plantlets sent to farmers
Sold in 24 unit trays	Sold in 98 unit trays
Sold for R$2.10 / plantlet	Sold for R$1.70 / plantlet

ORDERING & DEMAND PLANNING PROCESS

- Multiplanta plants new materials everyday with anticipated demand
- Farmer advance orders
  - For large orders (40,000+ plantlets), require 4-5 months notice
  - For smaller orders (<40,000), 2 months is usually sufficient
- 30% payment made up front; the remainder in installments after delivery
- Use computer tracking to monitor order progress daily
- Transportation of materials enabled by robust trucking and air cargo network and paid for by farmers

CLONAL GARDEN MANAGEMENT

- On-site clonal garden contains a range of cultivars (~40% Cavendish, ~40% Prata, ~20% Silk/BRS Princesa/other)
- Clones are analyzed every 3 years (tested for virus, replaced as needed based on new materials available)
- Several varieties are registered and royalties are paid
  - **Conquista** – discovered & developed in the Amazon
  - **Platina** – Embrapa variety; 7% royalties paid
  - **BRS Princesa** – Embrapa variety; no royalties paid because not registered

Biocell

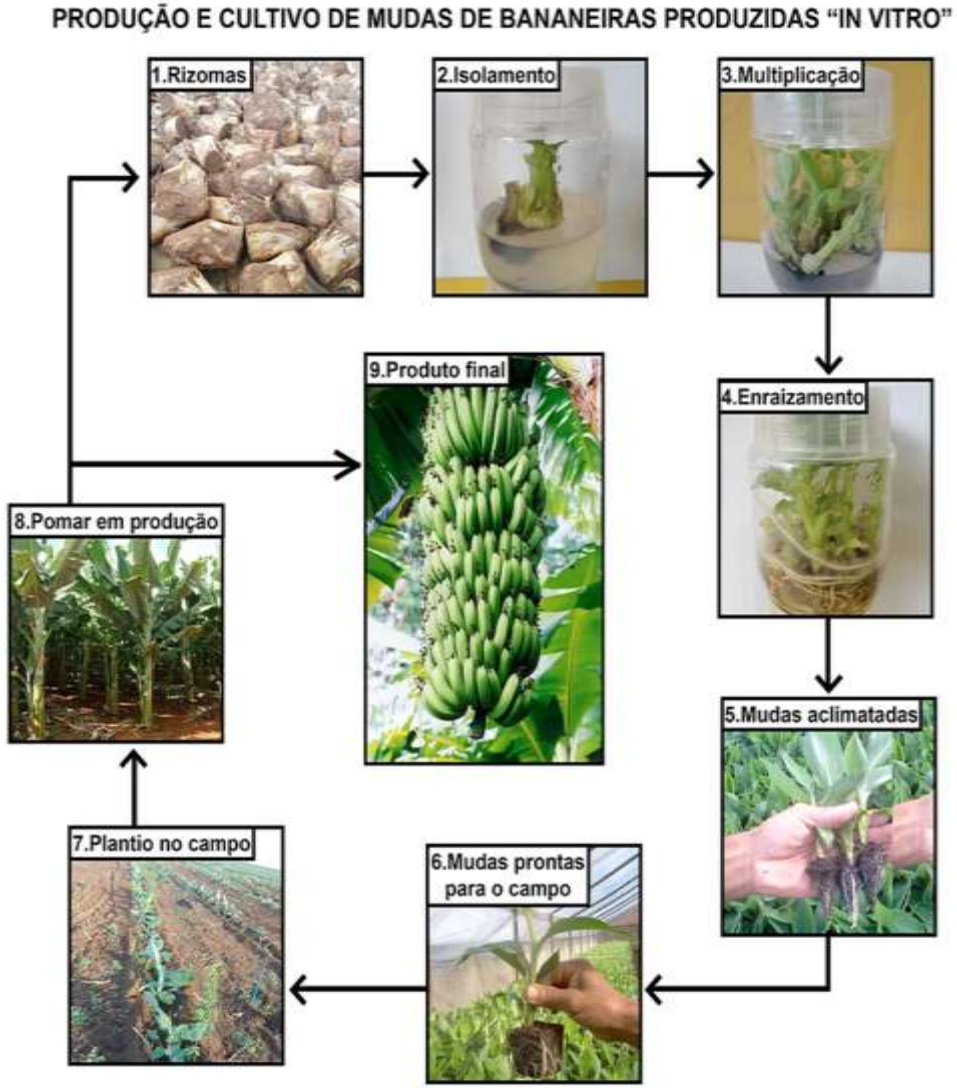
Edilson Paiva,
Director

"Talk with numbers: prepare the numbers into graphs and the numbers will talk to you"

BIOCELL is a private Brazilian company of Plant Biotechnology whose main social objective is to commercialize seedlings of plants of commercial interest, produced through the process of micropropagation in the laboratory, using modern techniques of Tissue Culture "in vitro".

Location:
Sete Lagoas-Minas Gerais

Established in **2000**	Produce **~3.5M** plantlets annually (>90% banana)	**4** ha, with plans to expand to 6 ha in coming years	**50** employees



CONTEXT | GLOBAL DEVELOPMENT

Biocell – Key Elements of Business

Sell 100% to large farmers through long-term contracts

- In Edilson's view, Biocell was and is successful because large farmers had/have scale, infrastructure and knowledge for using TC plantlets
- Set expectation for placing orders at least 1 year in advance; 30% paid in advance and 70% paid in 3 installments after delivery of materials

Minimize risk of contamination and variation

- Train staff to carefully identify and remove contaminated materials and somaclonal variations
- Multiply a maximum of 10 cycles to minimize somaclonal variation; train staff to identify and rouge out variance in greenhouse stage
- Produce an additional 20% of plantlets, send 3% extra to the farmer

Signs of somaclonal variation include yellow discoloration, asymmetrical leaves, waxy leaves, etc.

Continuously evaluate and reduce costs

- Biocell switched from glass to plastic jars, and also invested in efficient, durable LED lights in growth chambers
- Techniques and training of new employees are focused on minimizing contamination and maximizing efficiency; low turnover

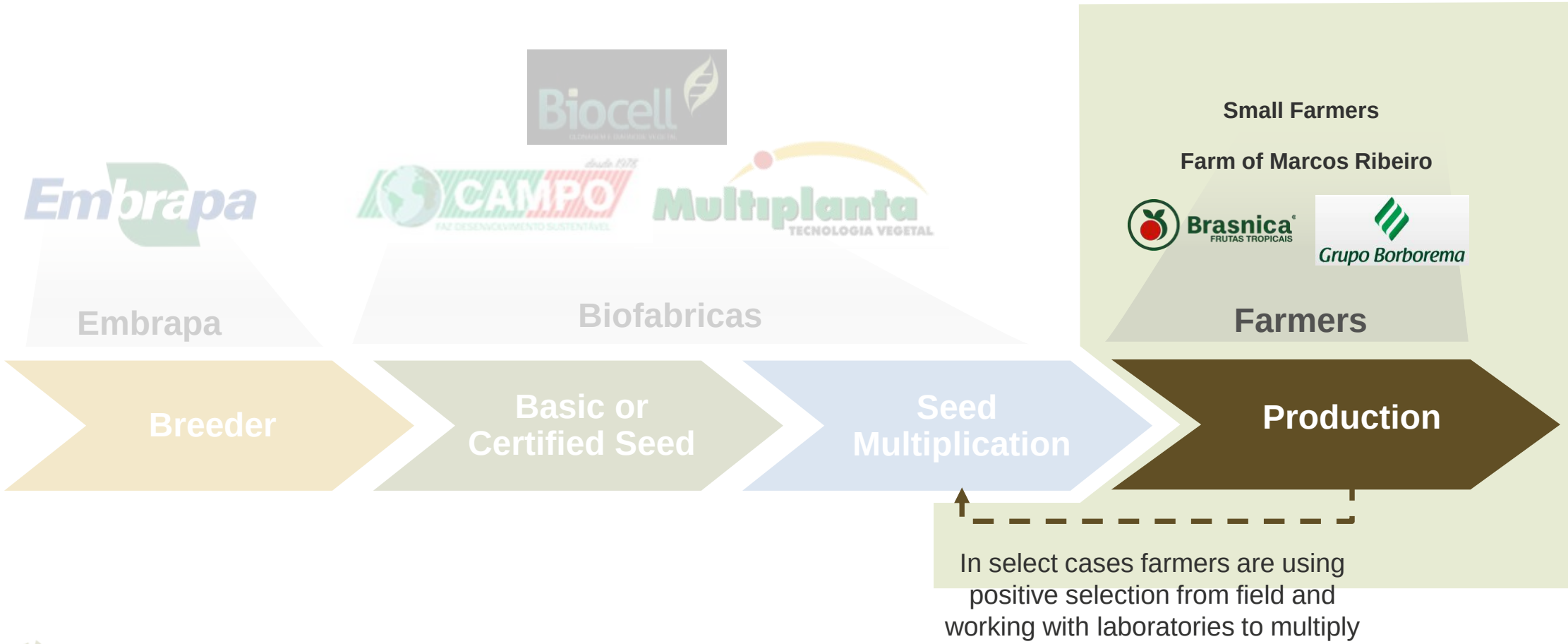
Traceability and continuous monitoring of plantlet production progress

- All materials are labeled and traced clearly (stage, variety, technician, hood #); currently manually but in the process of adopting a computerized system
- Weekly status check of order progress to ensure timely production and preemptive communication of issues to customers

Biocell – Three Types of Plantlets Sold

	Small Bare Root	Medium in Substrate	Large in Substrate
% Biocell Business	~2%	~30%	~70%
Price per plantlet	R$0.80	R$1.60 – R$1.80	R$1.90 – R$2.10
Characteristics	Require sophisticated farmer knowledge and greenhouses; Farmers must sign contract accepting liability for plantlets	Not yet ready for field – require acclimatization prior to planting	Ready for field

Organizational Leadership by Value-Chain Step



Overall TC Complaints from Farmers

Lack of varietal consistency	Farmers claim to receive incorrect materials from what was ordered (ex: Prata Ana instead of Prata Catarina)	Within a single variety, farmers experience a high degree (15% or more) of somaclonal variation in the TC materials, even though Brazilian regulations set a maximum of 2.5%
Lack of disease control	Farmers claim to receive TC plantlets that are not free from Panama disease, even through Brazilian regulations require biofactories to test for diseases	
Lack of uniformity	Due to natural variation and/or packaging, plantlets often arrive with a range of heights and maturity within a single product type (“large” vs “small” as defined by TC labs)	
Unreliable delivery	Delayed delivery of TC materials results in farmers missing the ideal market windows	
Uncertain plantlet lifespan	The ROI of the planting material is inconsistent and unpredictable	While some TC materials have had strong in-field banana production for 20+ years, others have quit producing bananas after 4 years.	Most farmers assume area will need to be replanted every 8-12 years

Farmer Demographics

	LARGE FARMERS	SMALL FARMERS
	Brasnica FRUTAS TROPICAIS, Grupo Borborema **Farm of Marcos Ribeiro** **Other Large Farmers**	**Small Farmers**
# HECTARES	>15 ha	<15 ha
% BRAZIL PRODUCTION	<10%	>90%
REGIONS	Clustered in large banana-producing regions of Brazil, including Sao Paulo, Bom Jesus da Lapa, Delfinópolis, and Northern Minas Gerais	Throughout Brazil
TC PLANTLET ADOPTION	Have greenhouse / nursery infrastructure near farms to enable the purchase of smaller TC plantlets (acclimatization) TC plantlets used at a higher rate (~10-20% of area)	More commonly buy larger TC plantlets that can be planted directly to the field TC plantlets used at a lower rate (<10% area if at all); additional replanting done conventionally *Of farmers with less than 6 ha, ~1% use tissue culture*

CONTEXT | GLOBAL DEVELOPMENT

Large Farmer Techniques

Greenhouse / Nursery On-Farm	On-farm positive selection	Over-planting & elimination	Integrated Pest Management against Panama disease
Purchase smaller plantlets from biofactory and acclimate on-farm in greenhouse	Select plants w/ favorable bunches, synchronization, disease resistance, etc.	Example: Plant 3x1m (3334 plants/ha) and eliminate the weakest plant → 3x2m (1667 plants/ha)	Nutrition (but w/ risk of fusarium spread)
Use soil, organic matter & manure to plant in pots, then into the ground after 1-2 months	Send mother plant materials to labs for multiplication		Trichoderm (micro organism / fungus-antagonist to fusarium)
Irrigated and treated with biofertilizer and chemical treatments			Liming pH control
			Bacillus subtillus and bacillus protogen

Large Farmers – Greenhouse Nursery

Large Farmer Nelson Jr. and his On-Farm Nursery in Bom Jesus da Lapa – BA

Plantlets treated with nutritional blend (both biofertilizer and chemical treatment) through overhead irrigation

Some plantlets potted in manure mixture, others with soil/organic matter mixture, until transplanted to field

Farmer coalition in Jaiba – MG constructed a greenhouse to support their 400 ha operation after frustrations with high loss during acclimatization

Positively select mother plants from their fields for multiplication by Flora Biofactory (buy for R$1.50/plantlet), then plantlets acclimated in greenhouse for 50-70 days before planting

Experiencing <1% loss in greenhouse; receive support from Flora lab technicians

Would consider selling to local small farmers after operation scales; would charge R$2.00-2.10/plantlet (margin of at least R$0.50)

CONTEXT | GLOBAL DEVELOPMENT

Large Farmers – Positive Selection (Borborema & Marcos Ribeiro Farms)

The agronomists and technicians are looking for several key characteristics during positive selection process:

Yield & Uniformity of Bunch

Larger bunches improve yield; More uniform bunches offer improved handling, cutting and shipping

Synchronization of 2nd and 3rd stems

The timing and synchronization of the second & third stem impacts the consistency of harvests; ideally the second stem can be harvested 2-3 months after first

Disease Resistance

Mother plant must be resistant to Panama disease

Others

- Shorter plants
- Straightness of banana fruit fingers
- Fruit that do not ripen in the field

It typically takes at least 3 cycles for the positively selected materials to stabilize; the consistency and true benefits of positive selection are still unclear / unproven

CONTEXT | GLOBAL DEVELOPMENT

Brasnica (Fazenda Oriente)

Brasnica
is the
LARGEST COMMERCIAL BANANA PRODUCER
in Brazil

PATRICK
Technical Manager,
Fazenda Oriente

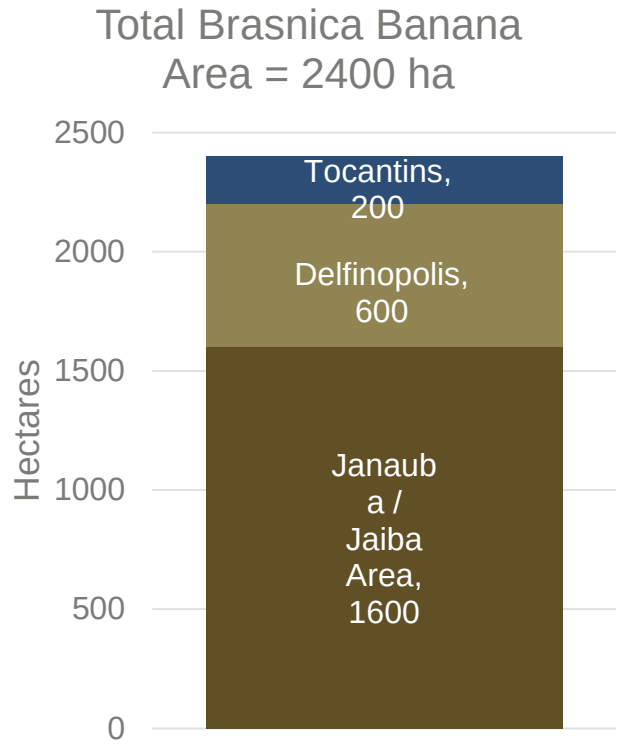
Brasnica sources **all of its new planting materials from TC labs** (mostly CAMPO and Multiplanta) due to disease pressure

- Out of its 2400 ha, the company plants about 50 ha of new material annually, or ~2% (a large area was planted in 2012 and therefore is not yet part of the replacement cycle)
- Conventional re-planting is only done in the case of TC plantlet failure (~5% of the time)

Brasnica has considered **investing in their own biofactory**, but the high investment and specialization required has deterred the decision to date

Demand by variety is determined by centralized Brasnica management based on market expectations and trends; each farm is then given the directive on what and how much to plant

Brasnica **exports part of its BRS Princesa banana production to the United States** (first Embrapa variety to be exported)



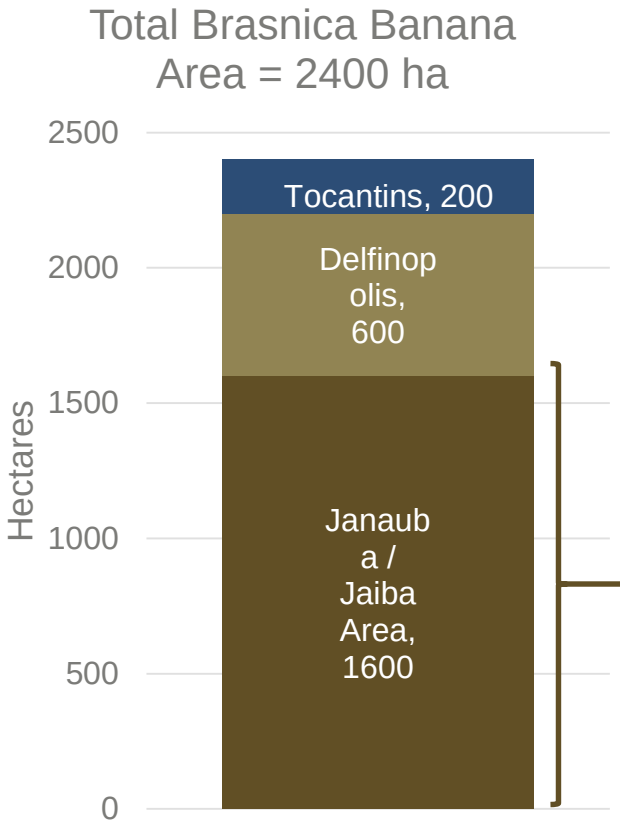
THE COMPANY'S BANANA PRODUCTION IS 100% ORGANIC

All TC materials were originally sourced as naked root to abide with organic certifications for limited substrate (today allowed small amount of substrate)

Avoid chemical treatments for disease control, relying solely on organic treatments (bacillus)

http://www.brasnica.com.br/

Brasnica (Fazenda Oriente)



Location:
Jaiba-Minas Gerais

Fazenda Oriente = 116ha or ~5% of Brasnica banana area

Prata = ~60 ha	Cavendish = ~20 ha	Princesa = ~30 ha

TC plants acclimated in a regional greenhouse close to Fazenda Oriente (shared by several Brasnica farms near Jaiba)

Technical Manager Patrick demonstrating Fazenda Oriente, one of Brasnica's production farms (Fazenda Oriente)

Borborema Farms

MARIO BORBOREMA
Owner/Director

DILHOMAR
Technical Manager

Borborema farms was **established in early 1990s; produce primarily bananas**, but also mangos, papayas and other fruits

Current production is in Jaiba-Minas Gerais across **four farms totaling 750 hectares**; Expansion is underway to add **400 hectares** to the operation, located in Montes Claros-Minas Gerais

Source banana plantlets (multiplied entirely from their **positively selected mother plants**) from **small labs**; prefer small labs because of perception that large labs have lost quality and consistency in material as they scaled

Borborema is **exploring the possibility of exporting bananas**, but do not currently export due to the regulatory burden and uncertain economic benefits

Instead, the strategy is to **shift production closer to major Brazilian cities** for easier transport to domestic markets

Borborema is aware of **climate changes' effects**. The north of MG is extremely hot during summer which reduces yields in the banana plants. One option Borborema is considering is moving to places where temperatures are not so high, such as Delfinópolis – MG.

Location:
Jaiba-Minas Gerais

Borborema Farms Positive Selection Strategy

Due to low satisfaction and reliability with TC planting materials from large labs' clonal libraries, Borborema has established a partnership with three small biofactories to multiply their own positively selected planting materials

FARM – LABORATORY PARTNERSHIP

Grupo Borborema

Borborema Farms performs in-field positive selection and provides the mother plant material to be multiplied

Labs provide monthly technical support, training and acclimatization techniques, and multiplication of plantlets

FLORA biotecnologia mudas micropropagadas

ELITE BIOFACTORY

RGN BIOFACTORY

Newer and/or smaller labs are willing to support such an initiative in order to establish their market presence in a competitive biofactory landscape

Borborema pays a premium of R$1.75/plantlet for the positively-selected plantlets, which includes the technical support (Cost of TC material from clonal libraries would be ~R$1.40)

Farm of Marcos Ribeiro

ADAILTON VIENO.,
Technical Manager

380 banana hectares currently with plans to **expand to 500 ha total**

Primarily Prata Gorutuba

Small area of BRS Princesa

Replants ~10% annually with TC materials

Location:
Jaiba-Minas Gerais

Does positive selection of field plants (managed by a single agronomist) and sends to CAMPO Biofactory for multiplication

Pays R$2.10/plantlet for replicated mother plant material

CONTEXT | GLOBAL DEVELOPMENT

Small Farmers

GOVERNMENT:

INPUT PURCHASE SUPPORT

Government involvement in TC orders is most prevalent in Amazonas state, where farms are smaller and less specialized

IDAM is a government organization that manages consolidated, large TC banana plantlet orders for small farmers in Amazonas state

In Amazon region, farmers / organizations are buying plantlets from biofactories and having them shipped to their region (minimal incremental cost: ~R$150 for large box)

In this region, intercropping bananas with acai, palm, guarana, etc. is common, so farmers are less specialized in banana as compared to the Central and Southern regions of Brazil

ASSOCIATIONS:

COMMERCIAL SUPPORT

Farmer cooperatives / associations negotiate banana fruits' market price for small + large farmers

While this banana fruits' market price guarantee is beneficial during off-market window periods, it can mean that small farmers receive much lower prices during peak market

Example: One small farmer interviewed is member of Abanorte Association. At time of visit, national price for Cavendish was R$0.70/kilo, but he was only receiving R$0.40/kilo

In some select cases, associations support the pooling/purchases of TC orders, but this is typically among larger farmers vs. smaller

CONTEXT | GLOBAL DEVELOPMENT

Small Farmers

ELADIO SANTOS LIMA,
15 ha farmer

CARLOS HENRIQUE CARDOSO,
6 ha farmer

Technical background: ag technician, formerly worked in forestry

4 employees

Member of Abanorte association which ensures guaranteed pricing of bananas

Uses TC material on 70-80% of replanting, but has experienced issues with disease, variation, and size of plantlets received (too small, so needed to assemble makeshift screenhouse to grow and acclimate before planting)

No aggregate view of farm budgets, but could build up to estimates based on input costs and pricing

Small farmers' biggest challenges are how to cope with high prices of inputs, which are determined in US Dollars. The prices payed for banana fruits are in Brazilian Reais, and in recent years, prices have decreased.

Non-technical background; farm handed down through generations

Does not use TC material; only replants conventionally

No aggregate view of farm budgets, but could build up to estimates based on input costs and pricing

CONTEXT | GLOBAL DEVELOPMENT

Research & Varietal Development

MARKET DYNAMICS

Bananas are Classified by Genomic Groups and Subgroups

Genomic Groups Developed Out of Crossing Two Original Banana Cultivars:

1. Musa acuminata (AA)
2. M. Balbisiana (BB)

Subsequent Crosses Evolved into the Following Genomic Groups:

AA	BB	AAA	AAB
AAAA	AAAB	AABB	

Each genomic group exhibits differentiating characteristics in taste, look, and feel.

The Main Banana Cultivars (and their Genomic Groups) in Brazil Include:

- Ouro (AA)
- Nanica (AAA)
- Nanicão (AAA)
- Great Naine (AAA)
- Maca (AAB)
- Mysore (AAB)
- Prata (AAB)
- Pacovan (AAB)
- Dwarf Prata (AAB)
- Terra (AAB)
- D`Angola (AAB)
- Fig (AAB)

AA Plants of the AA genomic group are usually thin, presenting pseudostem with many dark spots and leaves erect and narrow, with the base of the open petiole

AAA *Includes Cavendish varieties* The plants of the AAA genomic group are similar to group AA, usually more vigorous, presenting dark on the pseudostem, petioles with open base and pigmentation opaque on the inner face of the male bracts.

AAB The plants of the AAB genomic group present, generally, few dark spots on the pseudostem, petioles with margins erect and bright pigmentation on the inner side of the male bracts.

Bananas Grown in Brazil are “Dessert” Varieties:

Northern Varieties:	Southeastern Varieties:	Southern Region:	Midwest Region:
Pacovan, Prata, Terra (Plantains) (AAB varieties)	Prata, Dwarf Prata, Maca (AAB varieties) & Cavendish (AAA variety)	Cavendish and Prata	Prata and Maca

SOURCE: Brazilian Banana Crop: Current Situation and Research Challenges; Embrapa 500 Questions, 500 Answers

RESEARCH & VARIETAL DEVELOPMENT

Embrapa Hybrids

Embrapa receives 6% royalties for any licensed varieties

Banana BRS SCS Belluna

Launched: 2016

Indicated for fresh and processed consumption, especially for flour and dehydration

Recommended for planting in Santa Caterina and has been adopted by several growers in that state

BRS Japira

Launched: 2010

Recommended for growers in North & Northeast regions, and North of Minas Gerais

Has been key in restoring the viability of banana farming in the Northern region of the country

BRS Princesa

Launched: 2010

Good disease tolerance and is recommended to replace some issues growers face with the Maca cultivar, including increased consumer demand and disease susceptibility

BRS Platina

Launched: 2012

Exhibits high qualities that command the highest marketing classification

Meets consumer demand for Prata type bananas in areas that Prata Ana is limited by disease

BRS Vitoria

Launched: 2005

50% average increase in productivity in regions that grow traditional banana varieties

Fully meets demand in the State of the Amazonas

SOURCE: Embrapa

Embrapa Hybrids (cont.)

Garantida

Pacovan Ken

Preciosa

Pioneira

Tropical

Caprichosa

Pacoua

Cultivars

Prata-Anã

Pacovan

Embrapa's Expertise and Breeding Effort by Variety

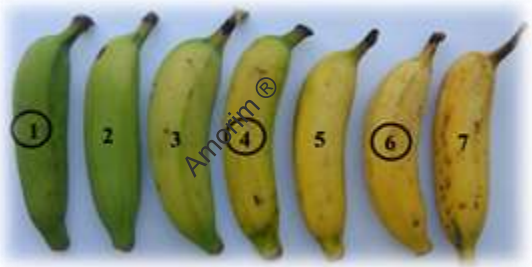
	Prata	Silk (Maca)	Cavendish	Gros Michel
Knowledge	High	Intermediary	Low	Low
Crosses/seeds	Frequent	Difficult	More difficult	More difficult
Effort/work	Medium	High	Very high	High
Time to results	Medium	Long	Long	Long
Budget	$$	$$	$$$$$$$	$$$$
Impact	Hihg	Very high	Extremely high	Extremely high
Consumers	Brazil/Australia	Brazil/Africa	World	World again

Amorim, 2017

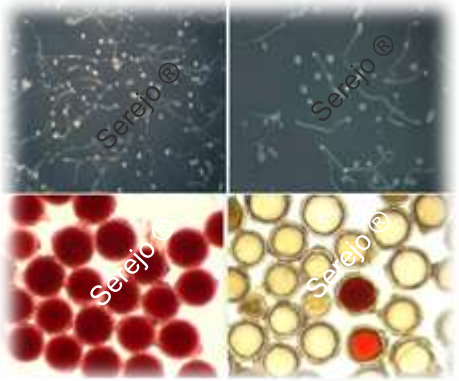
Embrapa's Breeding Strategy has Several Focus Areas

Chromosome doubling

Drought tolerance

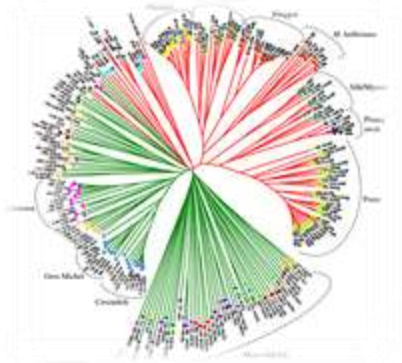


Fruit ripening



In vitro fertilization

Avoid finger drop



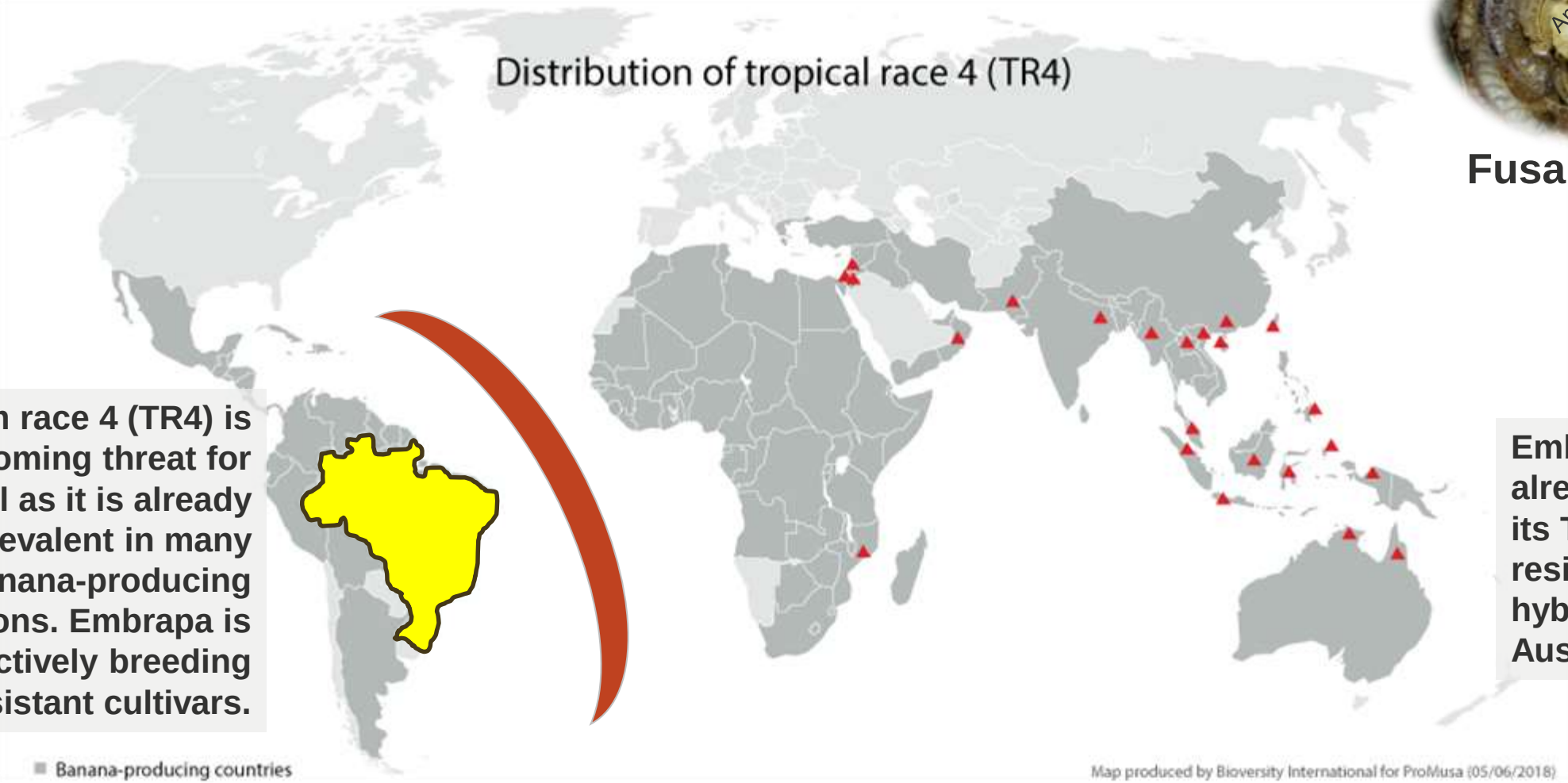
Molecular markers

Germplasm conservation

Somaclonal variation

Embrapa Preventive Breeding for TR4

Fusarium wilt



Fusarium race 4 (TR4) is a looming threat for Brazil as it is already prevalent in many banana-producing regions. Embrapa is proactively breeding resistant cultivars.

Embrapa is already testing its TR4-resistant hybrids in Australia

Embrapa Participatory Breeding Program with Farmers is a Key Part of Their R&D Program

BANANA BREEDING PROGRAM FOR NEW VARIETAL DEVELOPMENT & TESTING

Stage 1: Evaluation in Cruz das Almas (agronomic and taste testing)

Stage 2: Large farmer participatory breeding

Stage 3: Further evaluation by Embrapa & large farmers

~30 Farmers across two key banana regions are provided 100 plants of region-specific hybrids to evaluate for 2 years

Northern Minas Gerais

Borborema • Brasnica • Marcos Ribeiro

South (Santa Catarina & Rio Grande do Sul)

Material sent to ASBANCO (Association of banana growers in Corupá), which is distributed across 5 producers

After testing period, farmers provide feedback to Embrapa on both agronomic characteristics and market/end user receptiveness

CONTEXT | GLOBAL DEVELOPMENT

Embrapa Played a Key Role in Developing DATAMusa

DATAMusa is the SECOND LARGEST DATABASE of BANANA GENOMICS in the world

In 2002, to preserve bananas as a **KEY FOOD SOURCE** in Brazil, Embrapa encouraged collaboration between national and international organizations

This collaboration would employ **RESEARCH ON GENOMICS AND BIOTECH** to find solutions to issues with disease, insects, and the growing environment

The initial research project was funded by Conselho Nacional de Desenvolvimento Cientifico e Tecnologico

The research project resulted in the **CREATION OF DATAMusa**, the database where all of the genomics information is housed

CONTEXT | GLOBAL DEVELOPMENT

GENOMA BANANA

DATAMusa is a collaboration between:

Universidade Católica de Brasília

Embrapa Genetic Resources & Technology

INRA SCIENCE & IMPACT

Research into banana genomics and biotech resulted in identification of over 5,300 genes, including those that address:

Drought Tolerance

RESISTANCES TO:

- **Fungi (Black and Yellow Sigatokas and Fusarium wilt)**
- **Bacteria**
- **Nematodes**
- **Insects**

SOURCE: EMBRAPA

Demand Planning and Operations

Standardization Exists Across the Industry of Order/ Production Processes and the Two Key Product Options

SMALL PLANTLETS
(more common for large farmers)

LARGE PLANTLETS
(more common for small farmers)

FARMER ORDER PLACED

Biofactory Lab

MULTIPLICATION

ROOTING

Shipped to farmer

Biofactory Greenhouse

GROWTH AT BIOFACTORY GREENHOUSE

Farmer Greenhouse / Nursery

ACCLIMITIZATION AT FARM

Shipped to farmer

Field

PLANTED IN FIELD

CONTEXT | GLOBAL DEVELOPMENT

Biofactory Demand Planning

Orders typically taken 4-12 months in advance by a biofactory administrator via phone calls; this practice of advance orders makes demand planning more feasible for biofactories

TC material is shipped directly to the individual farmers; there are no satellite nursery operations that serve as distributors or enablers between biofactories and farmers

Shipping & transportation costs are the responsibility of the farmers; for longer distances, smaller plantlets are more ideal than large plantlets

Depending on the biofactory, business may be entirely or majority from large farmers; however, small farmers also participate in TC material purchases

Contracts are put in place for the great majority of orders. Typically 30-50% of the payment is due at time of order and the remainder is paid in installments after order is fulfilled

Producer Demand Planning

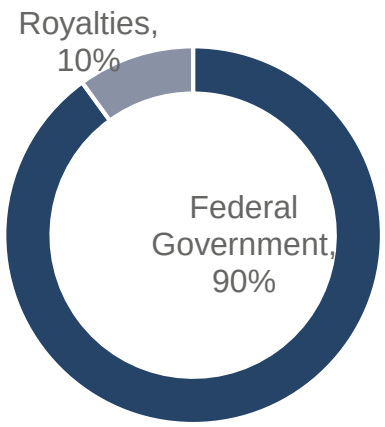
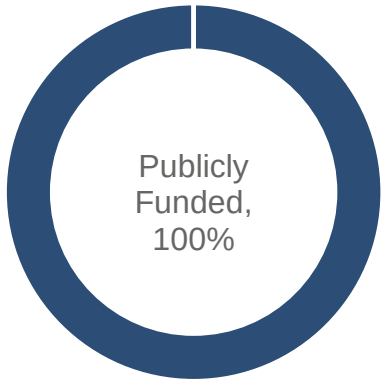
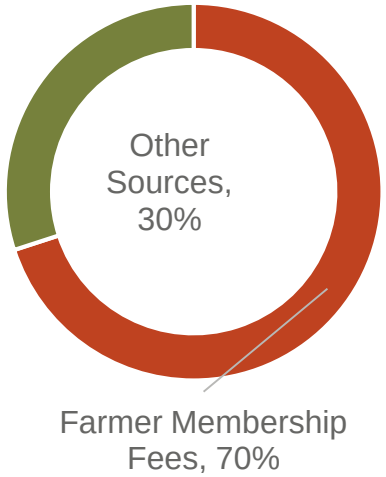
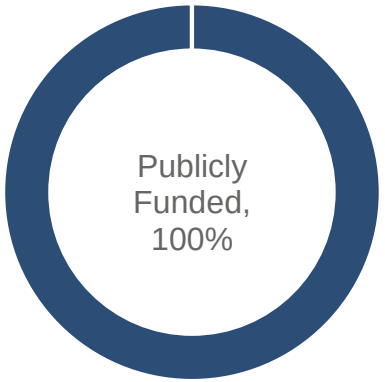
The varietal preferences of bananas (Prata, Cavendish, Pacovan, BRS Princesa, Silk, etc.) are consistent year-over-year since most production is consumed domestically and taste preferences do not dramatically shift

The banana market has been continuously growing but is dynamic (demand is cyclical with periods of boom/bust every 2-5 years)

Farmers strive to maximize production during market windows (Jan-Mar for Prata and Jun-Aug for Cavendish) when banana prices are highest; Timing for the first 2-3 harvest cycles is easier to manage; after a few years the harvest schedule is more sporadic and the best market windows are difficult to achieve

Financial Sustainability

Financial Sustainability

	Brazilian Agricultural Research Corporation	Brazilian Regional Seedling Distributors	Federal Ministry of Agriculture and Livestock	Farmer Associations	State Government Organizations
ORGANIZATION	Embrapa	Campo/ Biocell / Multiplanta / others	MAPA	Abanorte, Asbanco, Abavar, Frutas Oeste Bahia	IDAM *(Instituto de Desenvolvimento Agropecuario e Florestal Sustentavel do Estado do Amazonas)*
ESTIMATED FUNDING SOURCES					

CONTEXT | GLOBAL DEVELOPMENT

Estimated Revenues of two leading biofactories

Multiplanta TECNOLOGIA VEGETAL

# plantlets total	3,000,000

	Large Plantlets	Medium Plantlets
Price per plantlet ($R)	BRL 2.10	BRL 1.70
% plantlets	60%	40%
# plantlets	1,800,000	1,200,000
Revenue ($R)	BRL 3,780,000	BRL 2,040,000
Total Revenue ($R)	**BRL 5,820,000**	
Total Revenue (USD)	**$1,492,308**	

Biocell

# plantlets total	3,500,000

	Large Plantlets	Medium Plantlets
Price per plantlet ($R)	BRL 2.00	BRL 1.70
% plantlets	70%	30%
# plantlets	2,450,000	1,050,000
Revenue ($R)	BRL 4,900,000	BRL 1,785,000
Total Revenue ($R)	**BRL 6,685,000**	
Total Revenue (USD)	**$1,714,103**	

Neither Multiplanta nor Biocell are multiplying farmers' positively selected materials; all plantlets are produced from mother plants from clonal gardens

CONTEXT | GLOBAL DEVELOPMENT

Biofactory interviews; assumes 1 USD = 3.9 BRL

Estimated revenue of TC materials sourced from clonal library vs. positively selected

Two partnerships of positively selected TC multiplication were discovered:

FLORA biotecnologia mudas micropropagadas

ELITE BIOFACTORY

RGN BIOFACTORY

1

Grupo Borborema

Borborema purchases ~150-300k plantlets from positively selected material annually at R$1.75/plantlet

	Clonal library	Positively selected
# Plantlets (total across 3 labs estimated to be ~900k)	500,000	400,000
Cost per plantlet	BRL 1.40	BRL 1.75
Revenue ($R)	BRL 560,000	BRL 875,000
% Revenue	39%	61%
Total Revenue ($R)	**BRL 1,435,000**	
Total Revenue (USD)	**$367,000**	

2

CAMPO FAZ DESENVOLVIMENTO SUSTENTÁVEL

Farm of Marcos Ribeiro

Marcos Ribeiro purchases ~100k plantlets from positively selected material annually at R$2.10/plantlet

	Clonal library	Positively selected
# Plantlets (total ~600k)	500,000	100,000
Cost per plantlet	BRL 1.70	BRL 2.10
Revenue ($R)	BRL 840,000	BRL 210,000
% Revenue	80%	20%
Total Revenue ($R)	BRL 1,050,000	
Total Revenue (USD)	$269,000	

CONTEXT | GLOBAL DEVELOPMENT

Biofactory & farmer interviews; assumes 1 USD = 3.9 BRL

Assumes no additional positively selected TC multiplication partnerships exist; in reality small labs could be doing more

Enabling Environment

Regulatory Timeline (Ministry of Agriculture and Livestock – MAPA)

2003

Law 10711

Establish norms of production across many crops, designates technical responsible supervisor nurserymen, supervising all phases. In order to open plantlet company, need to get permission with this law

Of the registered biofactories, all banana seedlings go through the registration (non-registered are other fruits) and annual / biannual audits by MAPA

Defines THREE classes of plantlets
(All three are common; non-certified does not represent poor quality)

1 Non-certified without genetic origin

Clones collected from field – Technical report required to prove it is virus free

2 Non certified with genetic origin

Cones provided by Empraba

3 Certified

Certified and documented according to standards of MAPA, free to be marketed to all Brazilian states and abroad

2005

Normative Instruction No 24

Establish basic guidelines to be followed for the production, commercialization and use of planting material within the National territory, in order to assure identity and quality to any one interested in purchasing from companies in Brazil.

2010

Normative Instruction No 46

More quality control for banana plantlets and prove mother plants have been tested for viruses (Banana Streak Virus & Cucumber Mosaic Virus)

Happened because large farmers complained to MAPA, MAPA asked Embrapa to help implement feasible legislation to improve quality

Every 5 years it is put on private-public consultancy for alternating as needed

2012

Normative Instruction No 22

Establish the Standards for the Production and Marketing of Seedlings and other types of planting material obtained through Plant Tissue Culture

MAPA performs routine audits on biofactories

CONTEXT | GLOBAL DEVELOPMENT

Universidade Federal de Lavras Virus Indexing Center (CIV/UFLA)

DR. ANTÔNIA FIGUEIRA, Professor & Lab director of CIV/UFLA since 1993

As part of the regulated TC production process, biofactories are required to send samples (0.2% of their materials) to test two key viruses:

- Banana Streak Virus (BSV)
- Cucumber Mosaic Virus (CMV)

CIV/UFLA is one of the few virus indexing centers officially accredited by the Ministry of Agriculture to do this testing

- Test 50,000 samples per year
- Costs $R20/sample

The lab also plays an important role in shaping regulatory decisions with MAPA:

Tests international banana plantlet materials:
Ecuador is trying to enter the Brazilian plantlet market, but CIV/UFLA discovered virus in their materials and has worked with the Brazilian government to ensure regulations apply to imported materials

Argues for all TC materials to be screened as positive selection becomes more mainstream:
Small, Dutch-owned biofactories are trying to achieve an exception in the regulations for positively selected multiplied materials (side-stepping the virus testing requirement) but CIV/UFLA is working with MAPA to discourage this from passing due to the risk of virus dissemination

Projeto Famoso

Projeto Famoso is a government funded agricultural production region created in 1980s

There is a total of 9,800 hectares, 90% of which is banana (10% melon)

Originally intended for grain production but shifted to primarily banana production due to favorable agronomic conditions and demand

Government funded the installation of an irrigation system; now water management and ongoing maintenance done by farmer associations (via membership fees)

Canal irrigation systems provide essential water but also accelerates disease spread across the region

Now the region is almost fully privately owned and maintained

- 972 farmers with 6 hectares or fewer
- 188 farmers with 6-100 hectares

~70% of fruit produced in this region goes to Brasilia or Goiania

CONTEXT | GLOBAL DEVELOPMENT

IFB has an ongoing initiative to bring biofactory/ greenhouse to Projeto Famoso region

INSTITUTO FEDERAL
Baiano

Campus Bom Jesus da Lapa

Helder Sampaio is a former Embrapa employee who now is working at IFB to support technical agronomy classes and farmer extension services

One ongoing initiative Helder is spearheading is to bring a local biofactory and/or greenhouse nursery to the Bom Jesus da Lapa region of Bahia

RATIONALE	Currently the “Projeto Famoso” region has many farmers producing bananas, but all the planting materials are being sourced from CAMPO, Multiplanta, Biocell, etc. (each hundreds or thousands of km from the production region)
OPERATIONAL STRUCTURE	Seeking a Public-Private Partnership between IFB and a private company (~R$500K still needed); Plan to retro-fit an existing facility for biofactory specifications
FACILITY	Considering a range of options: • (Primary) Biofactory to produce banana TC plantlets • (Secondary) Greenhouse / Nursery to support acclimation of small TC plantlets in-region before planting
ENABLEMENT FROM LARGE FARMERS	If the project of IFB would be successful, Nelson Jr & Filipe (large farmers in area) would be interested in supporting small farmers w/ their greenhouse/nursery capacities

CONTEXT | GLOBAL DEVELOPMENT

Banana Farmer Associations

Four farmer associations represent

~60% of banana production in Brazil

Jaranuba-Minas Gerais	Corupa-Santa Catarina	Vale do Rebeira-Sao Paulo	Bom Jesus da Lapa-Bahia
abanorte	ASBANCO	ABAVAR	FRUTAS Oeste Bahia
			(Banana da Bahia)

Bananas da Bahia – Farmer Association

Ervino Kogler
Director

28 associated farmers in Banana da Bahia

In addition to membership fees, farmers pay the association R$1 for each 22-kilo box of bananas sold

Almost **12 years old**

Director – two roles administrative and the other commercial – both voted in and receive salaries. Must be producers.

1

Primary focus of the association commercial: Have brokers who sell directly to distributors or retailers and guarantee a minimum price regardless of the time of year

After harvest, association supports sell of banana fruit

Farmers paid a maximum of 45 days after delivery (independent of when it's sold in store) with check issued weekly

2

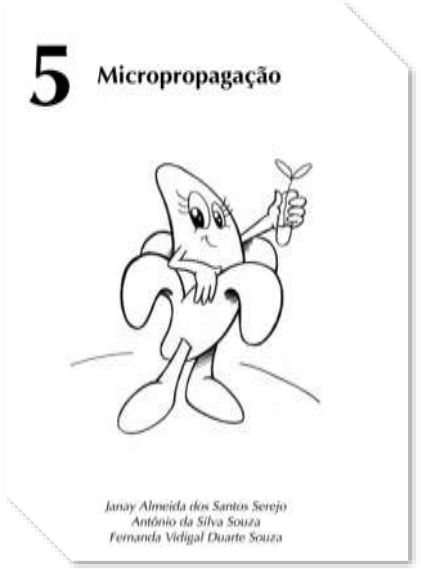
Secondary focus is on supporting the purchase of TC materials; group of large farmers join to place a large order and achieve better price w/ biofactories, but do not rely on this as only method (also purchase directly)

Embrapa Provides Agronomic & Economic Guidance to Brazilian Banana Producers

Embrapa's series of 500 Questions, 500 Answers contains information generated from questions raised by the The Customer Service Department (SAC) of Embrapa Mandioca and Fruticultura, through letters, phone calls, fax and e-mail, researchers and technicians.

Cultivar Information

Micropropagation



Soil Management

Economics

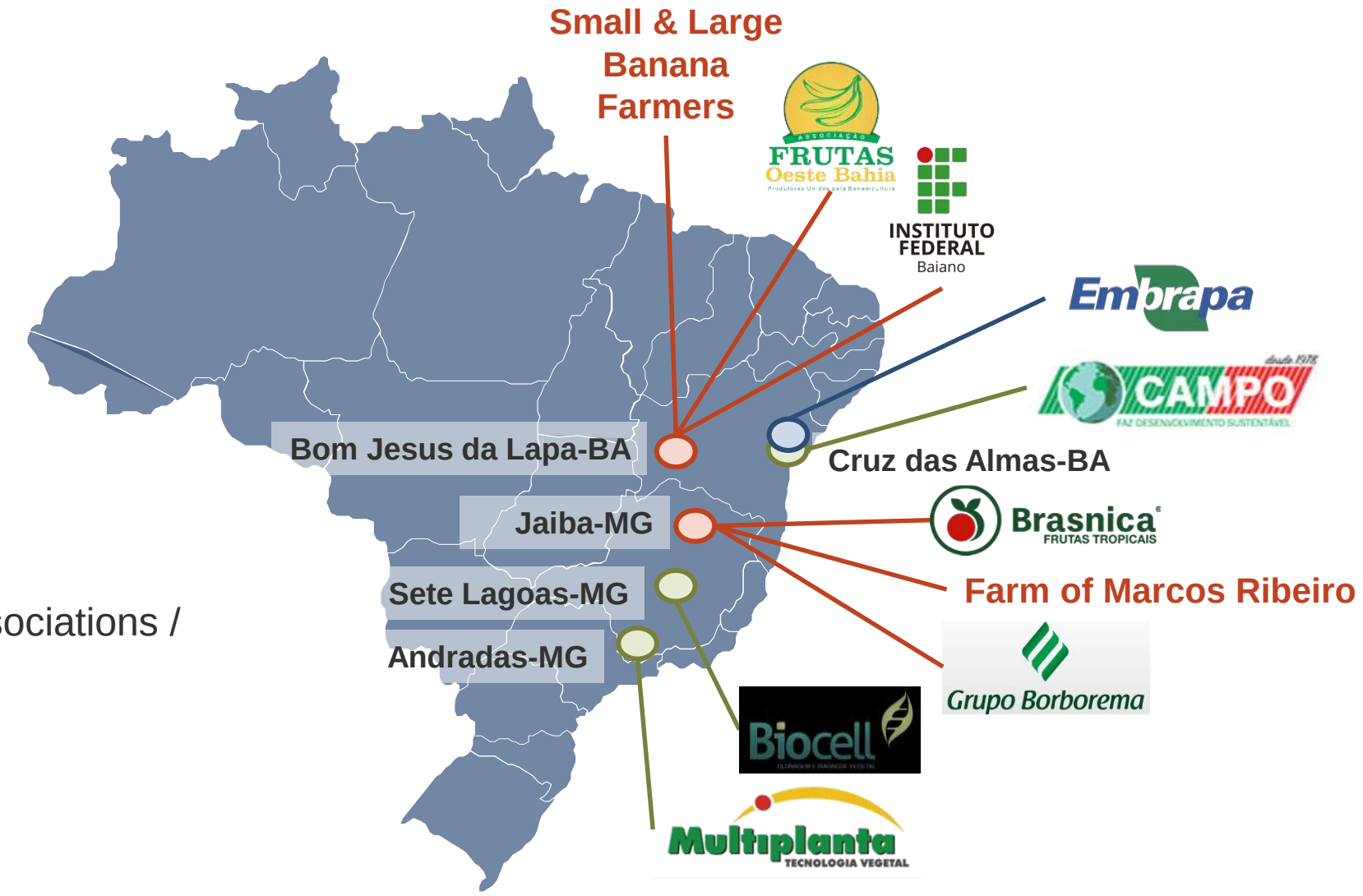
CONTEXT | GLOBAL DEVELOPMENT

Source: Embrapa's 500 Answers, 500 Questions

ACKNOWLEDGE-MENTS

May 6-11, 2019: Tour Included Visits to Leaders Throughout the Value Chain

- Research
- Biofactories
- Farmers / Farmer Associations / Academic Enablers



CONTEXT | GLOBAL DEVELOPMENT

Thank you for your time and support in the development of this Brazil Banana profile

Case profile built off of leading firms and farmers in the industry; as relevant, differences will be described for smaller or more mainstream actors in the banana production system

CONTEXT | GLOBAL DEVELOPMENT

Stakeholders Consulted

Name	Position	Organization
Herminio Souza Rocha	Analyst on Business Technology Transfer	Embrapa Cassava & Fruits
Edson Perito Amorim	Researcher – Banana Breeding	Embrapa Cassava & Fruits
Francisco Farraz Laranjeira	Assistant Director – R&D	Embrapa Cassava & Fruits
Mario Borborema	Director	Borborema Hortifuti
Edilson Paiva	Director	Biocell Clonagem e Diagnose Vegetal
Marcio de Assis	Partner & Administrator	Multiplanta Tecnologia Vegetal
Ervino Kogler	President & Director	Banana da Bahia
Nelson Estevao da Silva Jr.	Agronomic Engineer & Farmer	Banana da Bahia
Helder Sampo	Professor	Instituto Federal Baiana
Antonia Figueira	Professor / Head of Indexing Center	Universidade Federal de Lavras

thank you

CONTEXT | GLOBAL DEVELOPMENT

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