

SolubPhos - Inoculant as a support for phosphorus fertilization

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MINISTÉRIO DA
AGRICULTURA E
PECUÁRIA



Embrapa - Brazilian Agricultural Research Government Corporation

Every US\$ 1 invested in Embrapa by the Federal government generates an average return of US\$ 13.20 for the Brazilian society



Embrapa
Headquarter
Brasília

Embrapa
Maize and Sorghum
Sete Lagoas - MG - Brazil



- 47 research centers
- 4 laboratories/offices abroad
- 9,234 employees

Brazil is a powerhouse agricultural producer – 3 seasons of cropping/year

Production

244,9

Millions of tons

Grains

28,1

Millions of tons

Meat

43,6

Millions of tons

Fruits

35,4

Billions of liters

Milk



Fonte: IBGE; USDA; Cepea
Fonte referência: Embrapa/Sire - Novembro/2021

- Brazil has a largest area of agriculture and net exported in the world
- Is the top-5 producers of 34 commodities:
- soybean, maize, sugarcane, coffee, cotton, meat, etc

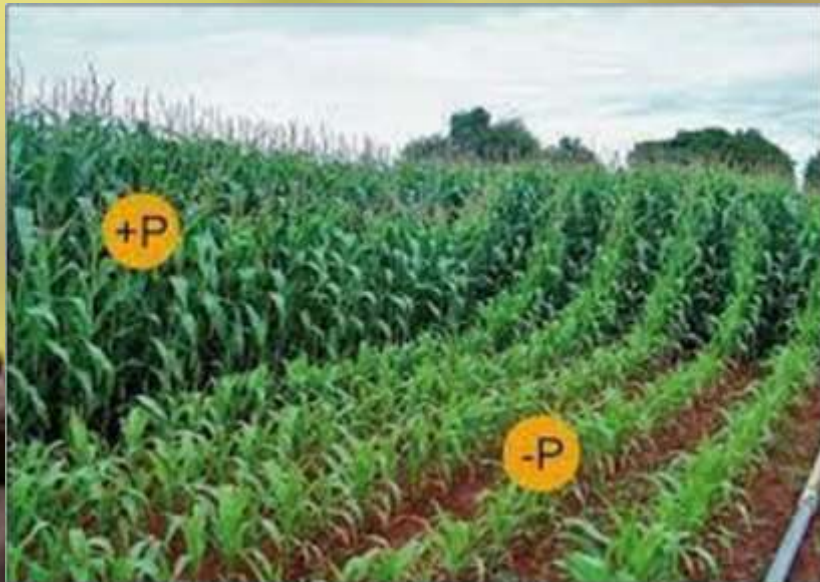
15

P

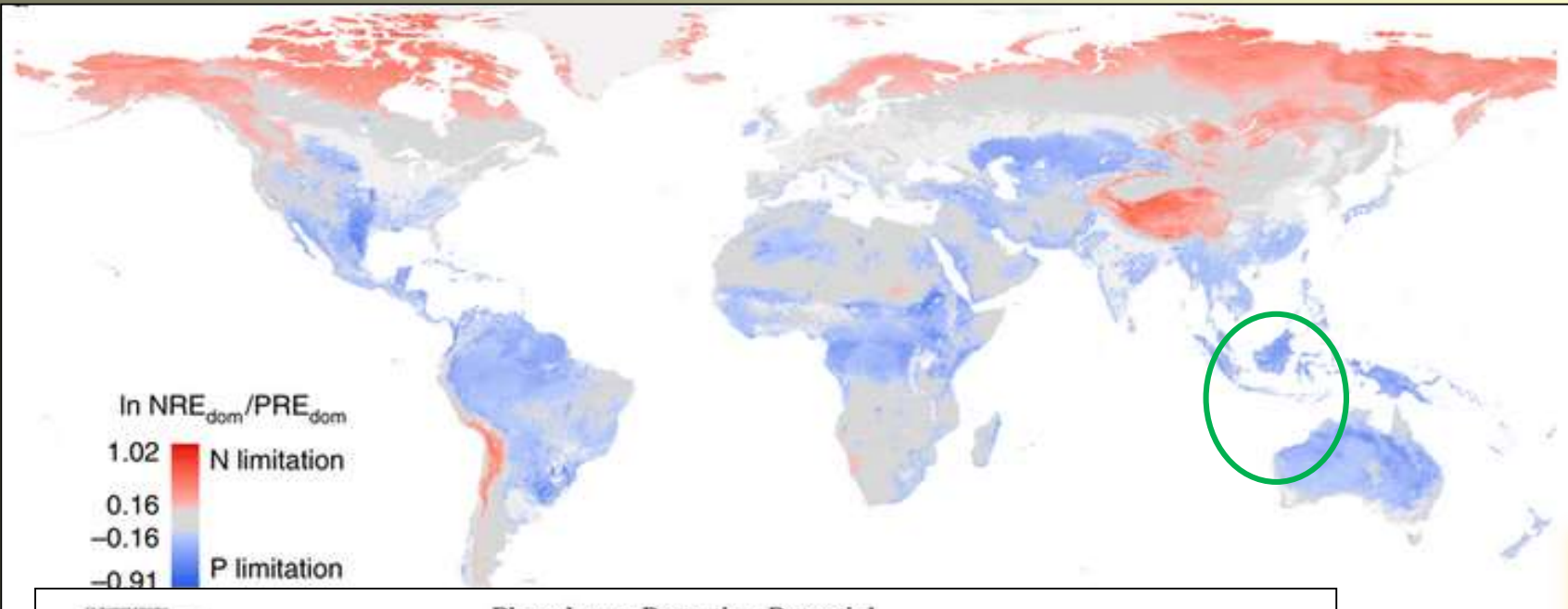
Phosphorus

30.974

PHOSPHORUS is important to plant energy, root growth, and food productivity



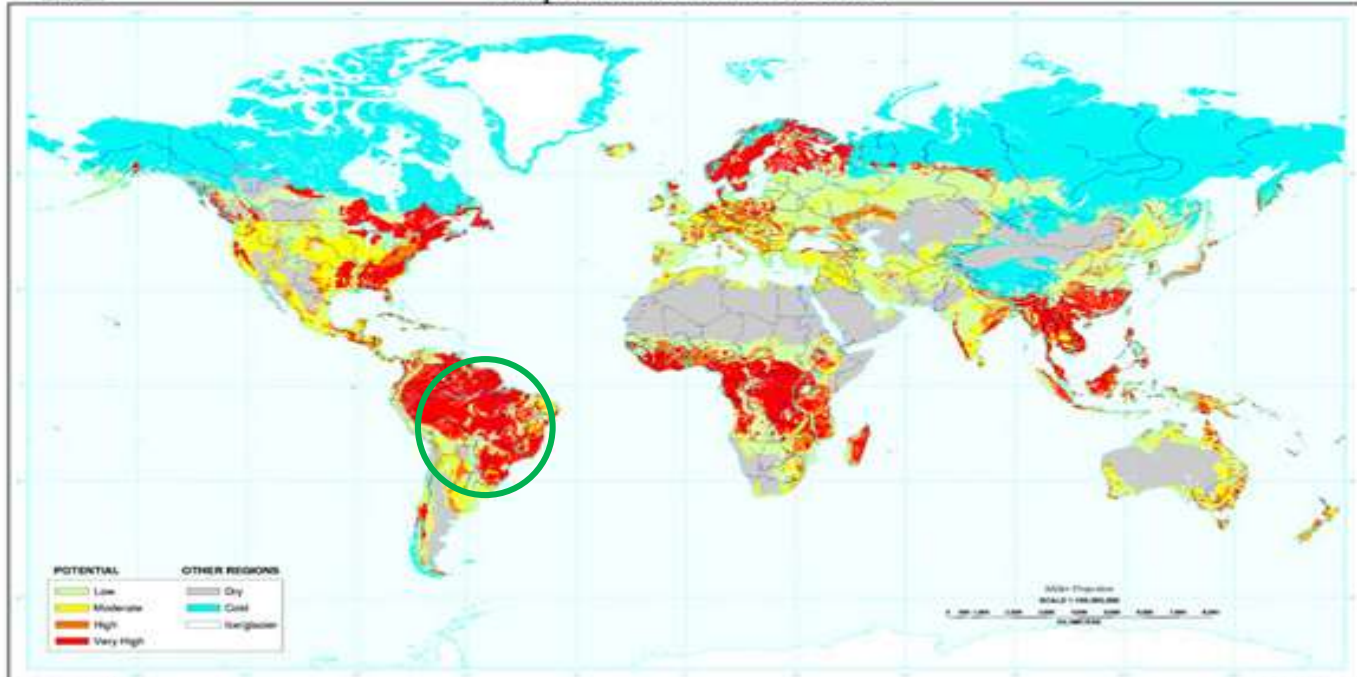
Global P Limitation and LEGACY P



Brazilian soils:

Low available P, oxides of Fe and Al, clays and High retention potential

Phosphorus Retention Potential



- Increase the demand for synthetic P fertilizer
- Higher production cost to Brazilian farmers
- Only 20% phosphate is reused by plants



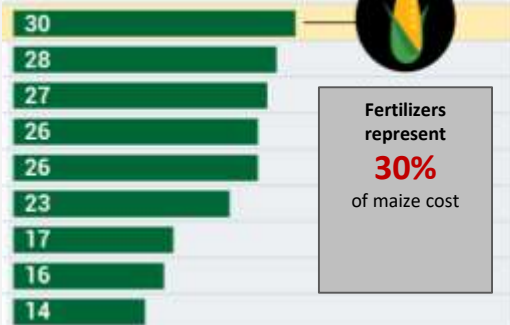
Brazil's dependence on **PHOSPHATE imports** - World Increasing demand for fertilizers

FERTILIZERS REPRESENT UP TO 30% OF THE PRODUCTION COSTS

Product

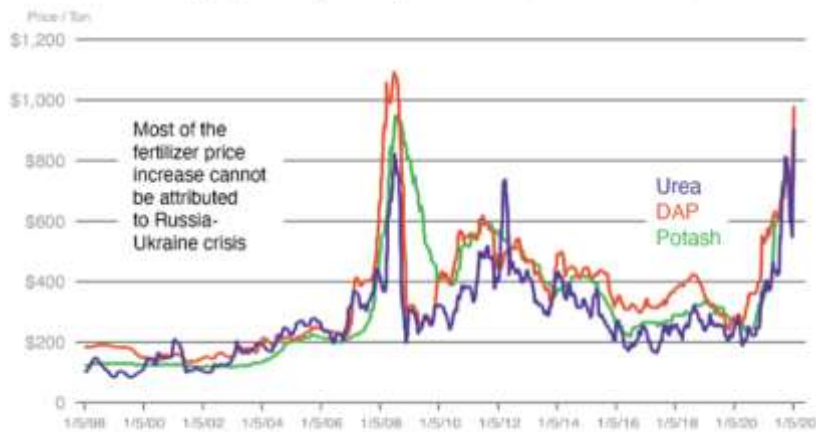
Maize 1st season
Wheat
Maize 2nd season
Bean
Coffee
Soybean
Rice
Sugarcane
Cotton

var. %



Fertilizers represent **30%** of maize cost

Chart 1. Monthly Index Prices for Key Nitrogen, Phosphatic, and Potassic Fertilizers



BRAZIL DEPENDS ON FERTILIZERS IMPORT

Brazilian average consume: **40 millions** tons, considering 1/3 for each group (NPK)



Importance:

Fertilizers are used in Brazilian agriculture, from the **commodities** (eg. soybean, maize and sugarcane) to **smallholders** (eg., rice, beans and vegetables)

Fertilizers (NPK)

Import on average:

Main sources:

Nitrogen (N)



Russia, China and Middle East

Phosphate (P)

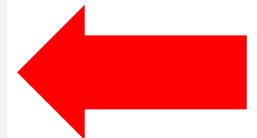


China, Marocco and Russia

Potassium (K)



Belarus, Canada and Russia



Biological solution: Efficient phosphorus cycling In the nature for the production system



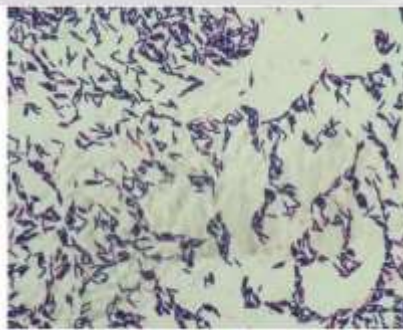
Fonte: <https://mycoterra.com/wp-content/uploads/La-vida-secreta-de-las-plantas.jpg>

P solubilizing and mineralizing microorganisms and Mycorrhiza

The first Technological BIO Solution was launched in 2019, Brazil



Bacillus megaterium
CNPMS B119



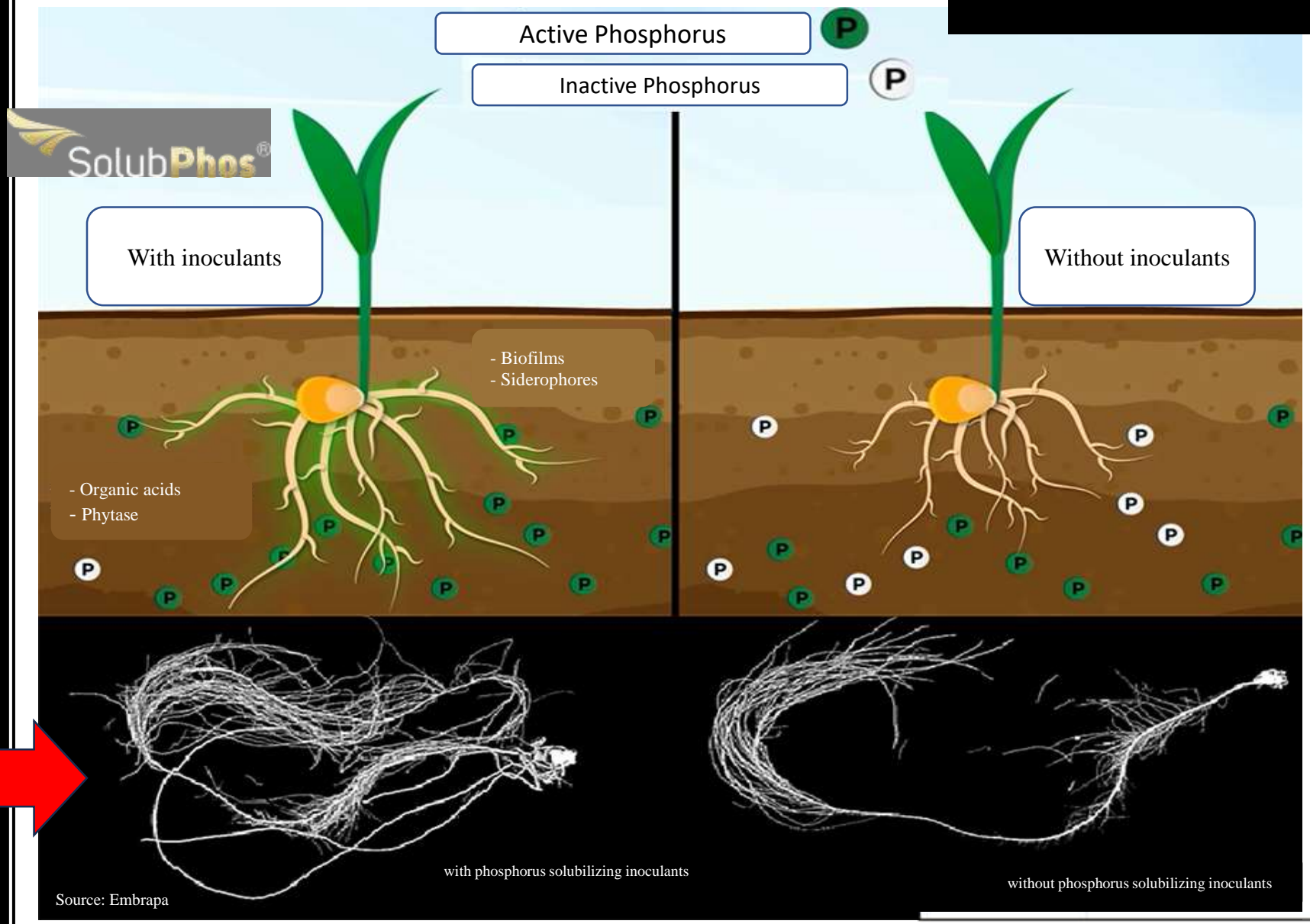
Bacillus subtilis
CNPMS B2084



- Different mechanisms of P solubilization and plant promoting growth
- rhizospheric and endophytic strains



MODE of ACTION



Published: 29 May 2020

Tropical *Bacillus* Strains Inoculation Enhances Maize Root Surface Area, Dry Weight, Nutrient Uptake and Grain Yield

Sylvia Moraes de Sousa, Christiane Abreu de Oliveira, Daniele Luiz Andrade, Chainery Gomes de Carvalho, Vitória Palhares Ribeiro, Maria Marta Pastina, Ivanildo Evódio Marriel, Ubiraci Gomes de Paula Lana & Eliane Aparecida Gomes

Journal of Plant Growth Regulation (2020) | Cite this article


30 Accesses | Metrics



SolubPhos

P moves slowly in the soil (max. 2-3 cm/year)

Source: Embrapa

 SolubPhos[®]



Bacillus megaterium
CNPMS B119



Bacillus subtilis
CNPMS B2084



PHOSPHATASE

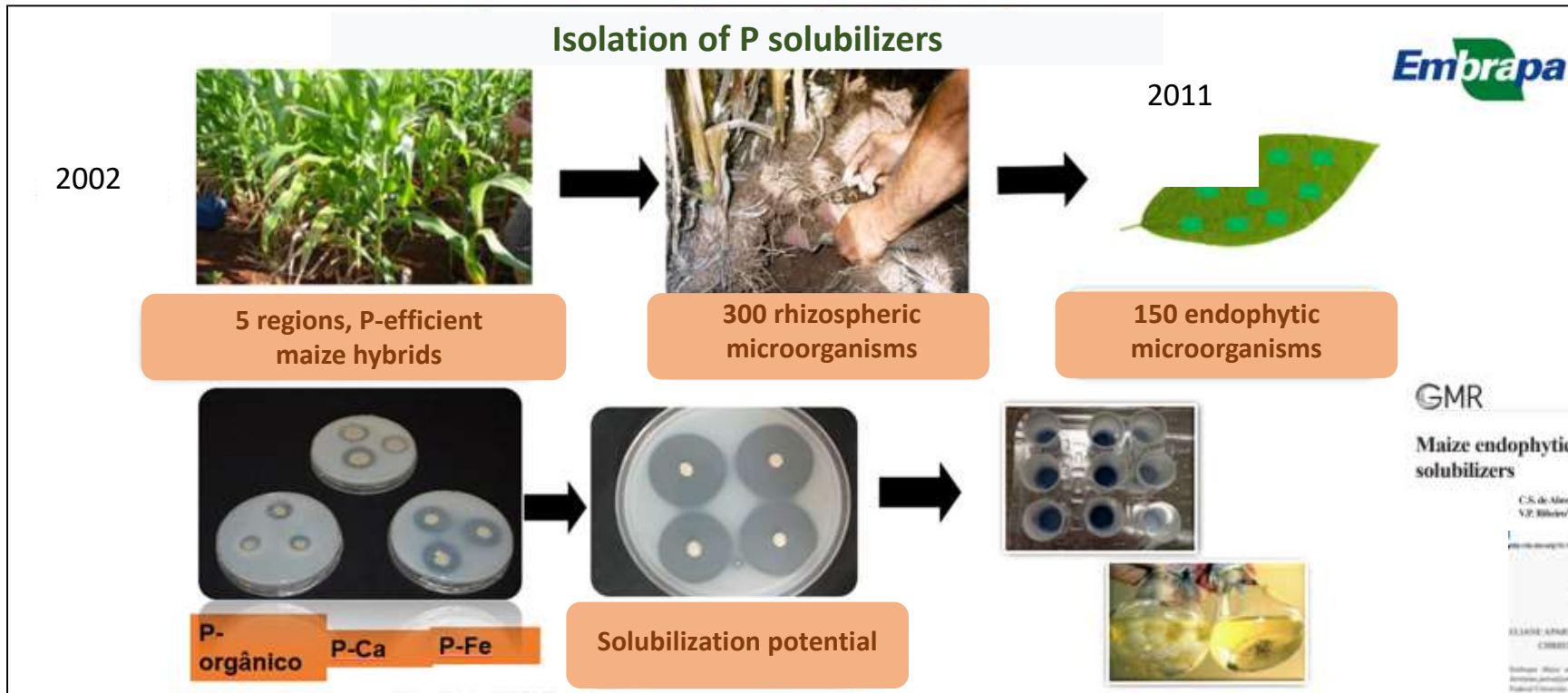
*Phosphorus
Organic*



From bacteria to bioinoculant - steps



History of isolation and selection of *B. subtilis* and *B. megaterium* strains in Brazil



Soil Biology and Biochemistry 41 (2009) 1760–1767

Contents lists available at ScienceDirect

Soil Biology and Biochemistry

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

Phosphate solubilizing microorganisms isolated from rhizosphere of maize cultivated in an oxisol of the Brazilian Cerrado Biome

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^aFederal University of Minas Gerais, Biome Department, CP 480, 35278-900 Belo Horizonte, MG, Brazil

^bEndeavor Mair and Sangham, CP 311, 35183-870 São Leopoldo, MG, Brazil

BRAZILIAN JOURNAL OF MICROBIOLOGY 45S (2018) 40-46





Brazilian Journal of Microbiology

http://www.bjmicrobiol.com.br/

Environmental Microbiology

Endophytic *Bacillus* strains enhance pearl millet growth and nutrient uptake under low-P

Vitória Palhares Ribeiro^a, Ivanildo Evódio Marriel^b, Sylvia Moraes de Sousa^a, Ubiraci Gomes de Paula Lana^a, Bianca Braz Mattos^a, Christiane Abreu de Oliveira^{a,*}, Eliane Aparecida Gomes^{a,c,d}

-  Efficiency in the solubilization of rock phosphates
-  Efficiency in the solubilization of iron phosphates
-  Efficiency in the solubilization of organic phosphates
-  Production of IAA, enzymes, phosphatases, biofilm, EPS

Maize Inoculation of selected *Bacillus* on the greenhouse conditions



Archives of Microbiology (2022) 204:143
<https://doi.org/10.1007/s00203-022-02759-3>

ORIGINAL PAPER

Co-inoculation with tropical strains of *Azospirillum* and *Bacillus* is more efficient than single inoculation for improving plant growth and nutrient uptake in maize

Vitória Palhares Ribeiro¹, Eliane Aparecida Gomes², Sylvia Morais de Sousa^{1,2,3}, Ubiraci Gomes de Paula Lana^{2,4}, Antonio Marcos Coelho⁵, Ivanildo Evódio Marmel^{1,2,4}, Christiane Abreu de Oliveira^{1,4}



BRAZILIAN JOURNAL OF MICROBIOLOGY 475 (2018) 40-46



BRAZILIAN JOURNAL OF MICROBIOLOGY

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Environmental Microbiology

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^a Universidade Federal de São João del-Rei, Sete Lagoas, MG, Brazil

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^c Empresa Solos, Rio de Janeiro, RJ, Brazil



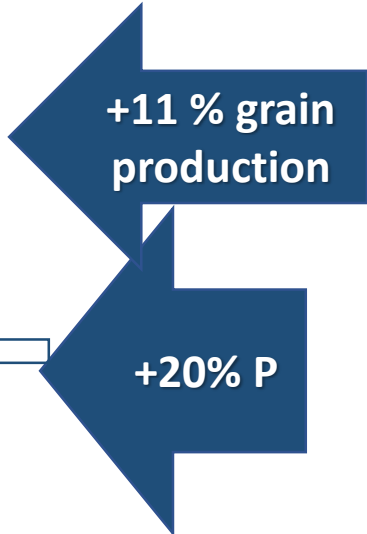


Bacillus Inoculation in maize under field conditions

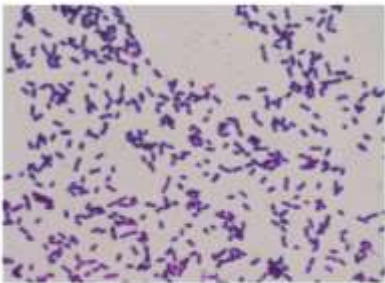
Table 5 Adjusted means for yield and grain phosphorus content of maize inoculated with strains B2084, B119, B116 and B70 after 120 days of cultivation under field conditions with no P added (P0) and triple superphosphate (TSP)

Treatment	Yield (kg ha ⁻¹)*		P grain (g kg ⁻¹)*	
	P0	TSP	P0	TSP
B2084	9082.85 ^{Ab}	8688.74 ^{Ab}	20.25 ^{Ac}	25.10 ^{Bb}
B119	8659.41 ^{Abcd}	10084.73 ^{Ba}	24.35 ^{Ab}	29.02 ^{Ba}
B116	11003.90 ^{Aa}	9430.11 ^{Ba}	31.79 ^{Aa}	25.66 ^{Bb}
B70	8370.80 ^{Acd}	8290.12 ^{Ab}	23.15 ^{Ab}	24.45 ^{Ab}
Non-inoculated	8089.37 ^{Ad}	8013.92 ^{Ab}	20.17 ^{Ac}	23.47 ^{Bb}

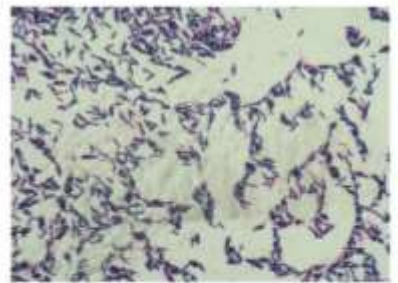
*Adjusted means followed by the same lower case letters indicate not significant differences between strains, and identical capital letters indicate not significant differences between P sources by Tukey's test ($p < 0.05$)



First seasons: 5 strains
Last seasons: 2 strains
CNPMS B2084
CNPMSB119



Bacillus megaterium
CNPMS B119



Bacillus subtilis
CNPMS B2084

Tropical *Bacillus* Strains Inoculation Enhances Maize Root Surface Area, Dry Weight, Nutrient Uptake and Grain Yield

Sigla Maria de Souza^{1,2,3}, Christiane Ribeiro de Oliveira^{1,2}, Daniela Lide Andrade¹, Cleofany Gomes de Carvalho¹, Silvana Falcão Ribeiro¹, Maria Martha Pereira^{1,2}, Suselma Sábido Moura^{1,2,3}, Wilson Gomes de Paula Lima^{1,2}, Gilson Aparecido Gomes¹

FEMS

RESEARCH ARTICLE
 Genotype-guided insights of tropical *Bacillus subtilis* efficient in maize growth promotion

Carla Cristina Vieira Veloso¹, Christiane Abreu de Oliveira^{2,3}, Eliane Aparecida Gomes¹, Wilson Gomes de Paula Lima^{1,2}, Cleofany Gomes de Carvalho¹, Larissa José Moreira Guimarães¹, Maria Martha Pereira^{1,2} and Sigla Maria de Souza^{1,2,3}

CIRCULAR TÉCNICA 260

Recomendação agrônômica de cepas de *Bacillus subtilis* (CNPMS B2084) e *Bacillus megaterium* (CNPMS B119) na cultura do milho

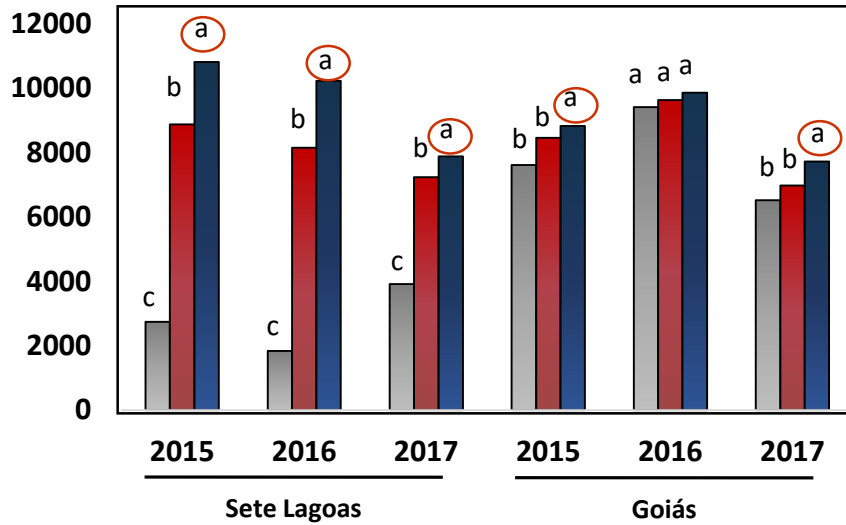
Christianne Ribeiro de Oliveira Pereira, Suselma Sábido Moura, Wilson Aparecido Gomes, Larissa Maria Costa

- Partnership between Embrapa and Simbiose



Validation of *Bacillus* inoculants in maize field

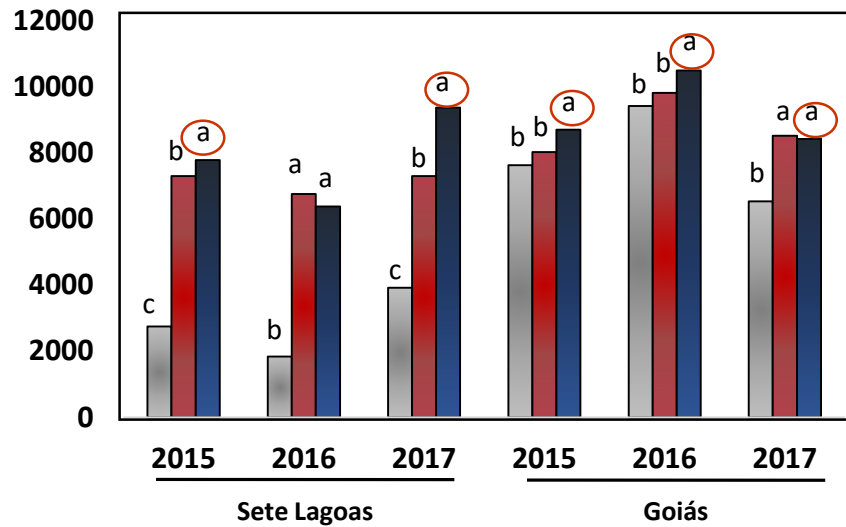
Maize yield (kg ha⁻¹)



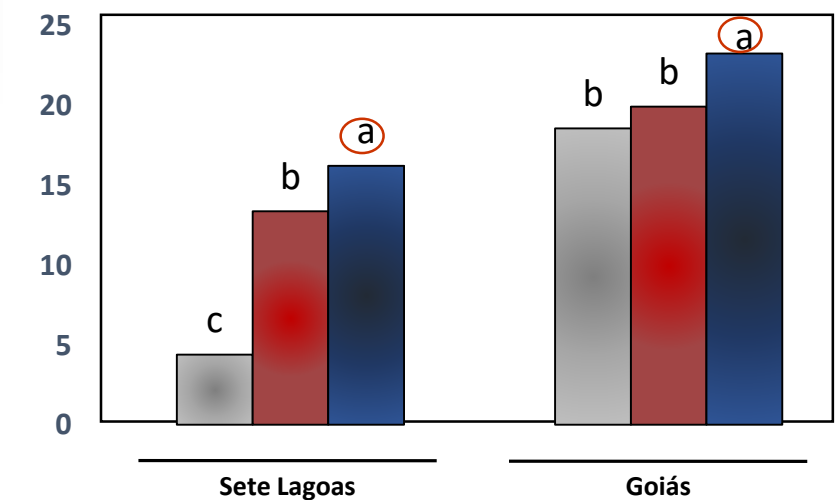
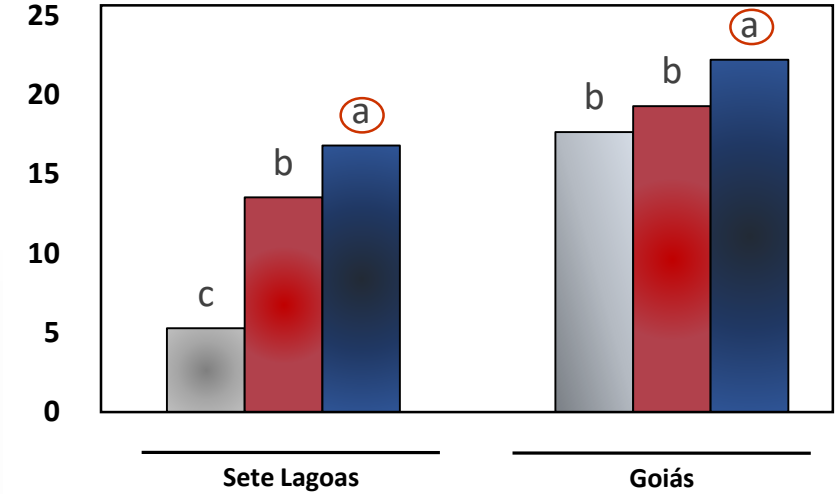
B2084



B119



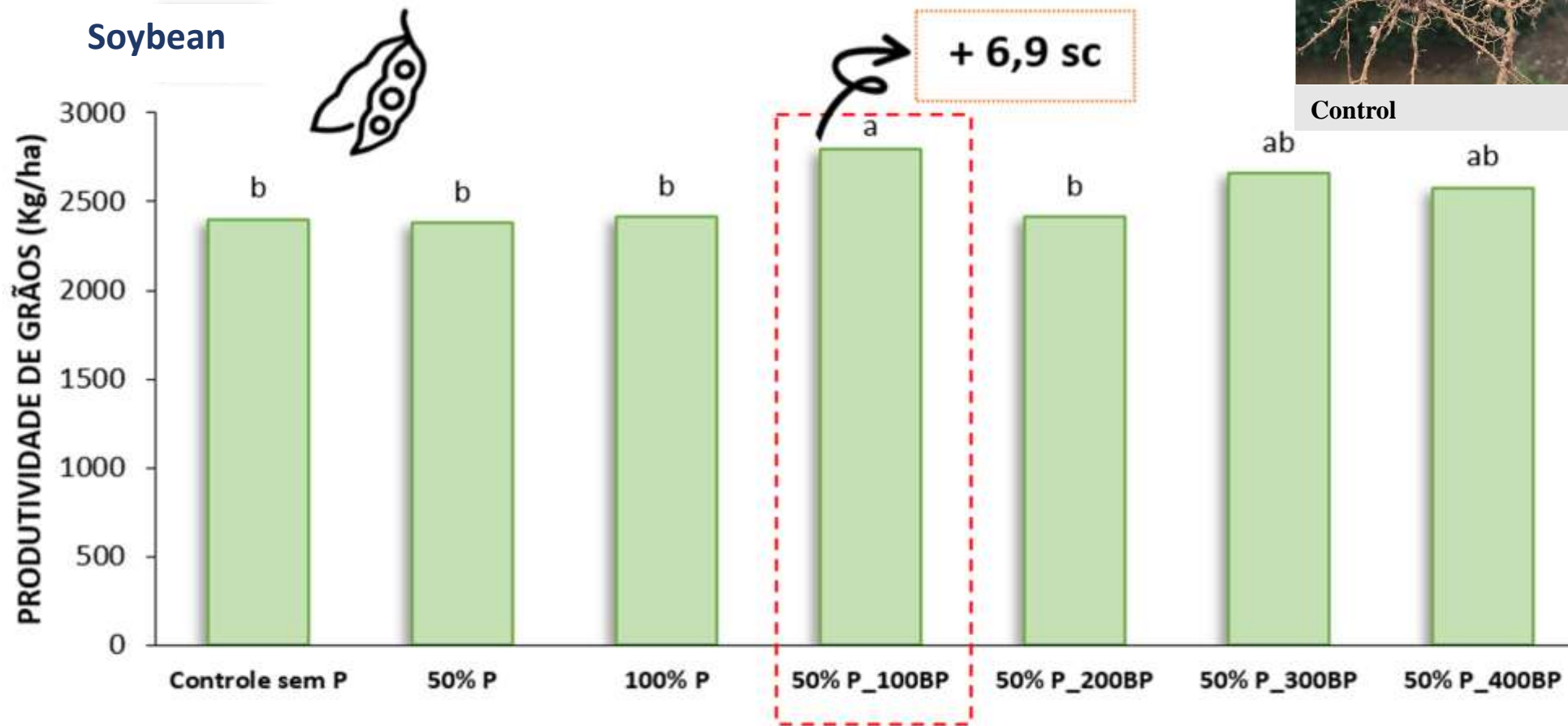
P grain (g kg⁻¹)



- Control
- Phosphate fertilization (- inoculation)
- Phosphate fertilization (+ inoculation)

Oliveira et al. (2020)

Inoculation of soybean with SolubPhos



Control



SolubPhos 150 ml/ha

 Lutécia-SP,
safra 2019/2020.

*Hungria & Nogueira et al, 2020 – Embrapa Soybean



Soybean

Data from 366 Field Tests

Corn

Data from 37 Field Tests



ROI 7.55

ROI 8.9

Sugarcane inoculated with SOLUBPHOS – 2020/2021 season

Sugar Tech
<https://doi.org/10.1007/s12259-023-01126-4>

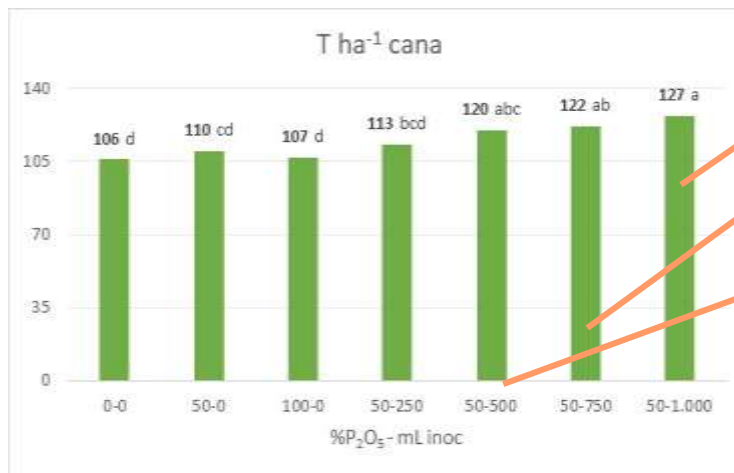
RESEARCH ARTICLE

Evaluation of Sugarcane Yield Response to a Phosphate-Solubilizing Microbial Inoculant: Using an Aerial Imagery-Based Model

Denize Palmito dos Santos¹ · Artur Soares² · Guilherme de Medeiros² · Daniel Christoforetti² · Caio Simplicio Arantes³ · Julio Cezar Souza Vasconcelos³ · Eduardo Antonio Speranza³ · Luiz Antonio Falaguasta Barbosa⁴ · João Francisco Gonçalves Antunes⁵ · Geraldo Magela de Almeida Cançado⁴



Tratamento	% P2O5	Inóculo (mL/ha)
T1	0	0
T2	50	0
T3	100	0
T4	50	250
T5	50	500
T6	50	750
T7	50	1000



20% mais T1
 15% mais T1
 13% mais T1

P inicial resina = 18,8 mg dm⁻³ (Bom)

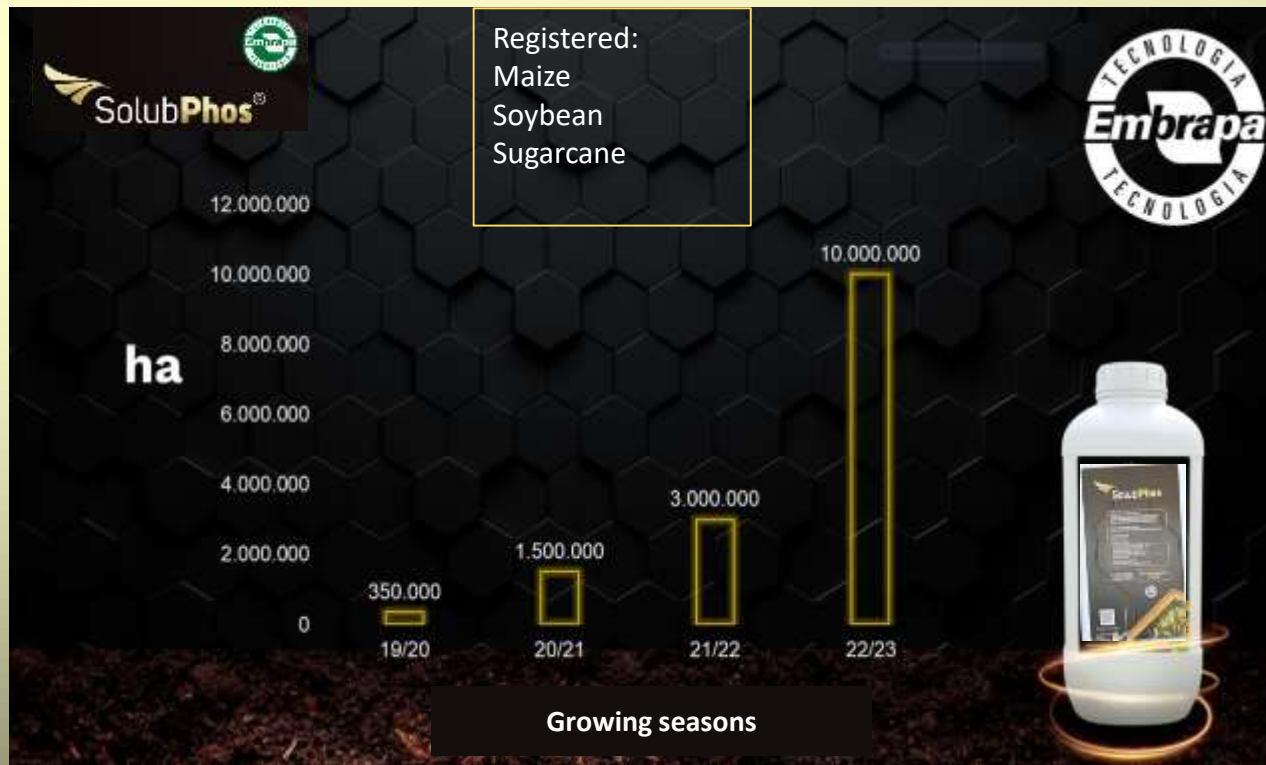


24% mais T1
 16% mais T1
 14% mais T1





**Inoculant to increase phosphorus absorption with microorganisms
that solubilize phosphates – Expanding a lot area in Brazil**



- B119 (*B. megaterium*)
- B2084 (*B. subtilis*)

- Registered in others countries: now in Germany, Argentine, Uruguai, EUA, Canada, Paraguai, etc

NEW TRIALS: Sorghum, brachiaria, tomato, carrot, rice, beans, coffee, wheat, banana, potato, cotton, etc.

Farmers report gains in roots, productivity across the country

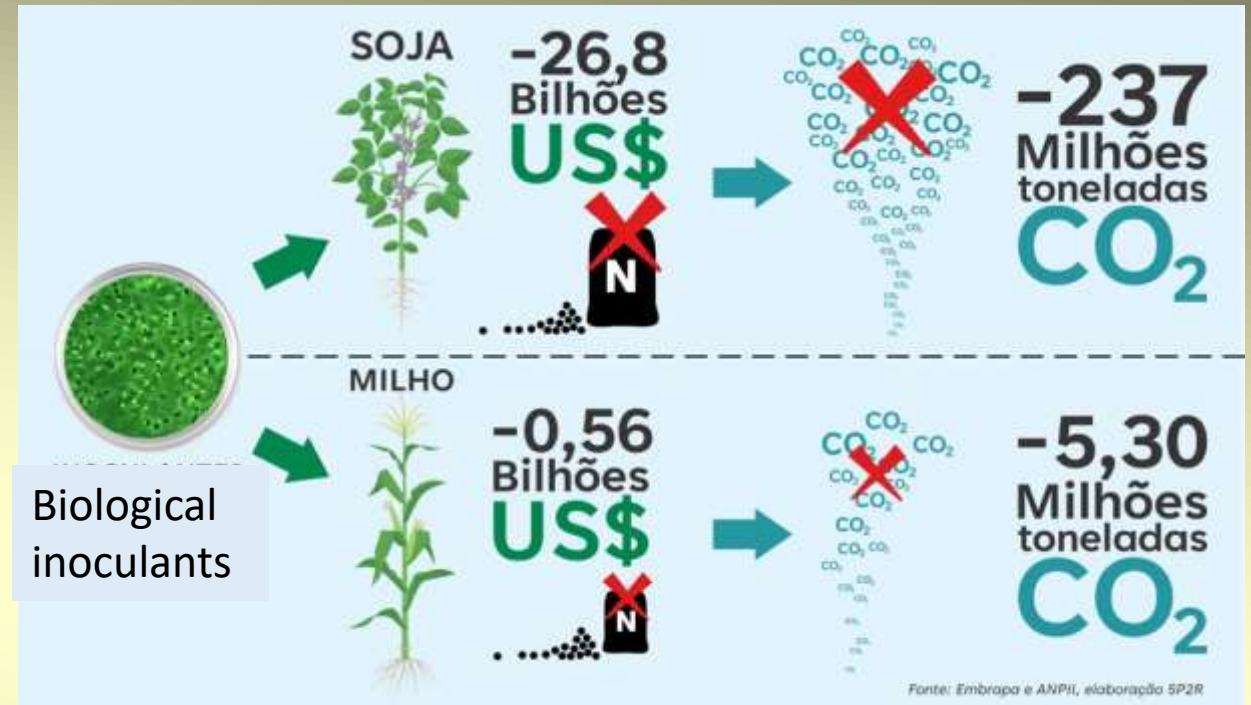
- Good to soil health, low C emissions, low cost, low water pollution, and reduce the use of synthetic fertilizers



- Difference in root initiation in soybean plants inoculated with SolubPhos compared to the untreated control. São Luiz do Oeste, PR.
- potential for **partial or total replacement of synthetic fertilizers**

R\$ 1.3 billion in social profit to the country in 2021: <https://www.embrapa.br/busca-de-noticias/-/noticia/61084904/biomaphos-rendeu-r-105-milhoes-ao-pais-em-2020-com-aumento-de-produtividade-de-soja-e-milho>

Bioinputs: Biological solutions to increase phosphorus and nutrient use efficiency – FAO and ONU goals



Demands

TO ADOPT MANAGEMENT PRATICES THAT INCREASE ORGANIC SOURCES OF NUTRIENTS, NUTRIENT CYCLING, BIOLOGICAL INPUTS AND LOW CARBON AGRICULTURE



Soil Biology and Biochemistry 41 (2009) 1763–1767

Contents lists available at ScienceDirect

Soil Biology and Biochemistry

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

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^aFederal University of Minas Gerais, Botany Department, CP 486, 31270-901 Belo Horizonte, MG, Brazil
^bEmbrapa Maiz and Sorgum, CP 231, 31701-070 Sete Lagoas, MG, Brazil

Biochemical Engineering Journal 198 (2023) 109030

Contents lists available at ScienceDirect

Biochemical Engineering Journal

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

Regular article

High yield of heat-resistant spores of *Bacillus megaterium* in bioreactors

Camila Cristina Vieira Velloso^{a,b}, Bruna Cerri Pereira Camargo^c, Marina Del Bianco Sousa^b, Mariane Molina Buffo^b, Christiane Abreu de Oliveira Paiva^a, Cristiane Sanchez Farinas^{a,b}, Alberto Colli Badino^{b,*}

International Journal of Biological Macromolecules 246 (2023) 125646

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

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

Modification of pectin/starch-based beads with additives to improve *Bacillus subtilis* encapsulation for agricultural applications

Marina Momesso Lopes^{a,b}, Christiane Abreu de Oliveira-Paiva^c, Cristiane Sanchez Farinas^{a,b,d,*}

ROCK PHOSPHATE SOLUBILIZING MICROORGANISMS ISOLATED FROM MAIZE RHIZOSPHERE SOIL

ELIANE APARECIDA GOMES^a, ULIANA DE CÁSSIA SILVA^a, IVANILDO EVÓDIO MARRIEL^b, CHRISTIANE ABREU DE OLIVEIRA^a and UBIRACI GOMES DE PAULA LANA^a

Embrapa Maiz and Sorgum, Sete Lagoas, MG, Brazil; eliane.a.gomes@embrapa.br; ivanildo.marriel@embrapa.br; luciana.palma@embrapa.br; ubiraci.gomes@embrapa.br
 Federal University of Minas Gerais, Belo Horizonte, MG, Brazil; eliane@ufmg.br

BRAZILIAN JOURNAL OF MICROBIOLOGY 49S (2018) 40-46

BRAZILIAN JOURNAL OF MICROBIOLOGY

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Environmental Microbiology

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GMR

Maize endophytic bacteria as mineral phosphate solubilizers

C.S. de Abreu¹, J.E.F. Figueiredo², C.A. Oliveira², V.L. dos Santos³, E.A. Gomes², V.P. Ribeiro¹, B.A. Barros², U.G.P. Lana² and L.E. Marriel^{1,2}

FEMS Microbiology Ecology, 66, 2020, 64217

RESEARCH ARTICLE

Genome-guided insights of tropical *Bacillus* strains efficient in maize growth promotion

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available at www.sciencedirect.com

ScienceDirect

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

Assessment of the mycorrhizal community in the rhizosphere of maize (*Zea mays* L.) genotypes contrasting for phosphorus efficiency in the acid savannas of Brazil using denaturing gradient gel electrophoresis (DGGE)

Christiane A. Oliveira^{a,*}, Nadja M.H. Sá^a, Eliane A. Gomes^b, Ivanildo E. Marriel^b, Maria R. Scotti^a, Claudia T. Guimarães^b, Robert E. Schaffert^b, Vera M.C. Alves^b

^aFederal University of Minas Gerais, Botany Department, PO box 486, 31270-901 Belo Horizonte, MG, Brazil
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<https://doi.org/10.1007/s00203-022-02759-3>

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Journal of Plant Growth Regulation
<https://doi.org/10.1007/s00344-020-10146-9>

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Thank you! Obrigada!

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MINISTÉRIO DA
AGRICULTURA E
PECUÁRIA



A public-private partnership between Embrapa and the company Simbiose is the first to offer an inoculant fully developed from Brazilian technology for the market - SolubPhos

Characteristics

Technology developed in partnership with **EMBRAPA**

Isolates - ***B. subtilis* BRM 2084 + *B. megaterium* BRM 119**

Formulation - **Suspension Concentrate (SC)**

Concentration - **4×10^9 CFU/mL**

Shelf life - **12 months in 25~30°C (77~86°F)**

Application – **In Furrow or Seed Treatment**

Pack Size (actual) – **0,5L, 1,0L, 2,0L.**

2 x 2,5 Gallons = 1 case*

***or another according to necessity**

 Solub**PHOS**



Simbiose®