The role of microbes to enhance soil fertility

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MicroAgro
INCT

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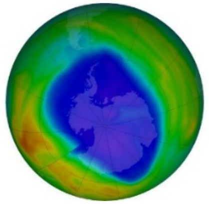
GLOBAL SOIL PARTNERSHIP

Chemical Fertilizers

1) Low efficiency of use by plants

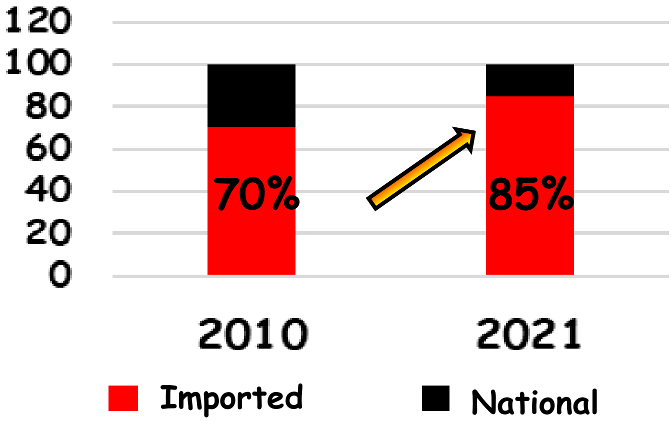
N, 30-50%;
P, 15%;
K, 50-60%

2) Water contamination, emission of GHG



1 kg N = 10.7 kg CO_2-e

3) Price, importation in most countries

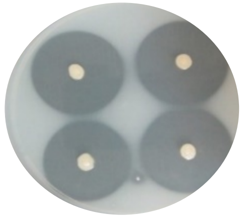


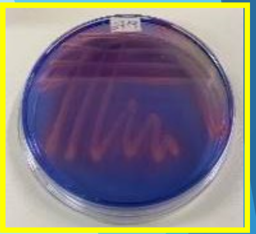
Alternatives?

Plant Growth Promoting Microorganisms

Partially or fully replacing chemical fertilizers

With economic, environmental and social benefits





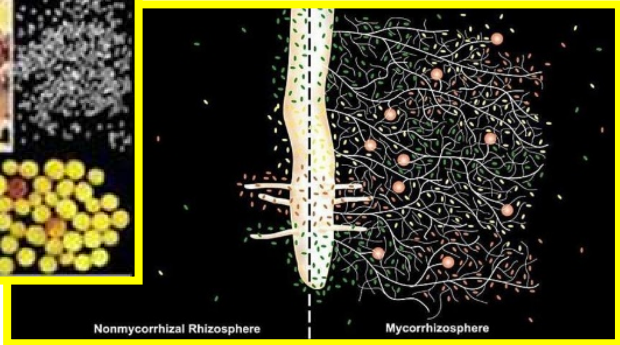
Plenty of opportunities!!!

Inoculants (=biofertilizers)

Phosphorus

Uptake

- ✓ Mycorrhizal fungi



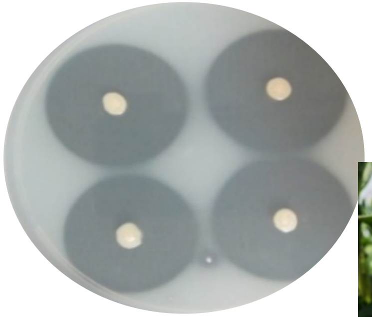
(+)mycorrhiza (-)mycorrhiza

Increase in plant growth >8,000%

Inoculant 2018

Solubilization and uptake

- ✓ CNPMS B2084: *Bacillus subtilis*
- ✓ CNPMS B119: *Bacillus (Priestia) megaterium*



Control | *Bacillus subtilis* B2084

Ribeiro et al. Braz. J. Microbiol. (2018)

Non inoculated | B2084

soybean

sugarcane

Inoculant 2019

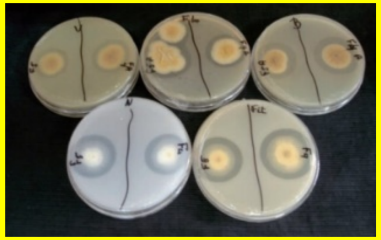
2022

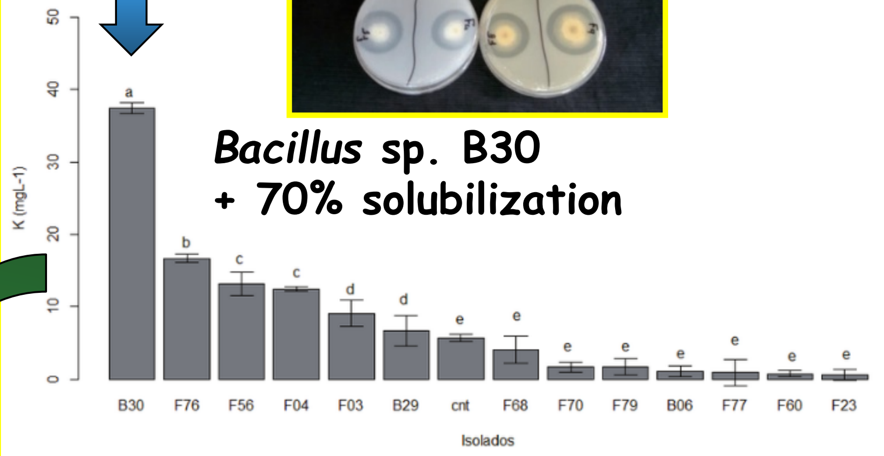
maize

+ 4 million hectares

Potassium

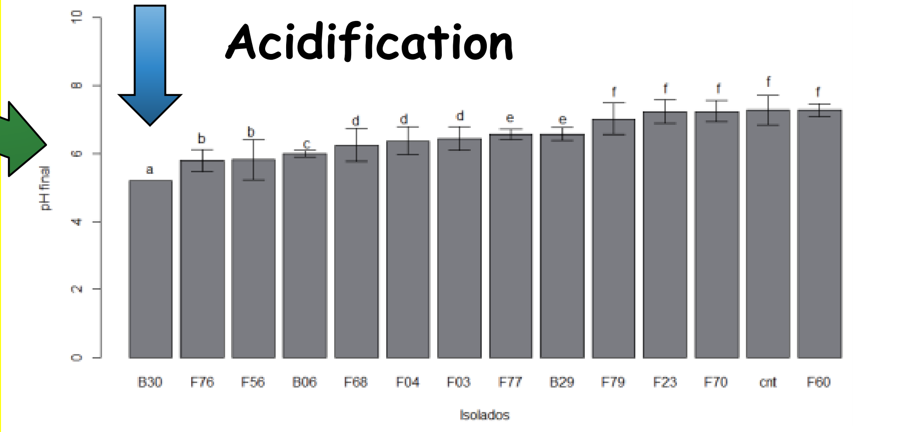
Solubilization





Bacillus sp. B30
+ 70% solubilization

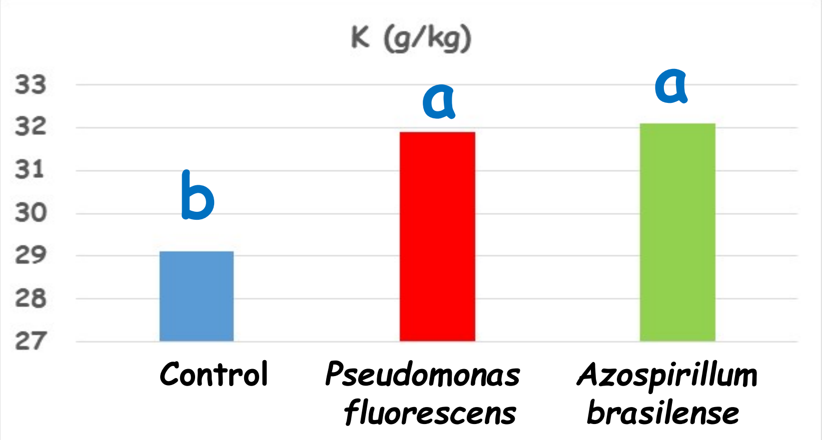
Acidification



Silva et al., Documentos (2015)

Uptake

Urochloa ruziziensis (brachiaria)



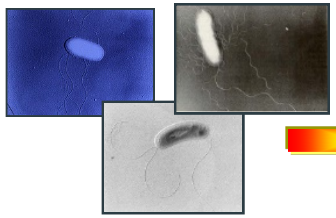
Inoculant 2021

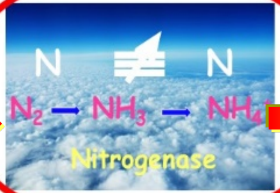
Control *Azospirillum brasilense*

Hungria et al., Plant Soil (2021)

Nitrogen

Biological nitrogen fixation





3.2 billion years

200 million years

symbiosis

+ bacteria   - bacteria

Acacia spp.	acacia	5-50
Arachis hypogaea	groundnut	32-206
Cajanus cajan	pigeonpea	68-88
Calopogonium muconoides	calopogonium	64-182
Centrosema spp.	centrosema	41-280
Cicer arietinum	chickpea	0-141
Desmodium spp.	desmodium	25-380
Gliricida sepium	gliricida	26-75
Glycine max	soybean	0-450
Lathyrus sativus	lathyrus	172-227
Lens culinaris	lentil	5-191
Leucaena leucocephala	leucaena	98-274
Lupinus albus	sweet lupin	40-160
Lupinus angustifolius	lupin	19-327
Lupinus mutabilis	bitter lupin	95-527
Macroptilium atropurpureum	siratro	46-167
Medicago sativa	alfalfa	45-470
Melilotus officinalis	yellow sweet clover	84
Neonotonia wightii	perennial soybean	126
Phaseolus vulgaris	common bean	0-165
Pisum sativum	field pea	4-244
Pueraria phaseoloides	tropical kudzu	115
Sesbania spp.	sesbania	7-109
Stylosanthes spp.	stylosanthes	4-263
Trifolium spp.	clover	67-260
Vicia benghalensis	vetch	125-147
Vicia faba	faba bean	12-330
Vigna mango	black gram	119-140
Vigna radiata	green gram	58-107
Vigna unguiculata	cowpea	9-201
Zornia glabra	zornia	61

kg/ha N

Ormeño-Orrillo et al., Chapter (2013)

Inoculants + 60 years

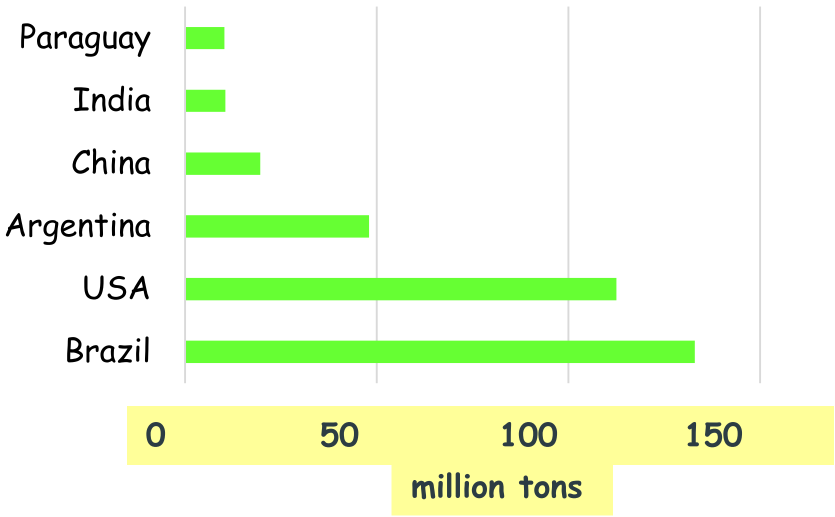
+ 100 million doses/year

Brazil is the first world soybean producer

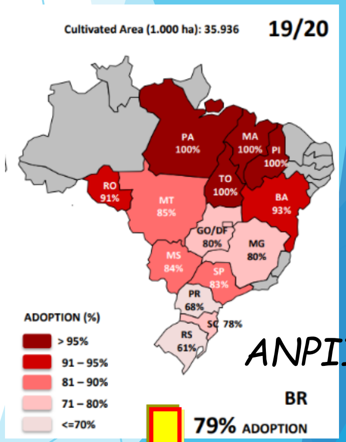
Position achieved only due to the biological nitrogen fixation

Contribution of BNF: Brazil (>90%); USA (50%); China (50%)

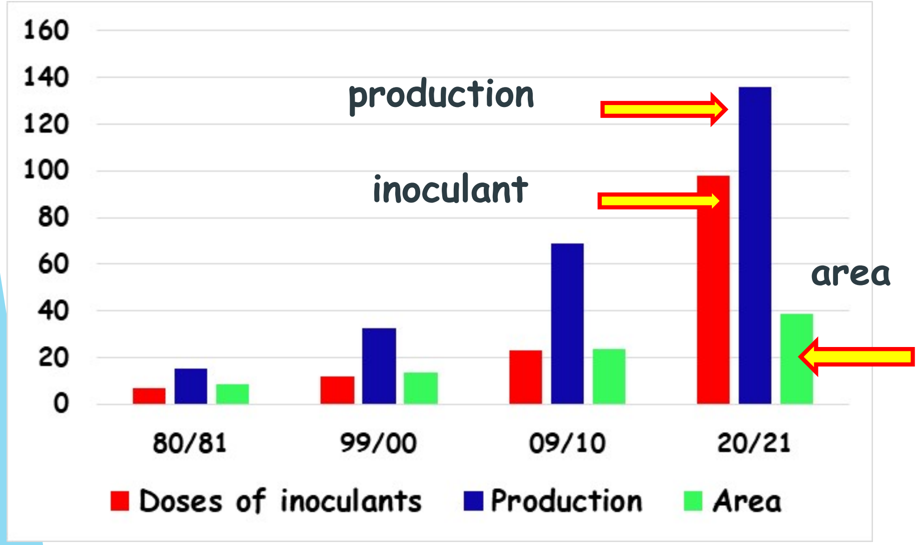
Main world soybean producers

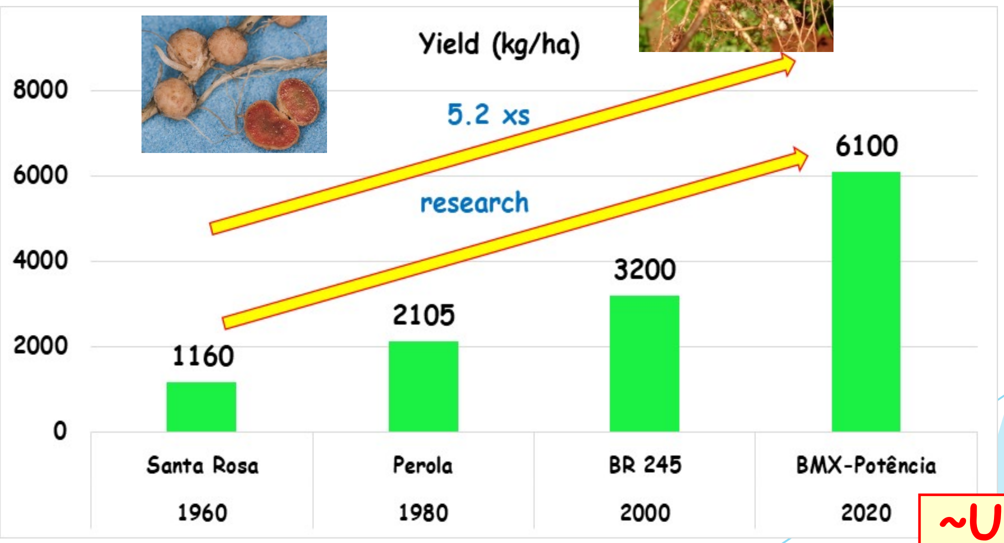


Farmers know about the benefits, farmers use



ANPII (2010)





~US$ 41.92 billion/year
~US$ 1,320/second!!!

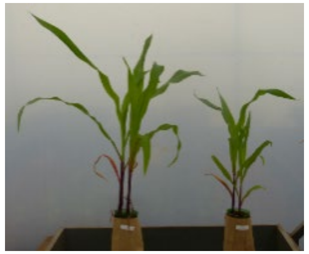
Hungria & Nogueira, Chapter (2022)

Other Plant Growth Promoting Bacteria

1998-2004

Azospirillum brasilense

BNF



Phytohormones

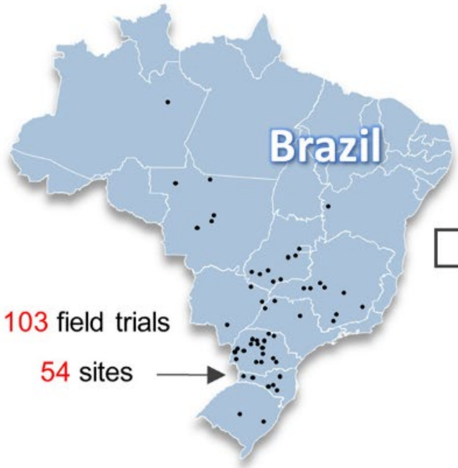
Hungria et al., Plant Soil (2010)

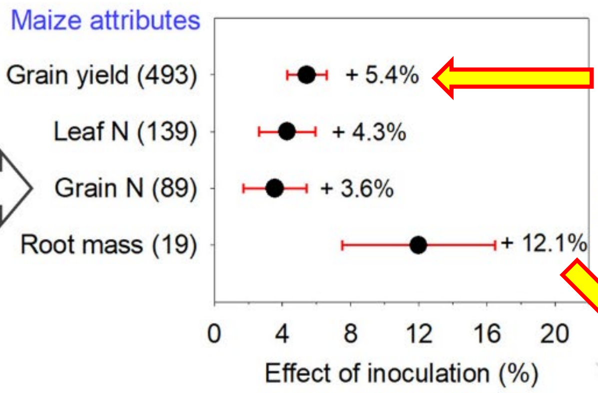
+24%

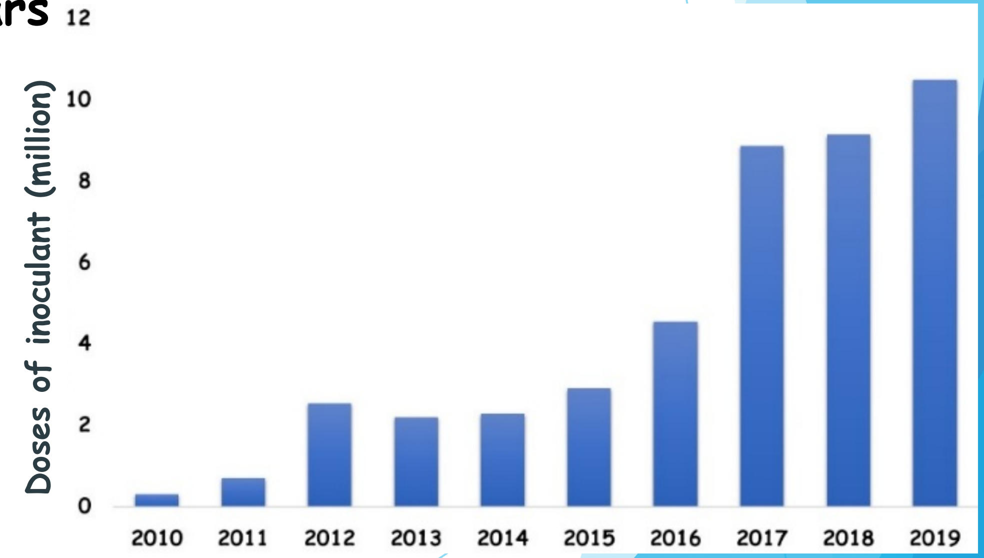
+19%

Inoculant in 2009

10 years







Barbosa et al., Appl. Soil Ecol. (2022)

Santos et al., Rev. Bras. Cienc. Solo (2021)

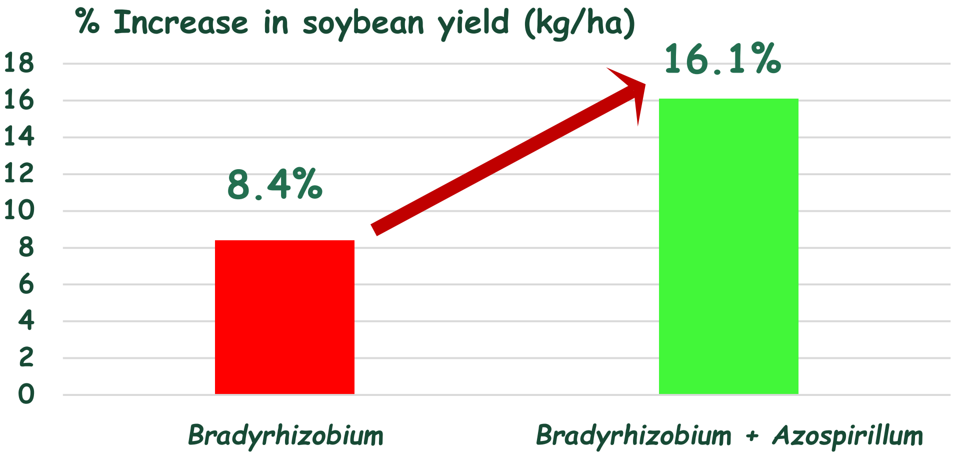
Combination of Microbial Processes

Co-inoculation !!!!! rhizobia + *Azospirillum brasilense*

"industry" of N-fertilizer

"industry" of phytohormones

Hungria et al., Biol. Fertil. Soils, 2013



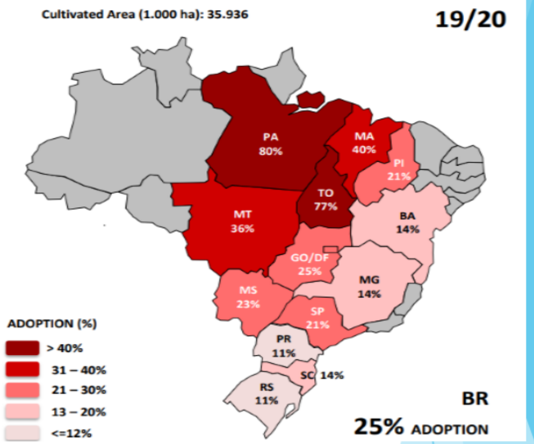
Inoculant 2013/14

5 years

- 51 publications,
- 39 sites-field trials

root dry weight: +11%
nodule number: +5.4%
nodule dry weight: +10.6%
N in grains: +3.2%
yield: +3.6%

Barbosa et al., Applied Soil Ecol. (2021)



ANPII, Spark (2020)

5 years

Opportunity: Microorganisms to start a "Micro Green Revolution"

- Brazil: 173 million ha with pastures

~21% of country´s territory (2.7xs crops)

60-70% degraded

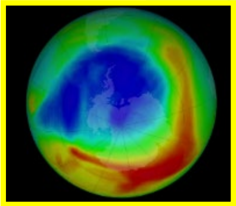
Inoculant 2021

1) More food for the cattle, food of better quality

Biomass production	22%
Azospirillum brasilense	N (13.0%), K (10.4%)
Pseudomonas fluorescens	P (30.2%), K (11.2%)

2) Environmental benefits

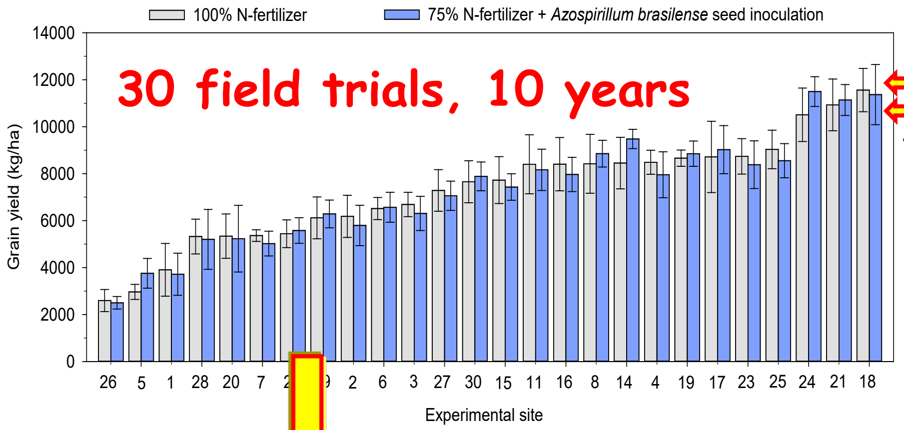
A. brasilense	Mitigation of GHG - 400 kg/ha CO_2-e
A. brasilense & P. fluorescens	Sequestration of 195 kg/ha of C
A. brasilense & P. fluorescens	Lower pollution of water reservoirs



Microbes helping agriculture in many ways

Improve the use efficiency of fertilizers

***Azospirillum brasilense* Ab-V5 + Ab-V6**



100%N

75%N + *A. brasilense*

Inoculant 2019

US$ 15.3/ha
236 kg CO_2-e/ha

Saving of 25% of N

Hungria et al., Agron. J. (2022)

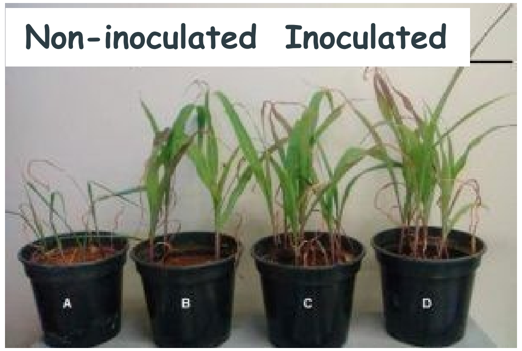
Enrich the soil on nutrients

Herridge et al., Plant Soil (2022): 25% of the N

30-60 kg/ha of N

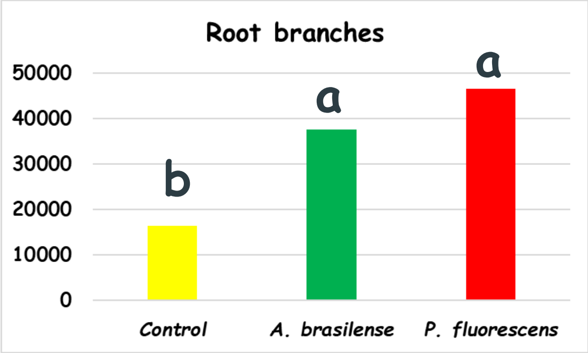
Mitigation of water stress

***Bacillus* (sin. *Priestia*) *aryabhattai* CMA 1363**



Kavamura et al. Microbiol. Res, 2013

Inoculant 2021



Hungria et al., Plant Soil (2021)

Inoculant 2021

Microbes can be the "stars" of a new sustainable and regenerative agriculture

Thank you !!!!

GLOBAL SOIL PARTNERSHIP