The physiology of symbiotic plant nutrition

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Biofertilizers, biostimulants and mineral nutrition

Soil fertility determines the landscape

Roots absorb **humus** and transform it into plant substance (384-322 BC)

Rejection of the humus theory

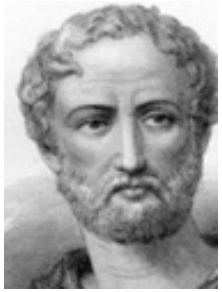
" The conclusion should have been reached long ago that humus is not such an important substance as we have been led to believe, and that the current doctrine of humus is exceedingly full of contradictions."

Carl Sprengel 1838

1888 – Hellriegel and Wilfarth

Biofertilizers

Organic matter Water Minerals (N)



Pliny (23-79 AC)
Growing a crop of lupines improves next crop

Justus von Leibig (1844)

Carl Bosch and Fritz Haber 1900

Building blocks

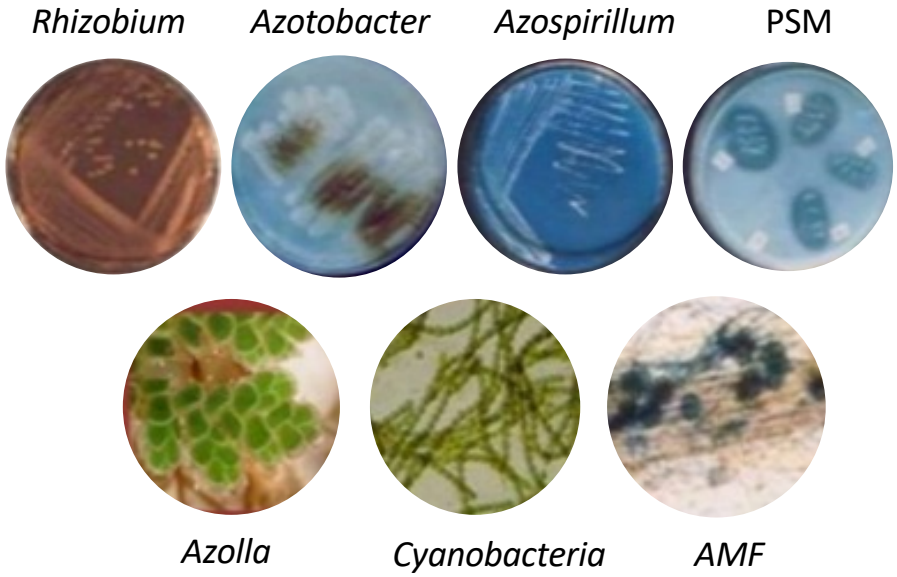
Regulators

What is a biofertilizer?

A biofertilizer is a substance which contains living microorganisms which, when applied to

- seeds
- plant surfaces
- soil

colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant.



Biofertilizers are a category of biostimulants

SYNTHETIC NITROGEN FERTILIZERS

"...It was clear that the demand for fixed N which at the beginning of last century (XX) could be satisfied with a few hundred thousand tons a year, most increase to millions of tons..."

Why do we need **biofertilizers**?

The use of fertilizers allows the increase of human population

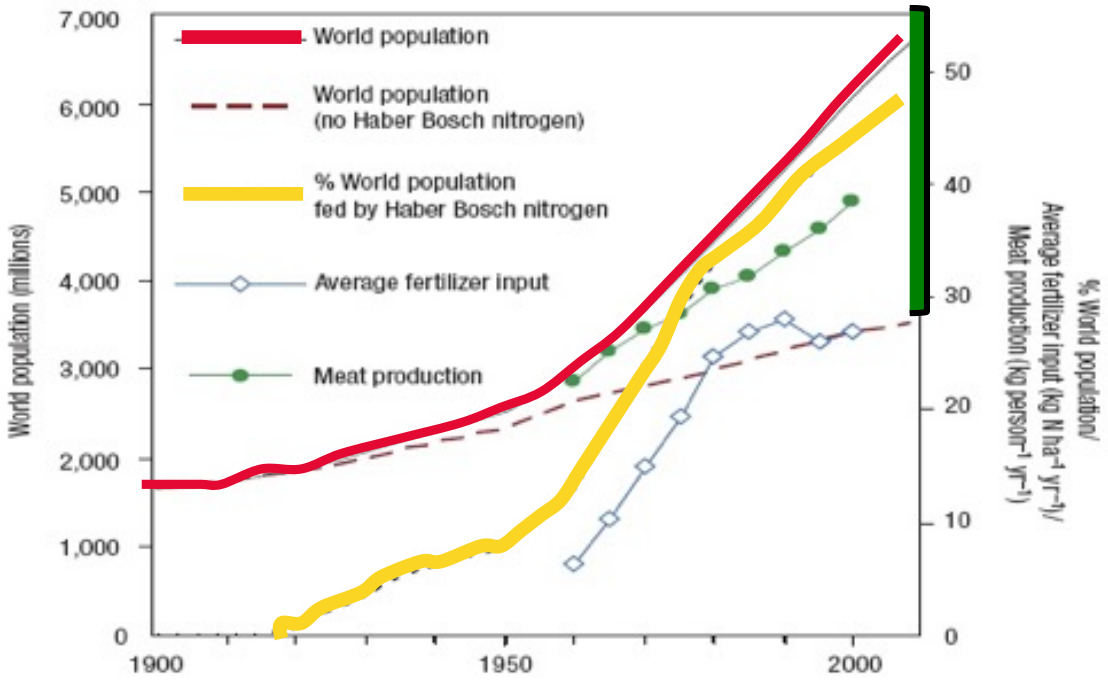
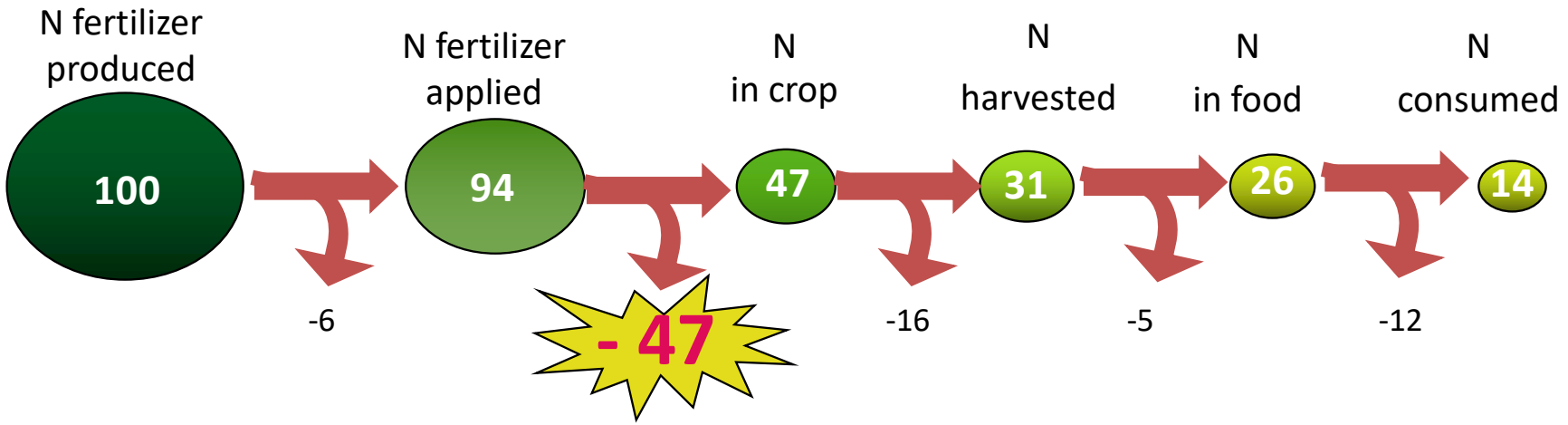


Figure 1 Trends in human population and nitrogen use throughout the twentieth century. Of the total world population (solid line), an estimate is made of the number of people that could be sustained without reactive nitrogen from the Haber–Bosch process (long dashed line), also expressed as a percentage of the global population (short dashed line). The recorded increase in average fertilizer use per hectare of agricultural land (blue symbols) and the increase in per capita meat production (green symbols) is also shown.

Erisman et al 2008, Nature Geoscience, 1: 636-639

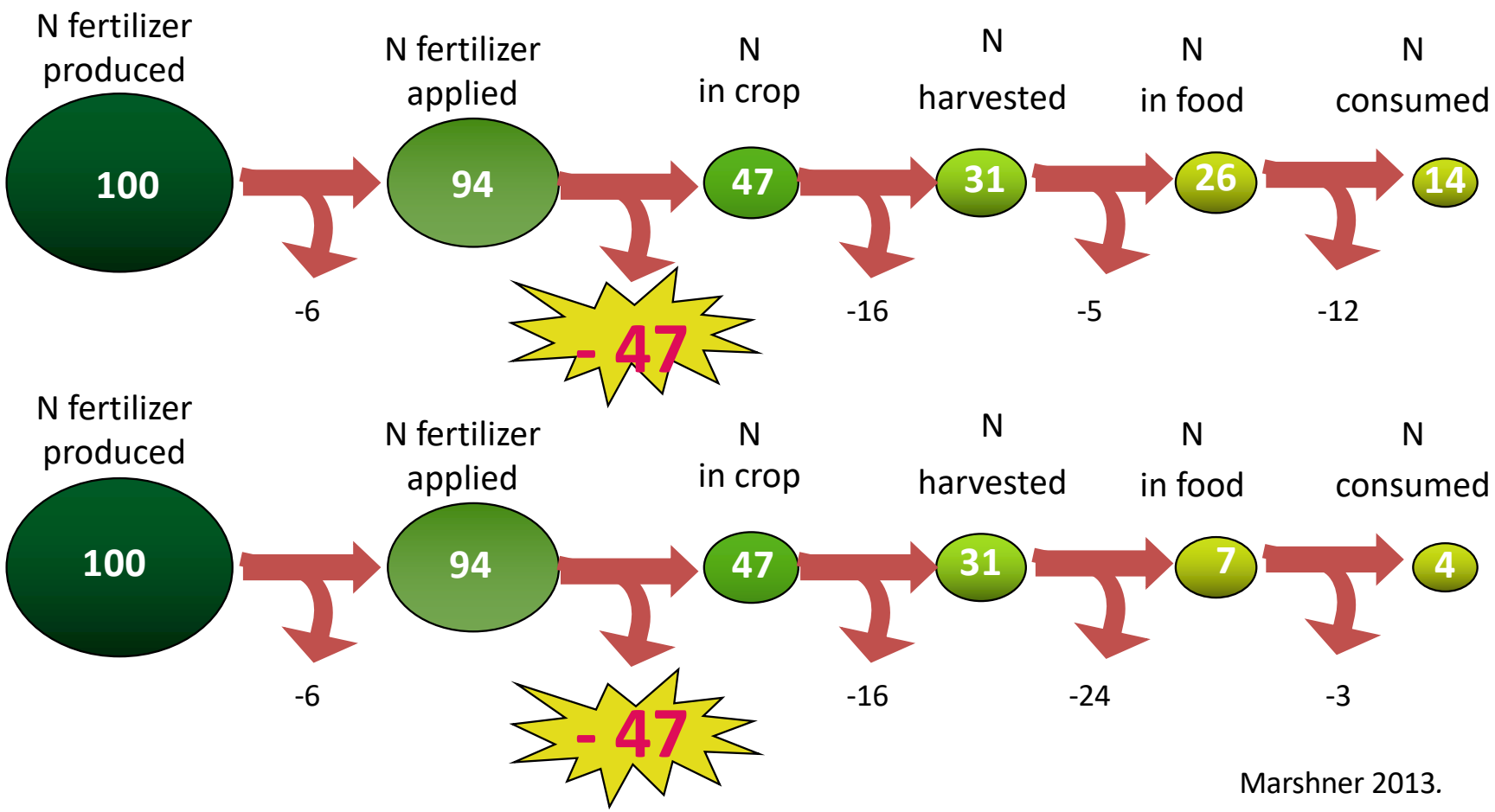
Why do we need biofertilizers?



Marshner 2013.

Biofertilizers are a category of biostimulants

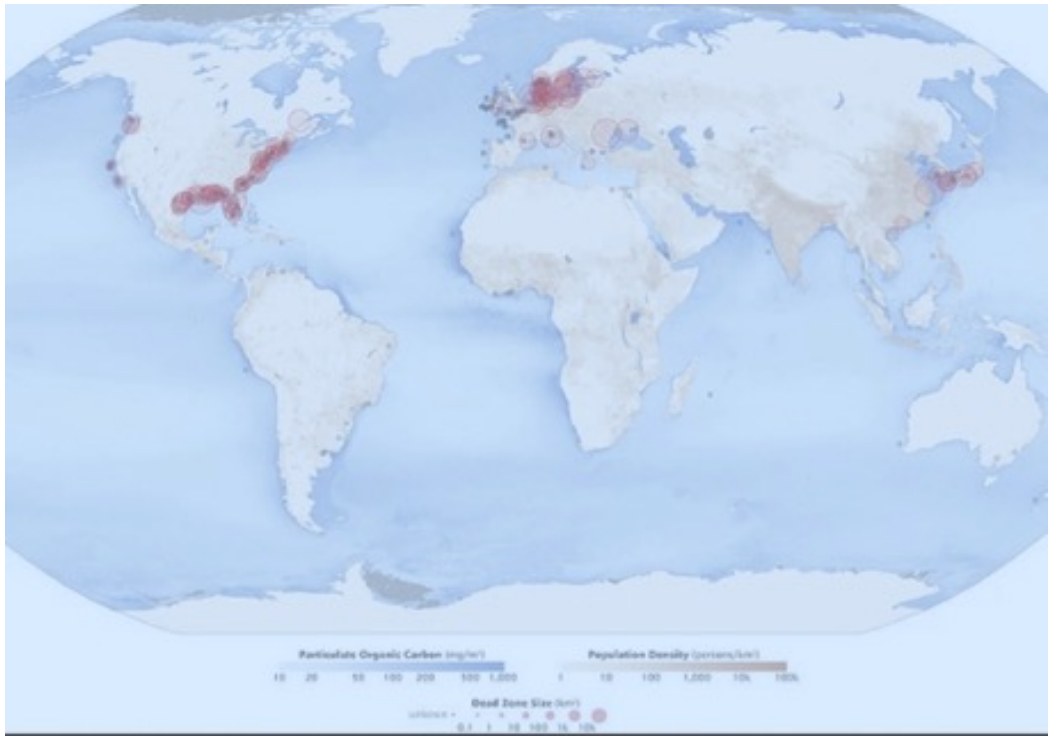
Why do we need biofertilizers?



Marshner 2013.

Why do we need **biofertilizers**?

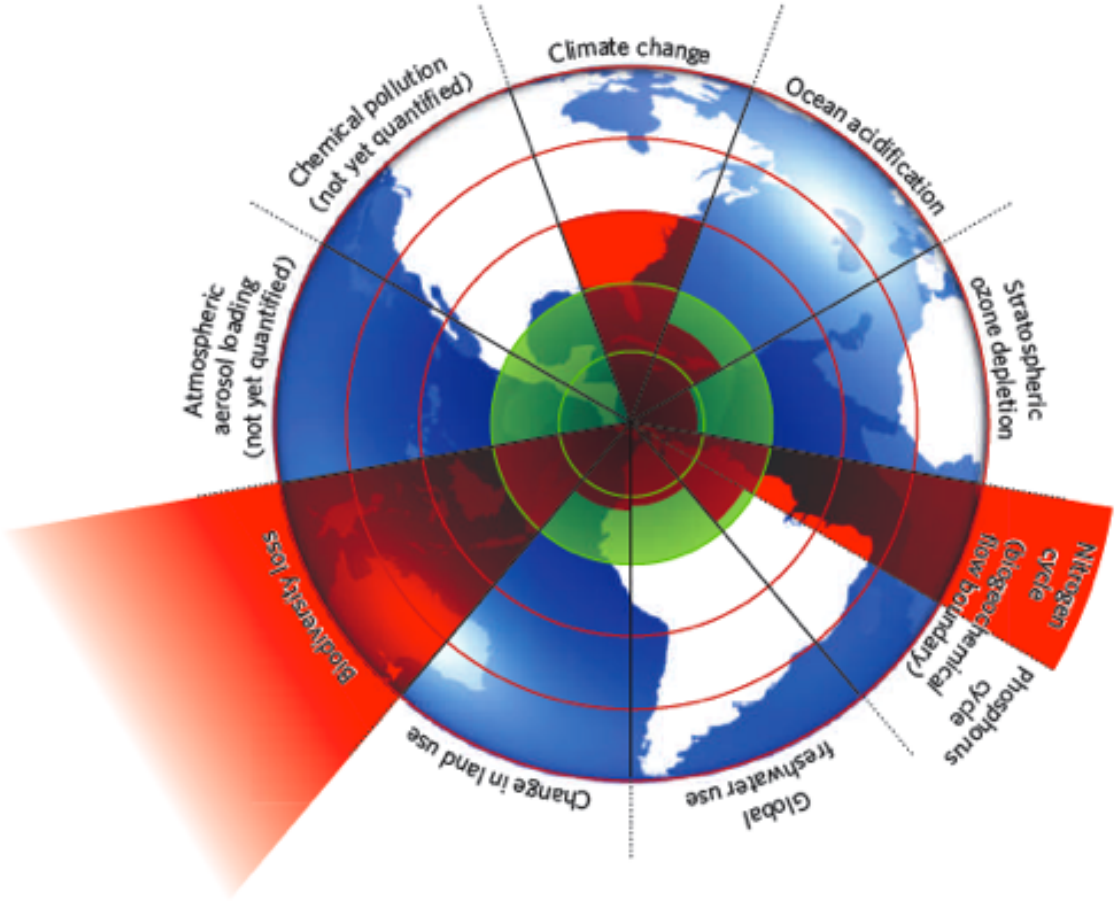
World **dead zones** are usually situated at costal waters are caused by fertilizer and other products runoff



Why do we need **biofertilizers**?

Holocene

Anthropocene



Rockström et al 2009, Nature
Dias et al 2018, LDD

Why do we need **biofertilizers**?

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Why do we need **biofertilizers**?

CENOURA. V. N. Mil Fontes. 2007.
Agricultor: Camposol.
Solo: Arenoso.
Dose NPK: 650 (520) kg/ha de 10-25-13

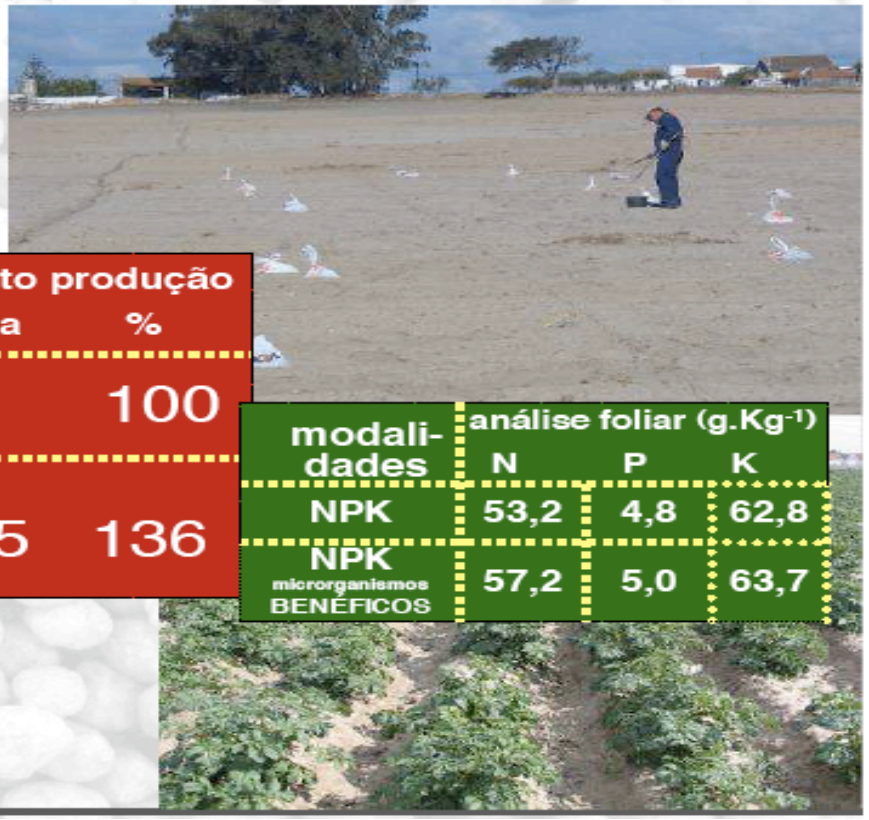
modalidades	produção t/ha	aumento produção t/ha	%
NPK	56,9		100
NPK microrganismos BENÉFICOS	60,8	+ 3,9	107
80% NPK microrganismos BENÉFICOS	63,3	+ 6,4	112

modali-dades	análise foliar (g.Kg^{-1}) N	P	K
NPK	33,9	4,9	65,3
NPK microrganismos BENÉFICOS	34,8	5,0	68,8
80% NPK microrganismos BENÉFICOS	35,3	4,7	71,7

Why do we need **biofertilizers**?

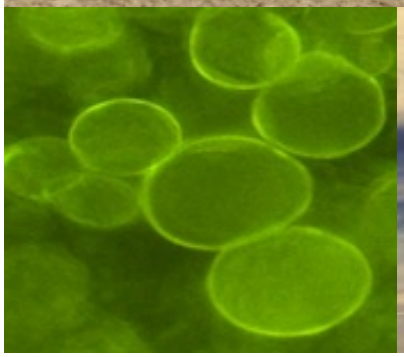
BATATA. Montijo. 2005.
Agricultor: Rui Afonso.
Solo: Areno-franco. pH: 6,1. MO: 1,3%
P_2O_5: 632 ppm K_2O: 84 ppm
Dose NPK: 1000 kg/ha de 6-20-18

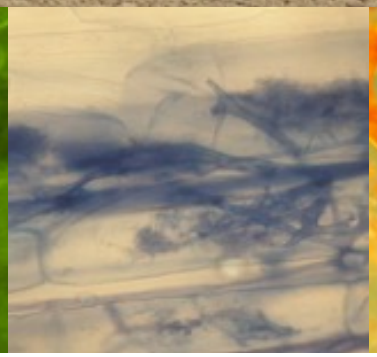
modalidades	produção t/ha	aumento produção t/ha	%
NPK	20,8		100
NPK microrganismos BENÉFICOS	28,3	+ 7,5	136

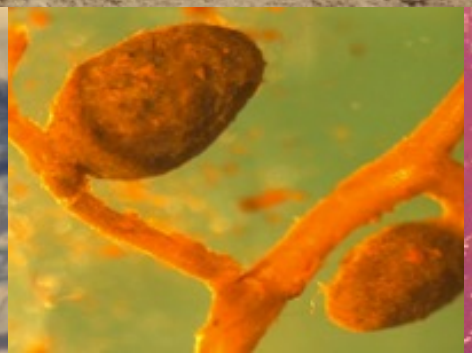


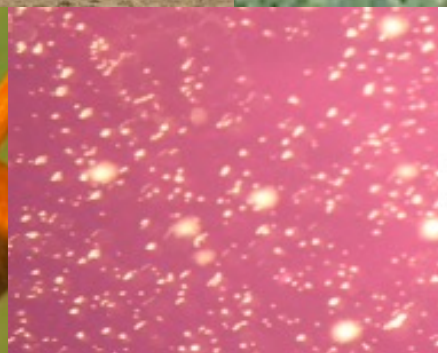
modali-dades	análise foliar (g.Kg⁻¹) N	P	K
NPK	53,2	4,8	62,8
NPK microrganismos BENÉFICOS	57,2	5,0	63,7

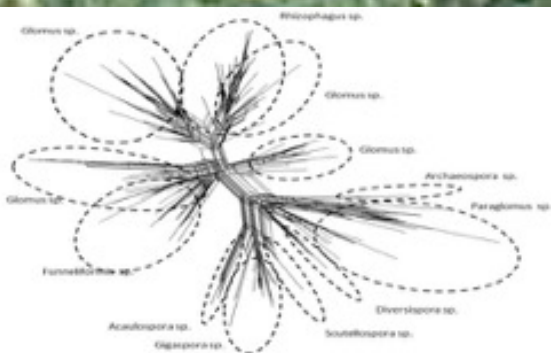
Applied soil ecology may help filling the productivity gap



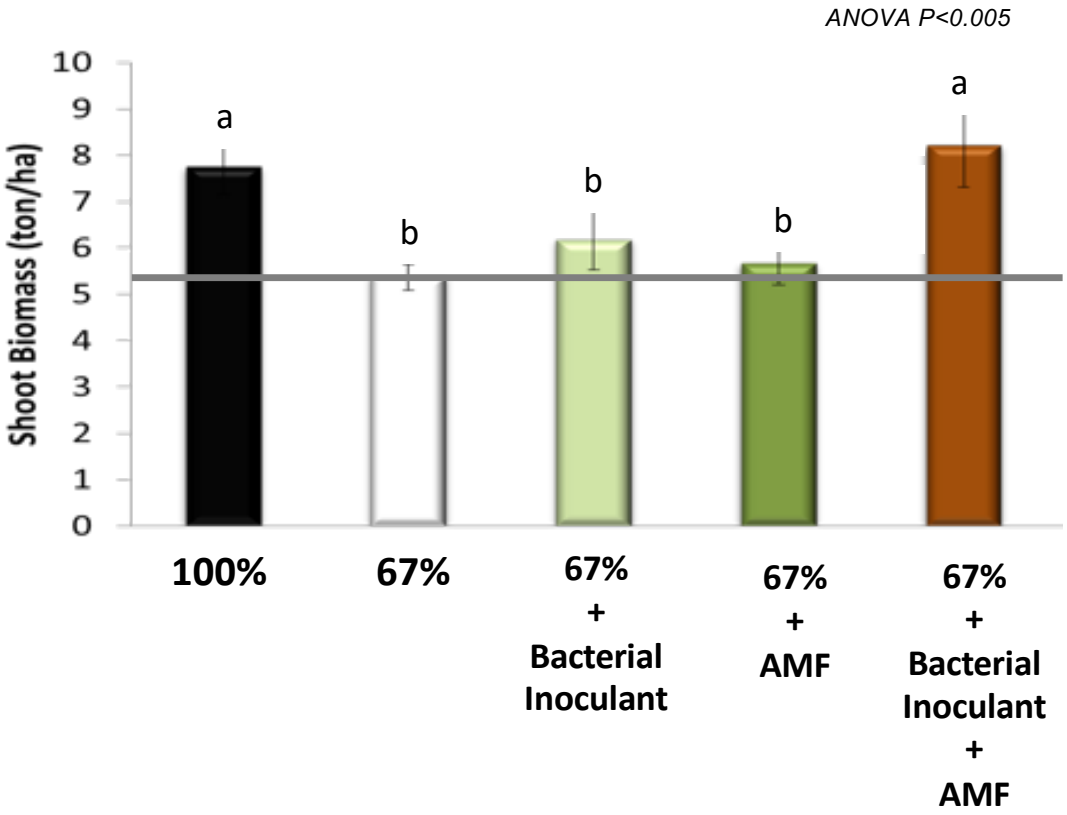








What do biofertilizers do?



Plants inoculated with a highly diverse microbial amendment showed a better performance when subjected to a lower background fertilization

Increased Nutrient Use Efficiency

What do biofertilizers do?