AN IMPROVED COMMON BEAN INOCULANT FOR A SUSTAINABLE AGRICULTURE

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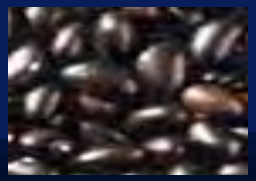


The agriculture in the world faces several challenges

Increased food demand

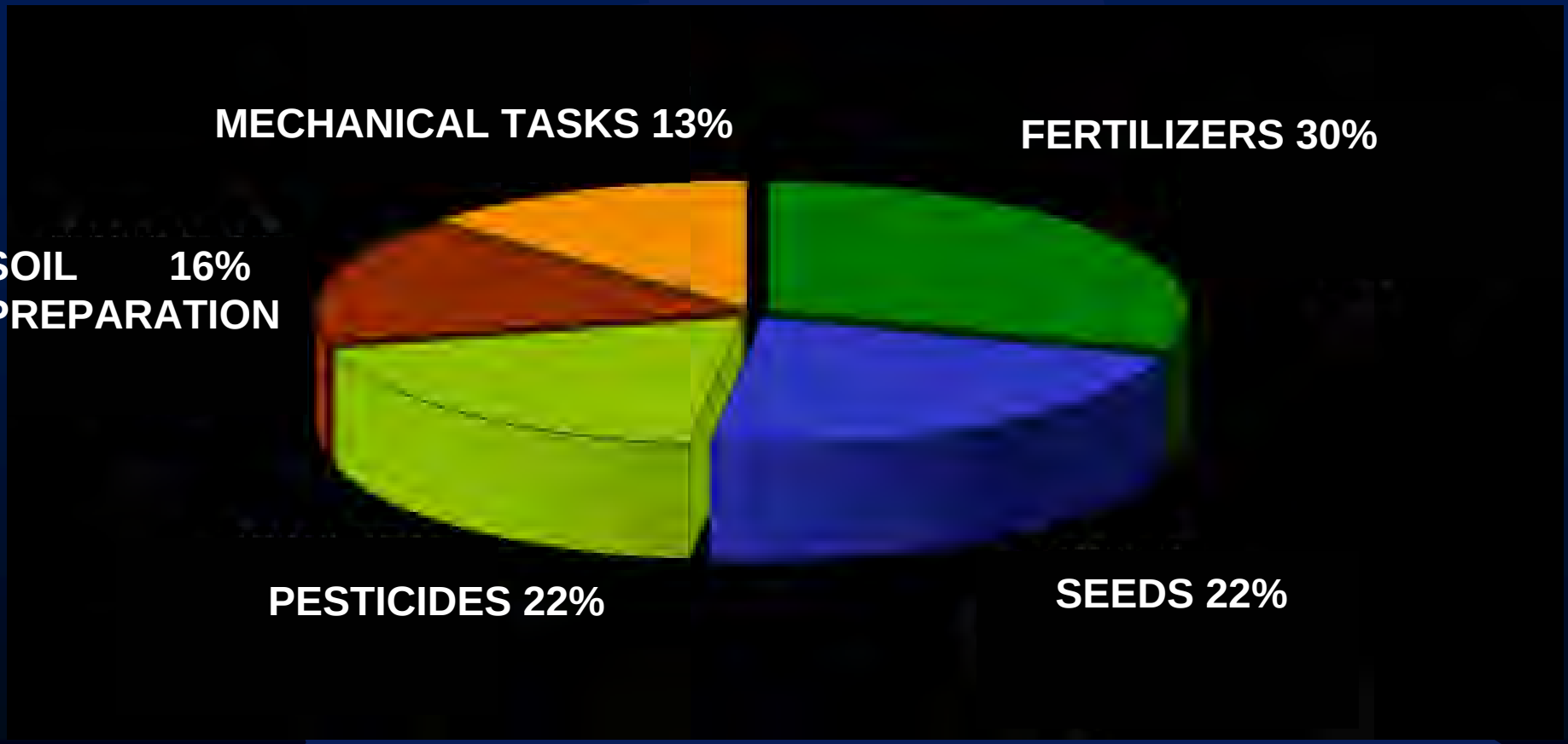
Environmental problems

Degradation of soils

High production costs

How to increase crop yields with a sustainable perspective?

Fertilization vs Inoculation



Fertilization vs Inoculation

Fertilizer:

High cost
Depends on fossil fuels
Hard to transport and store
Applied to soil
Plants acquire only a fraction
Contaminates water, air, soil

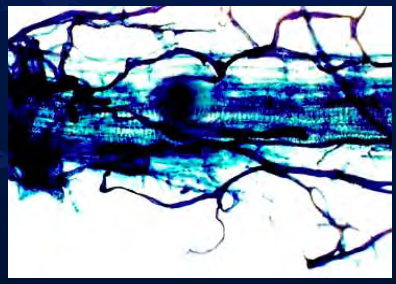
Inoculant:

Low cost
Natural resources
Easy transport, storage
Applied to seed
Efficient capture of nutrients
Recovers degraded soils

Microorganisms used as inoculants

***Azospirillum*, produces indol acetic acid, a hormone which induces root growth**

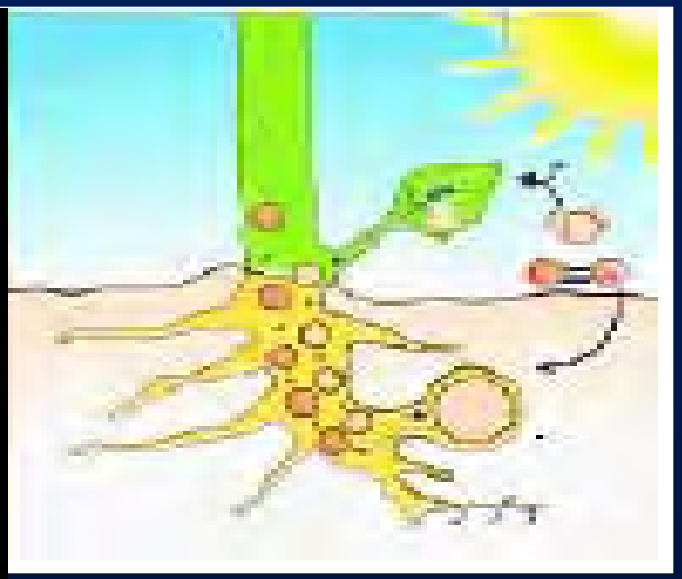
Mycorrhicic fungi, form a secondary root network and enhance nutrient and water capture



***Rhizobium*, fixes atmospheric nitrogen in the legume roots**

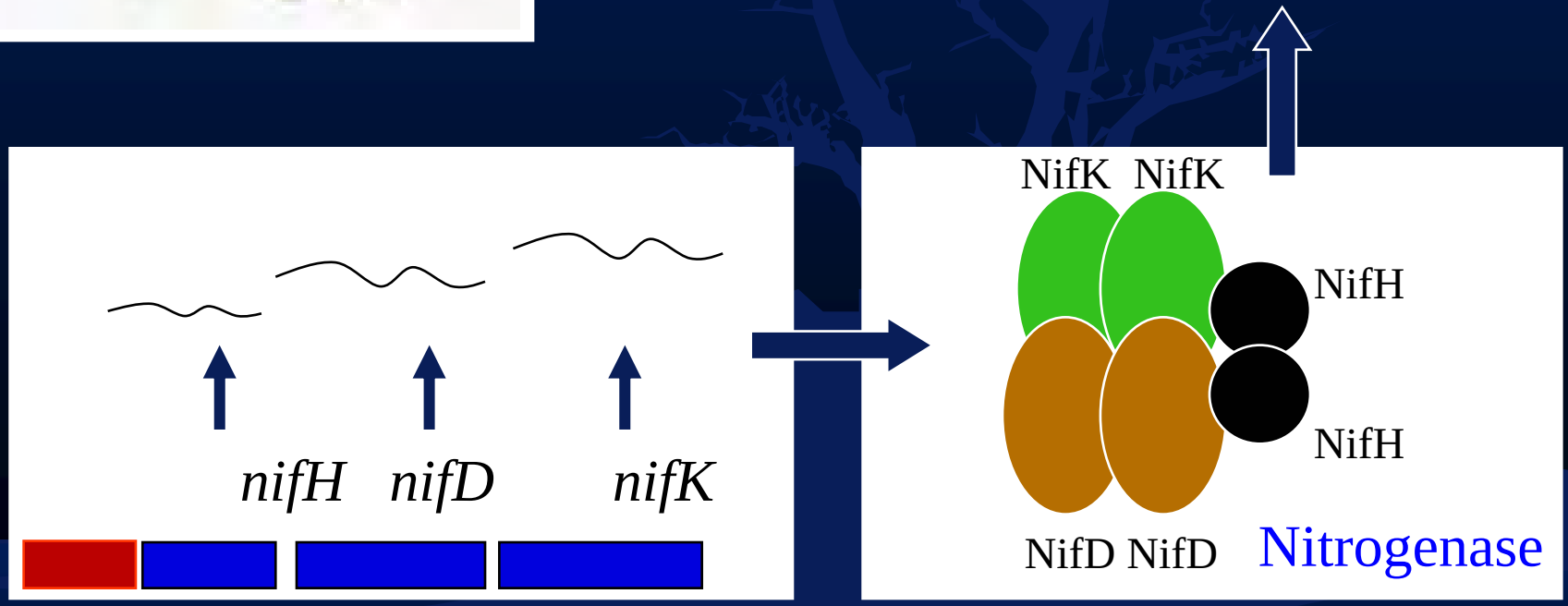
The common bean is the most important legume in Mexico and other countries

Nitrogen fixation process



Nitrogen → Ammonium

Nitrogenase + Energy



1981 UNAM-Nitrogen Fixation Research Center

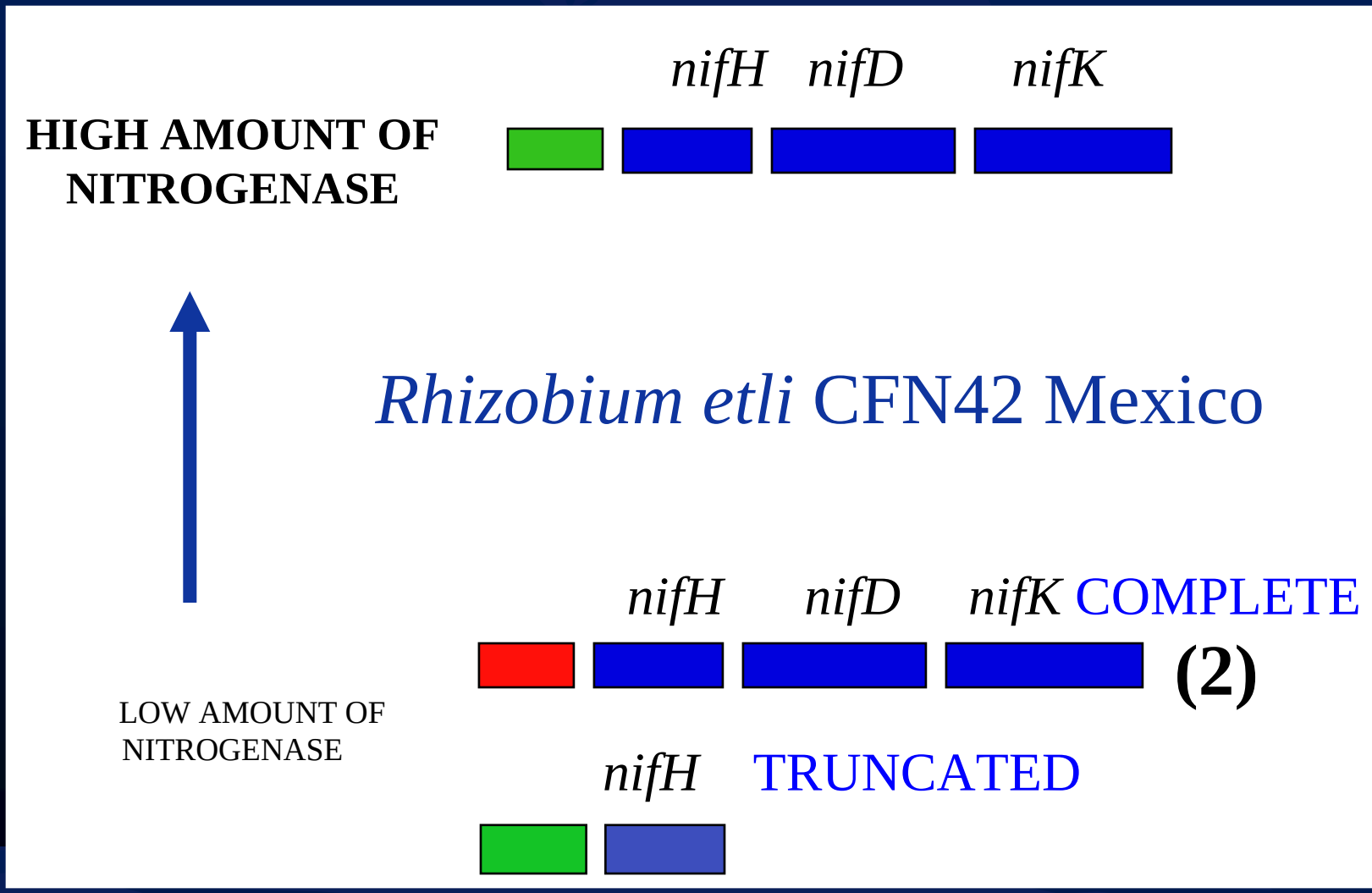
Rhizobium-common bean symbiosis as a model

***Rhizobium etli*, the prevalent species**

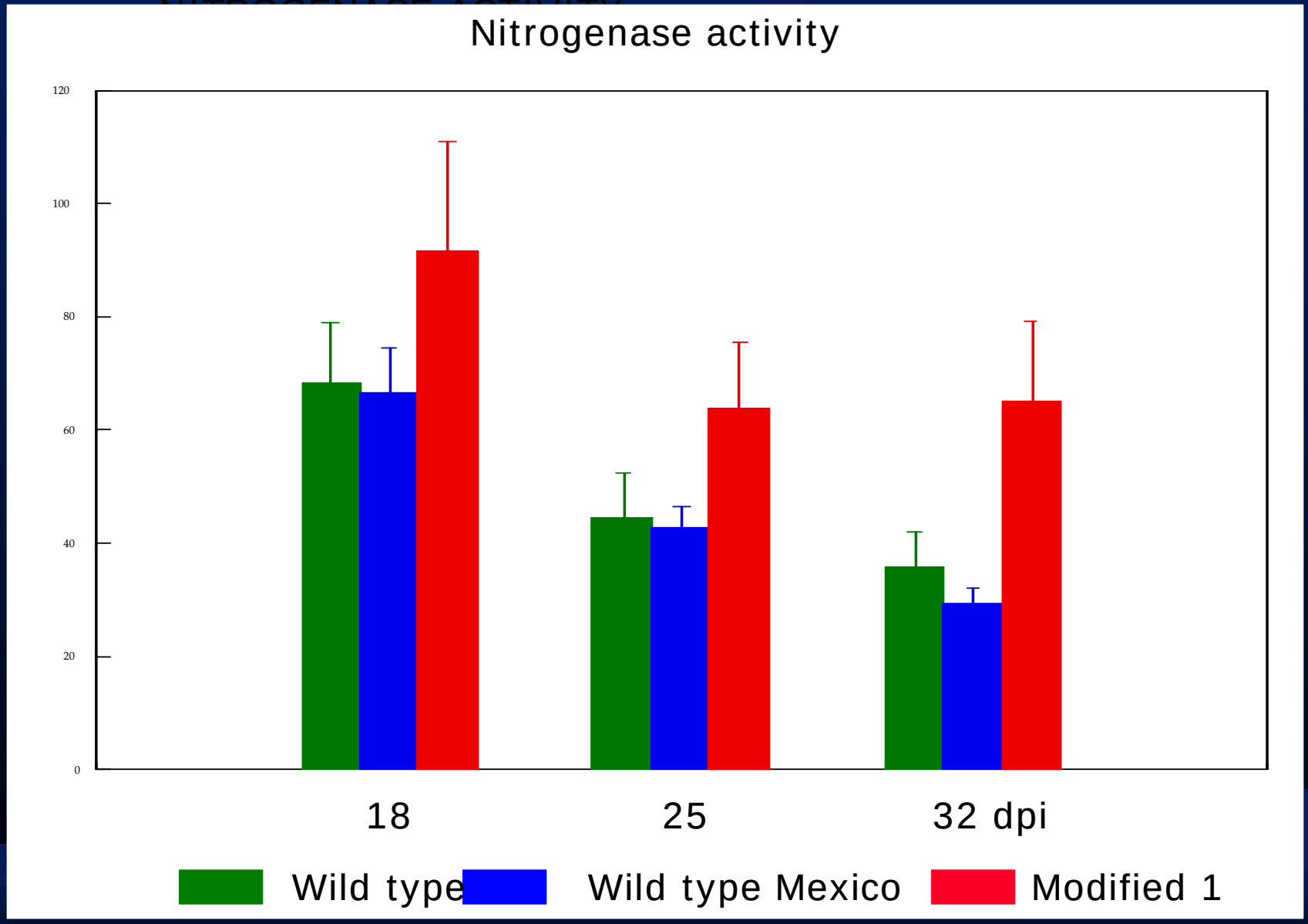
3 copies of nitrogenase genes

A poor nitrogen fixer

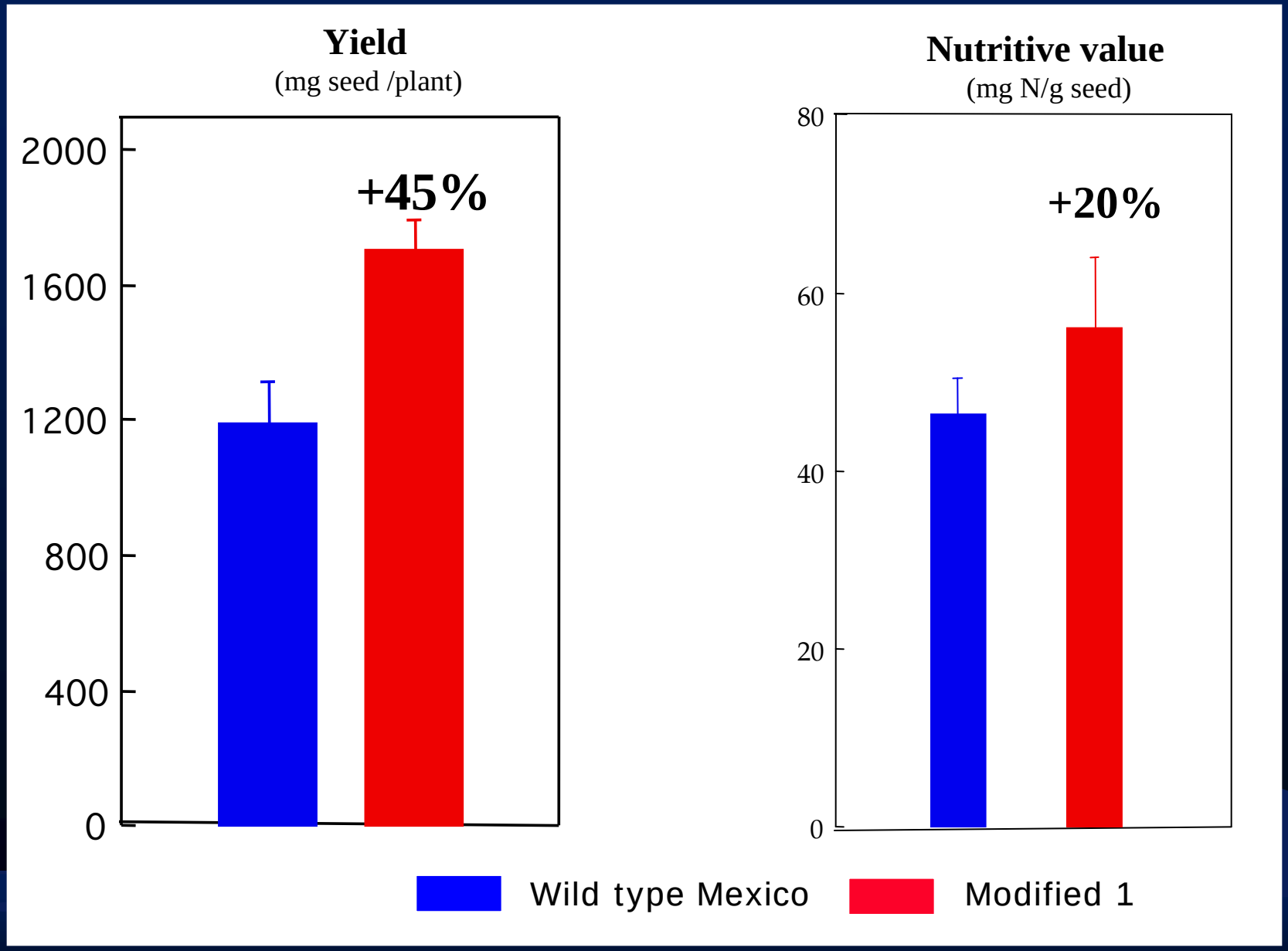
Improvement of nitrogen fixation
Modification 1



Improvement of nitrogen fixation



Improvement of nitrogen fixation



Improvement of nitrogen fixation

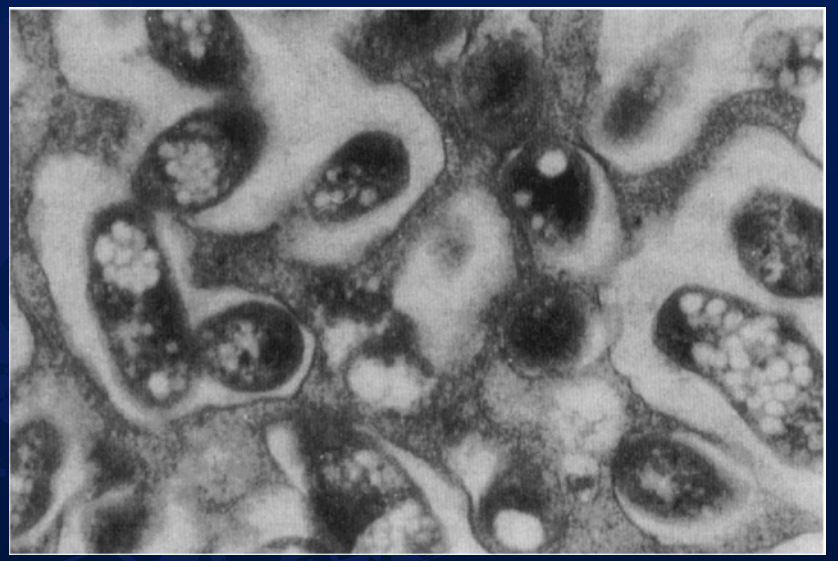
No fertilized

Wild type
Mexico

Rhizobium
Modified 1

With chemical
fertilizer

Improvement of nitrogen fixation
Modification 2



In symbiosis, *Rhizobium* accumulates a natural polymer (PHB) as a carbon and reducing power reservoir

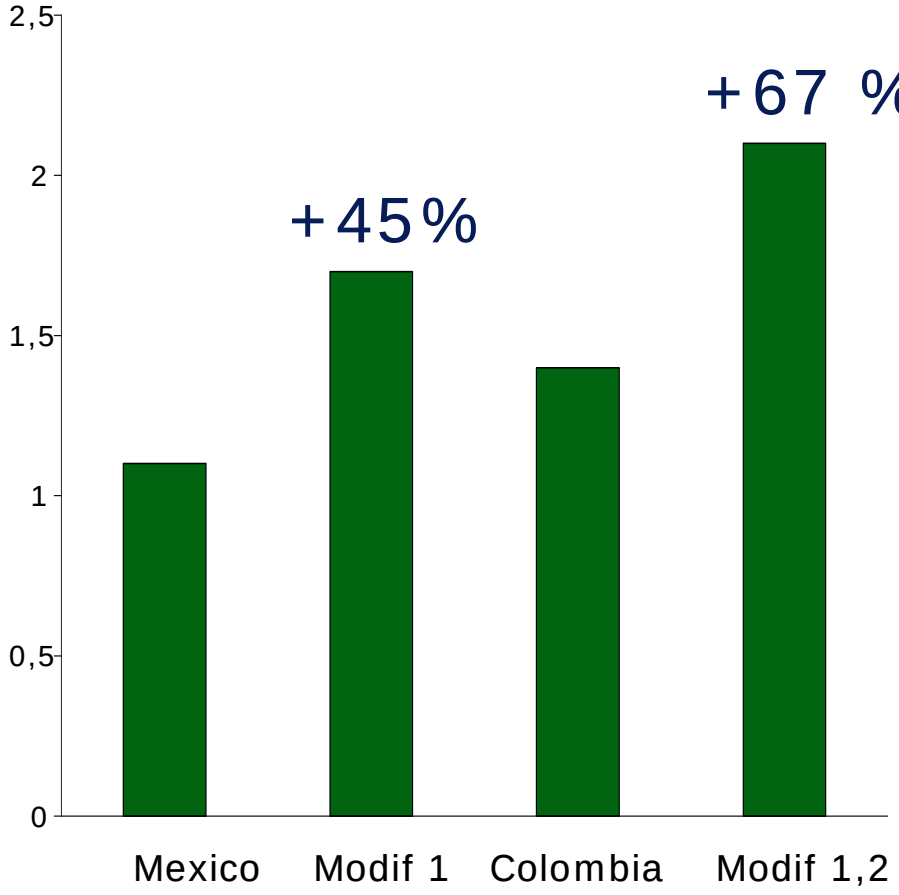
We supressed the PHB synthesis pathway to derive more energy to nitrogenase

This was performed on a strain from Colombia

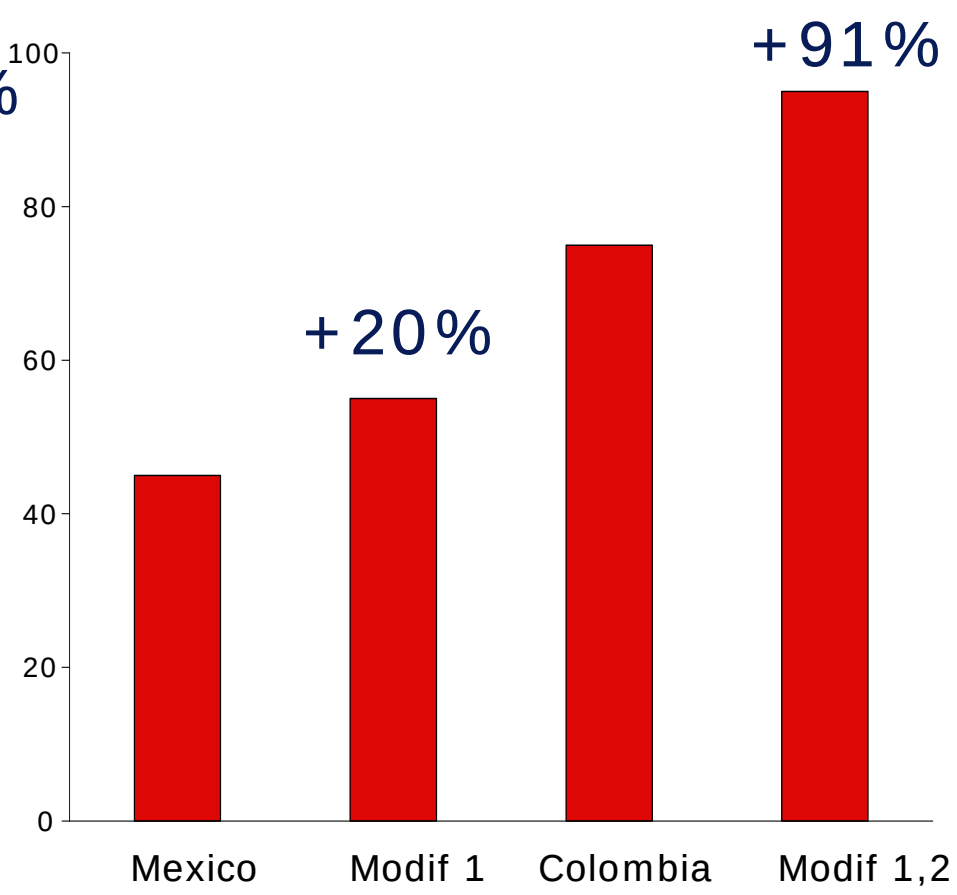
1999-2000

Improvement of nitrogen fixation

Yield
(g seed /plant)



Nutritive value
(mg N/g seed)



Improvement of nitrogen fixation

No fertilized Col., Modif 2 Col., Modif 1, 2 Chemical fertilizer

Peralta et al., App. Env. Microbiol. 70:3272-80 (2004)

Field assays

15 sites

4 states

5 cultivars

4 growing seasons

1 000 plants sampled for

20 000 nodules

Rain, irrigation by gravity or drip

1999-2002

Field assays

Site	Cultivar	Yield (Ton/Ha) +Fertilizer	Yield (Ton/Ha) Improved *Rhizobium*
Zacatepec	Pink	0.46	0.65
Celaya	Pink	4.48	4.34
Celaya	Pink	2.57	2.23
Juchitepec	Black	1.44	1.47
Texcoco	Black	2.83	3.45
Cotaxtla	Mottled	2.34	2.40
Cotaxtla	Black	1.80	1.75
Celaya	Pink	2.69	3.10
Celaya	Pink	3.60	3.40
Zacatepec	Yellow	2.07	2.34
Zacatepec	Yellow	1.81	2.26
Texcoco	Mottled	1.62	2.28
Texcoco	Black	1.77	2.29
Texcoco	Black	3.38	3.28

In 70% of cases yields increased by 35% avg

Field assays

Nutritive value (mg N/g of seed)

Site	Cultivar	no fertilized	Improved *Rhizobium*
Zacatepec	Pink	26	47
Celaya	Pink	34	56
Celaya	Pink	43	62
Juchitepec	Black	32	63
Texcoco	Black	30	67

Seed produced was 50 to 100% more nutritious

2003-UNAM transfers the improved strains to Biofabrica Siglo XXI

Assays with farmers (% in comparison with non fertilized parcels)

	Fertilized	Improved *Rhizobium*
2005 Durango, Mottled		
Yield	+32	+28
Benefits/Cost	+27	+44
2006 Durango, Mottled		
Yield	+50	+43
Benefits/Cost	+57	+64
2006 Nayarit, Black		
Yield	+25	+62
Benefits/Cost	+30	+110
Profits/hectare	US 97	US 150
Nutritive value	+20	+32

Fertilized *Rhizobium*

2008 Zacatecas, Black, Mottled **20 000 hectares**

Yield increases of 40% avg

Conclusions

The improved inoculant for common bean represents a valuable tool for sustainable agriculture in Mexico:

-Increased yields and nutritive value of the seed

-Reduced costs, more profits for farmers

-Additional benefits for environment

Perspectives

Current: efficient **alfalfa** inoculant
extending the **shelf life** of the product

Covered only **1 %** of crop surface

Official support + **Intensive** divulgation

Azospirillum **UNAM inoculant**
on **2.5 million** hectares

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Celaya: Javier Castellanos
Zacatepec: Aurelio Barrera
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