



Multiscale evaluation of Nitrogen Use Efficiency (NUE) in common bean (*Phaseolus vulgaris*) under different inoculation strategies in Cuba.
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Inoculation with *Rhizobium* sp. + Mycorrhizae in areas of small farmers.

The yield in all cases was higher with complete fertilization (between 20% - 50%) at inoculation.

Variations in yield were related to the knowledge and management practices of each farmer.



Table 1. **Grain yield (t ha^{-1})** in common bean plots cultivated by three modes of nitrogenous nutrition, in three farms in the municipality of Artemisa.

Treatments	Laureles (Farm 1)	Reboso (Farm 2)	Ernestina (Farm 3)	Treatments average
<i>Rhizobium</i> sp.	1.54	0.93	0.68	1.05 b
<i>Rhizobium</i> sp. + Mycorrhizae	1.06	1.05	0.51	0.87 c
NPK	1.90	1.50	0.74	1.38 a
Farm Average	1.49 a	1.16 b	0.64 c	

Inoculation with *Rhizobium* sp. + Mycorrhizae in areas of small farmers.

Nitrogen Use Efficiency (NUE) was 44% higher in Rhizobium-inoculated areas than in fertilized ones.

The differences in NUE were related to: i) fertilizer doses and technologies used, ii) knowledge and management practices of each farmer iii) differences in fertility and N content in the soils of these localities.

Table 2. Efficiency of N Use (kg of grains produced x each Kg N applied) in three farms in the municipality of Artemisa cultivated with common beans.

Treatments	Laureles (Farm 1)	Reboso (Farm 2)	Ernestina (Farm 3)	Treatments Average
<i>Rhizobium</i> sp.	36.6	22.14	16.19	24.97 a
<i>Rhizobium</i> sp. + Mycorrhizae	25.23	25.0	12.14	20.79 b
NPK	23.75	18.75	9.25	17.25 c
Farm Average	28.52 a	21.96 b	12.52 c	



**Inoculation with *Azotobacter* sp in maize crop (*Zea mays* L).
Area of 5 ha with irrigation and mechanized work.**

Combination of seed inoculation + fertigation.



The yield was 44% higher in the areas with complete nitrogen fertilization of mineral origin, while the NUE with inoculation doubled this nutrition alternative.

Treatment	Shoot dry weight g/pl	Grain yield tons/ha	NUE
Control	61.8 c	3.05 c	61.0
Inoculated with DiMARGON®	93.2 b	3.93 b	78.6
180 kg N x ha	152.1 a	5.66 a	31.4



When analyzing the results from the economic point of view, the use of inoculants allows the achievement of productions with lower amounts of fertilizer of mineral origin, lower costs and environmental impact.

**Inoculation with *Azotobacter* sp in sorghum culture (*Sorghum bicolor* L. Moench).
Area of 16.6 ha with irrigation and mechanized work. Intensive production system.**

Combination of seed inoculation + fertigation.

Treatment	Shoot dry weight g/pl	Stem weight g/pl	Panicle weight g/pl	Grain yield tons/ha	NUE
Control	114.03 c	179.02 b	163.71 c	3.77 b	75.40
Inoculated with DiMARGON®	147.03 a	182.28 b	188.09 b	4.22 b	84.4
180 kg N x ha	132.43 b	208.69 a	219.09 a	5.09 a	28.27



The sorghum yield was 17% higher in the plots with complete fertilization with mineral N, but the NUE was 300% higher in the plots inoculated with the DiMARGON® inoculum.



**Inoculation with *Rhizobium* sp. in bean cultivation (*Phaseolus vulgaris*).
Area of 13.4 ha with irrigation and mechanized work.**

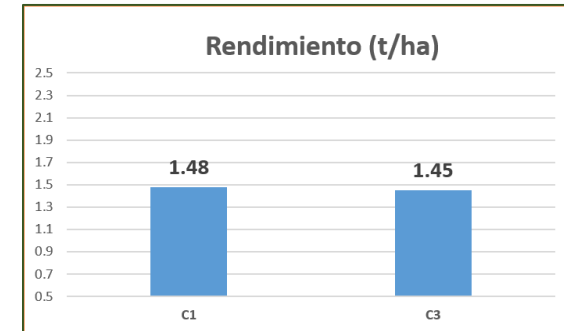
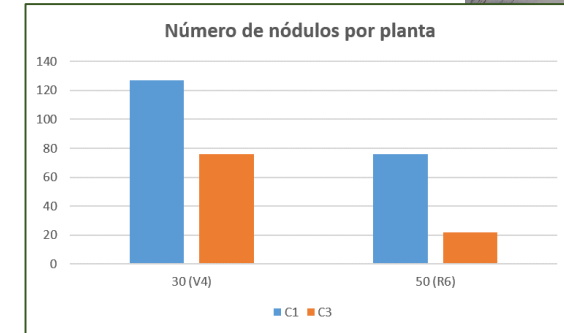
Combination of seed inoculation + fertigation.



Seed inoculation



Mechanized planting of pelletized seed



Plot of 13.42 ha comparing two nitrogen fertilization conditions:

C1) inoculation with BIOFER[®] + 10 kg of N urea + 21 kg of N via foliar, 15 kg of P₂O₅ + 20 kg of K₂O and,

C3) 7 kg N + 69.04 kgN via foliar + 10 kg of P₂O₅ + 13 kg of K₂O)

A **high nodulation** was obtained in the inoculated plants, and their yield had no statistically significant difference in relation to the plot with nitrogen fertilization of complete mineral origin. **The NUE was 250% higher in the inoculated plots.**

Coexistence of 2 production models of Bioproducts for agricultural use.

Artisan Production (small scale)



Industrial Production (Great scale)



- 5000 L fermenters
- 33 tons produced per campaign.
- Inoculation of 44,000 ha per year.



Conclusions.

1. **Lower yields are still achieved** in the areas with inoculation than in those treated with complete nitrogen fertilization.
2. However, **in all cases, the Nitrogen Use Efficiency (NUE) is higher (40% - 300%) in the inoculated areas.**
3. The positive impact of the use of inoculants estimated using NUE as an indicator depended on the experience of the producers, the management strategies and, probably, the scale.
4. In the current socioeconomic context, **the use of inoculants is the only viable alternative as a crop nutrition strategy.**



There is a **marked positive impact of the use of Bioproducts** in Cuban agriculture in the different production systems, regardless of their scale or crop management strategies.



Thank you !

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