Fisiologia Vegetal

aula TP Nutrição

Fisiologia Vegetal
2023-2024

Teresa Dias | Cristina Cruz

O que é a nutrição das plantas?

- Mineral elements, those acquired primarily in the form of inorganic ions, continually cycle through all organisms and their environment. Mineral elements enter the biosphere predominantly through the root systems of plants, so in a sense plants act like the “miners” of Earth’s crust (Epstein 1972, 1994).

- Plant mineral nutrition is unique because green plants, the only multicellular autotrophic organisms, **can mine inorganic elements from the environment** without having to rely on high-energy compounds synthesized by other organisms.

- The study of how plants absorb and assimilate inorganic ions is called mineral nutrition; which is central to modern agriculture and environmental protection.

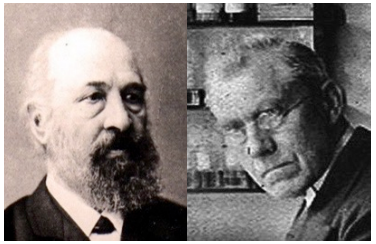
O que é a nutrição das plantas?

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

Rejection of the humus theory

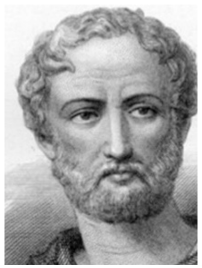
" The conclusion should have been reached long ago that humus is not such an important substance as we have been led to believe, and that the current doctrine of humus is exceedingly full of contradictions."

Carl Sprengel 1838



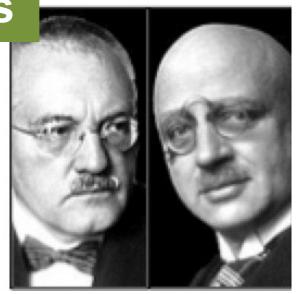
1888 – Hellriegel and Wilfarth

Organic matter — Water — **Minerals** **Building blocks** — (N)



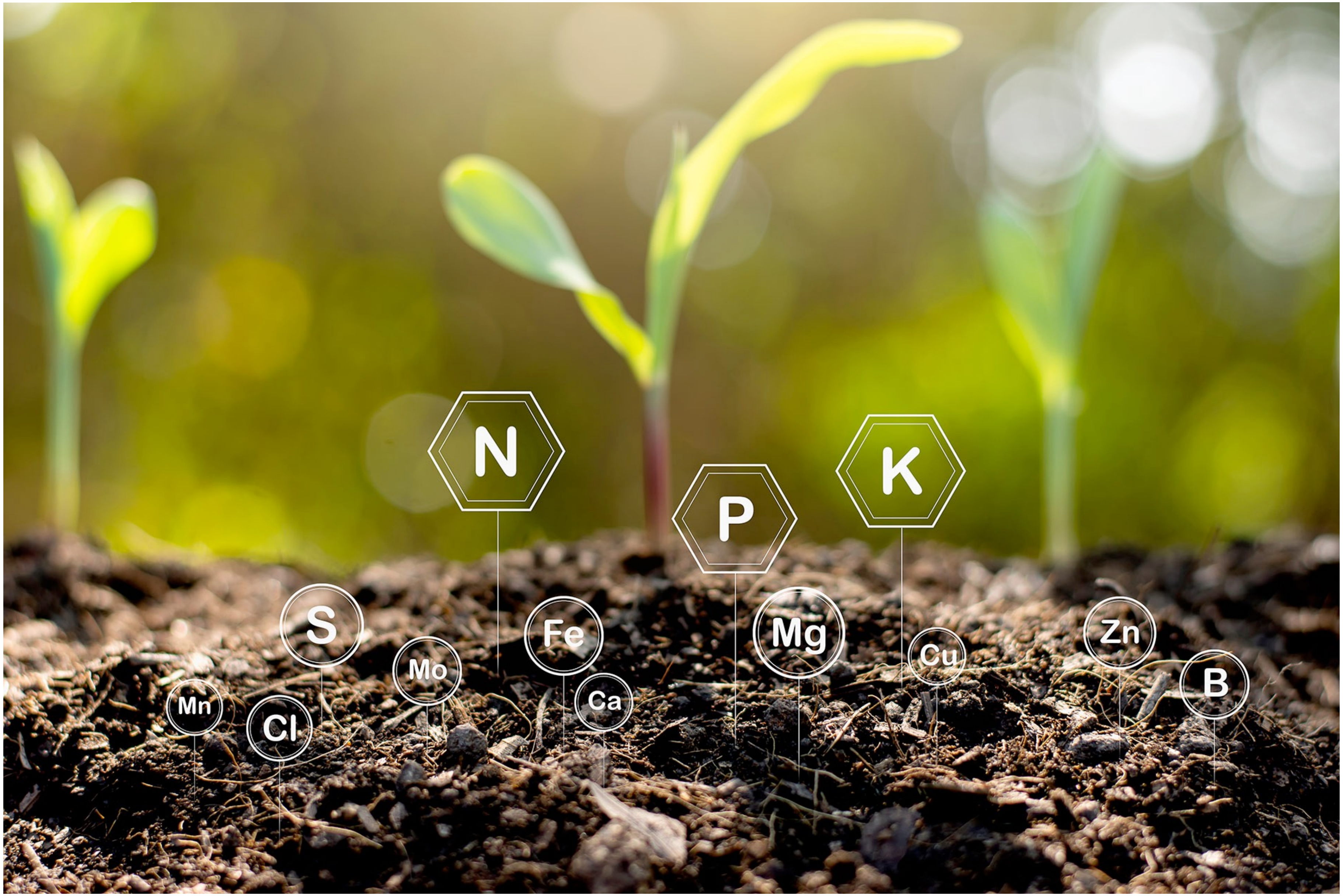
Pliny (23-79 AC)
Growing a crop of lupines improves next crop

Justus von Leibig (1844)

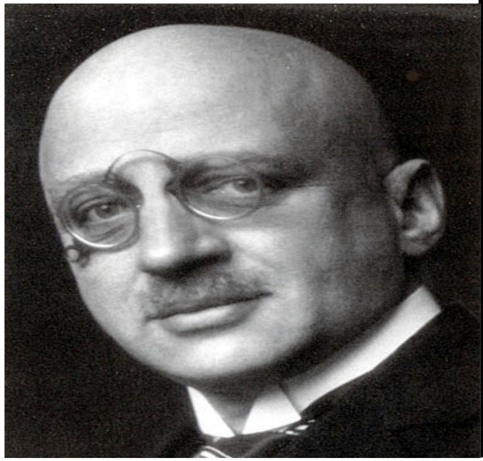


Carl Bosch and Fritz Haber 1900

O que é a nutrição das plantas?



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..."

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The industrialization of the N cycle

BASF
The Chemical Company

Science around us

Fertilizer out of thin air

… Green revolution

Consequências da revolução verde

The use of fertilizers allows the increase of human population

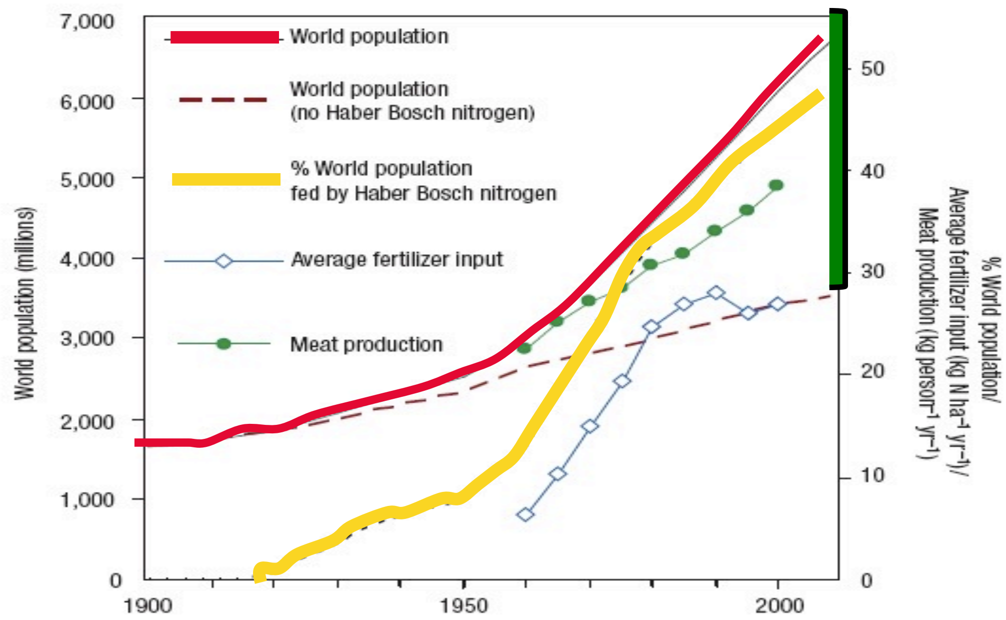

Figure 1 Trends in human population and nitrogen use throughout the twentieth century. Of the total world population (solid line), an estimate is made of the number of people that could be sustained without reactive nitrogen from the Haber–Bosch process (long dashed line), also expressed as a percentage 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

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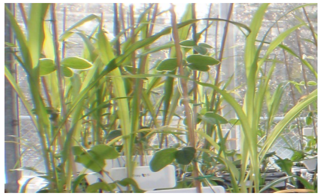
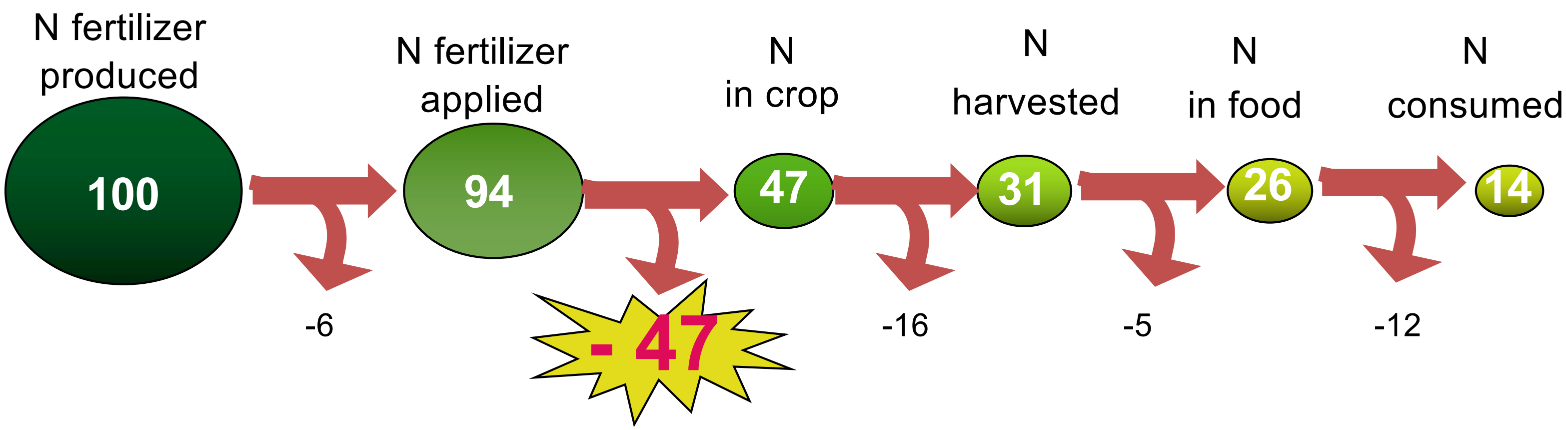
Consequências da revolução verde





Marshner 2013.

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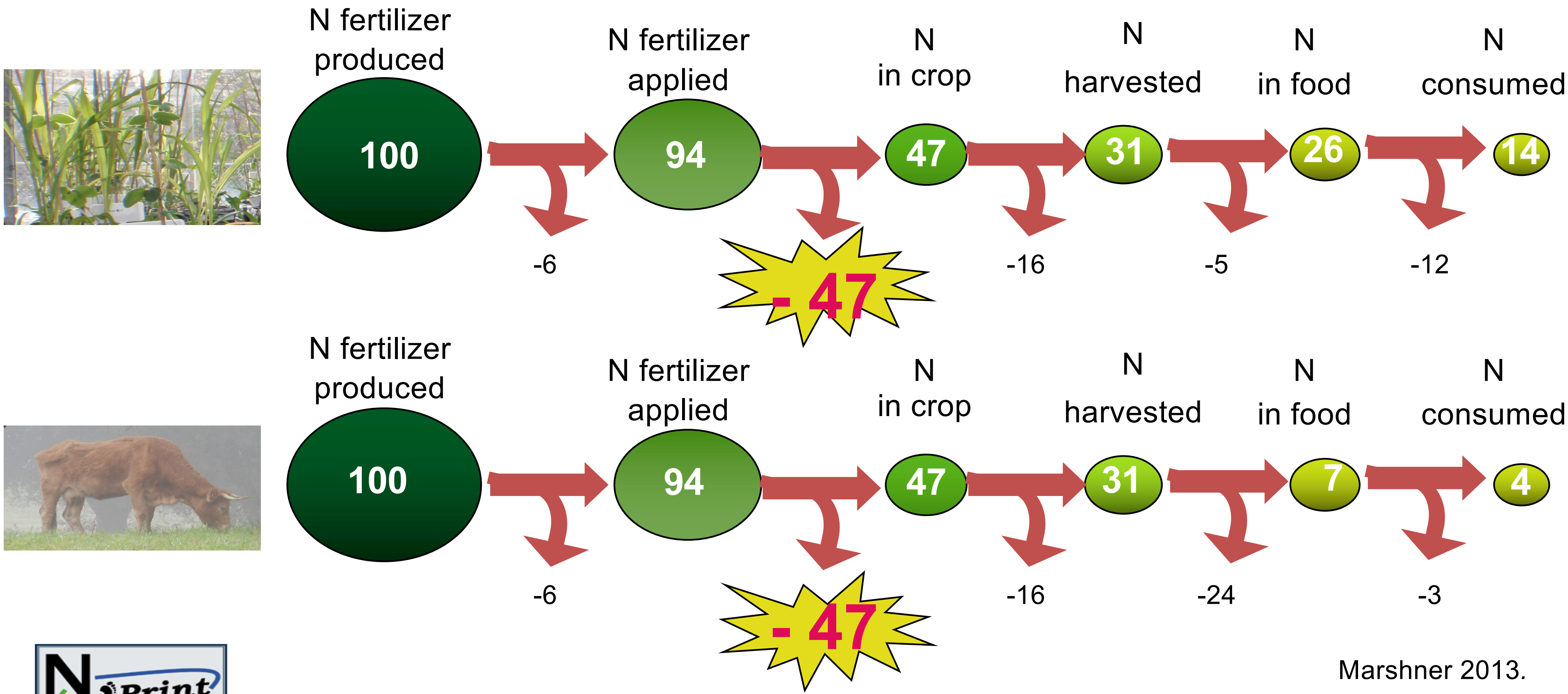
Consequências da revolução verde



Marshner 2013.

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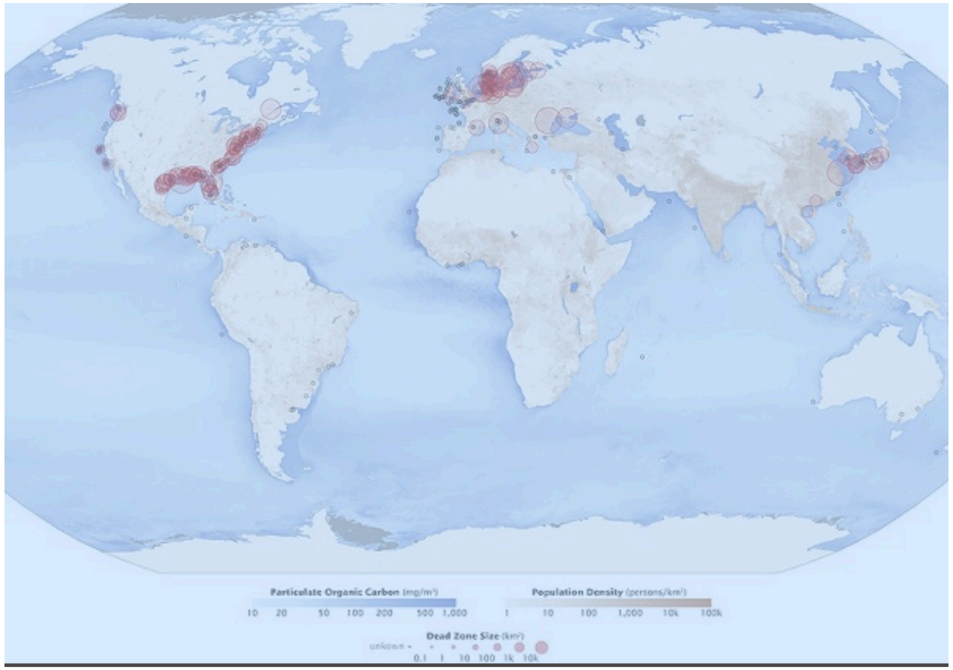
Consequências da revolução verde

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



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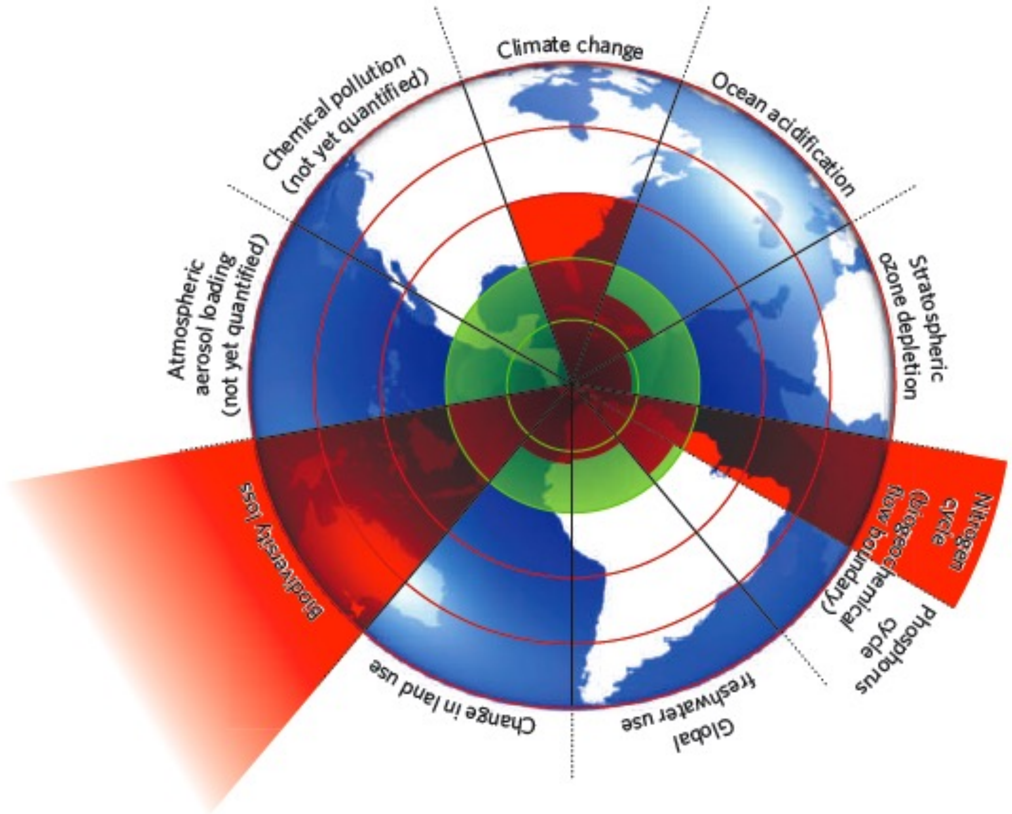
Consequências da revolução verde

Holocene

Anthropocene



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

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Como atingir e conciliar os múltiplos desafios?

Pode a nutrição vegetal ajudar?

Rejection of the humus theory

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" 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."

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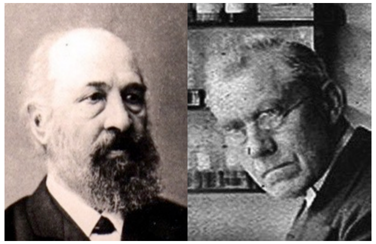
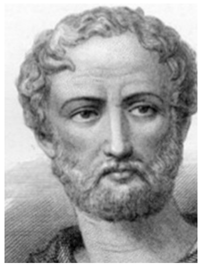


1888 – Hellriegel and Wilfarth

Organic matter — Water — **Minerals** **Building blocks** — (N) — **Biofertilizers**



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

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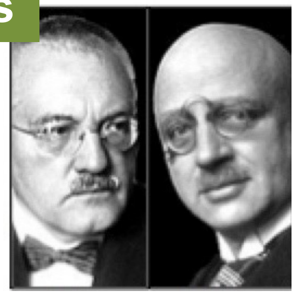

Carl Bosch and Fritz Haber 1900

Regulators

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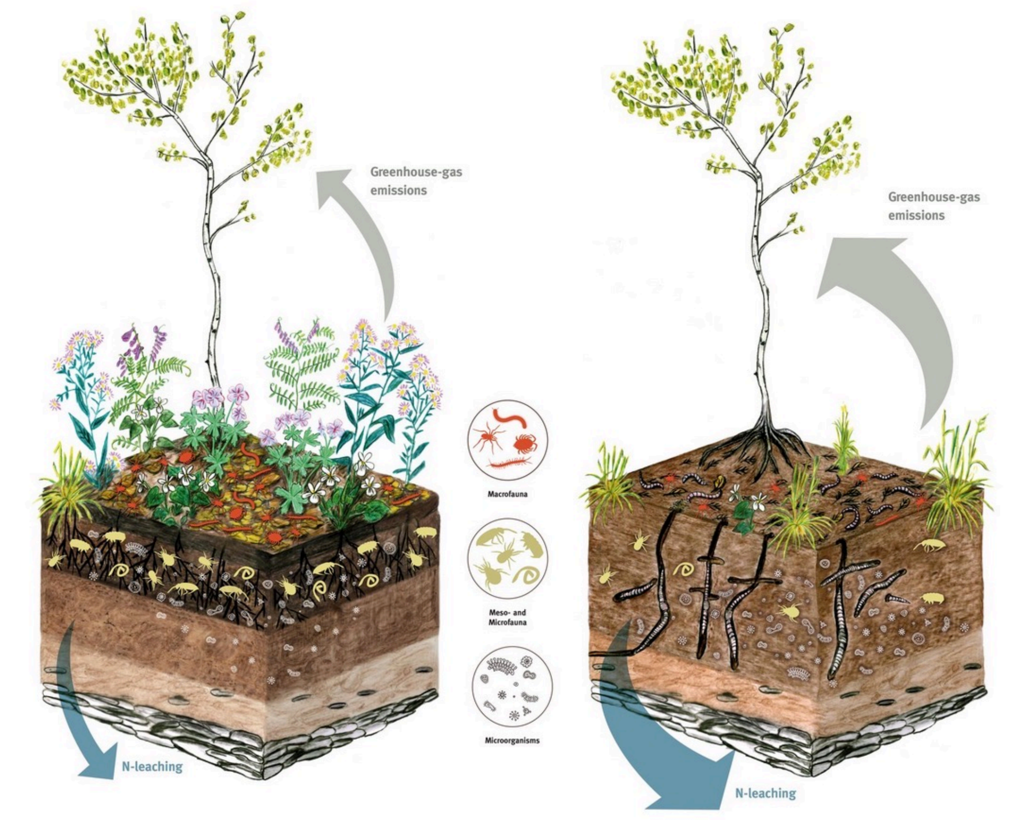
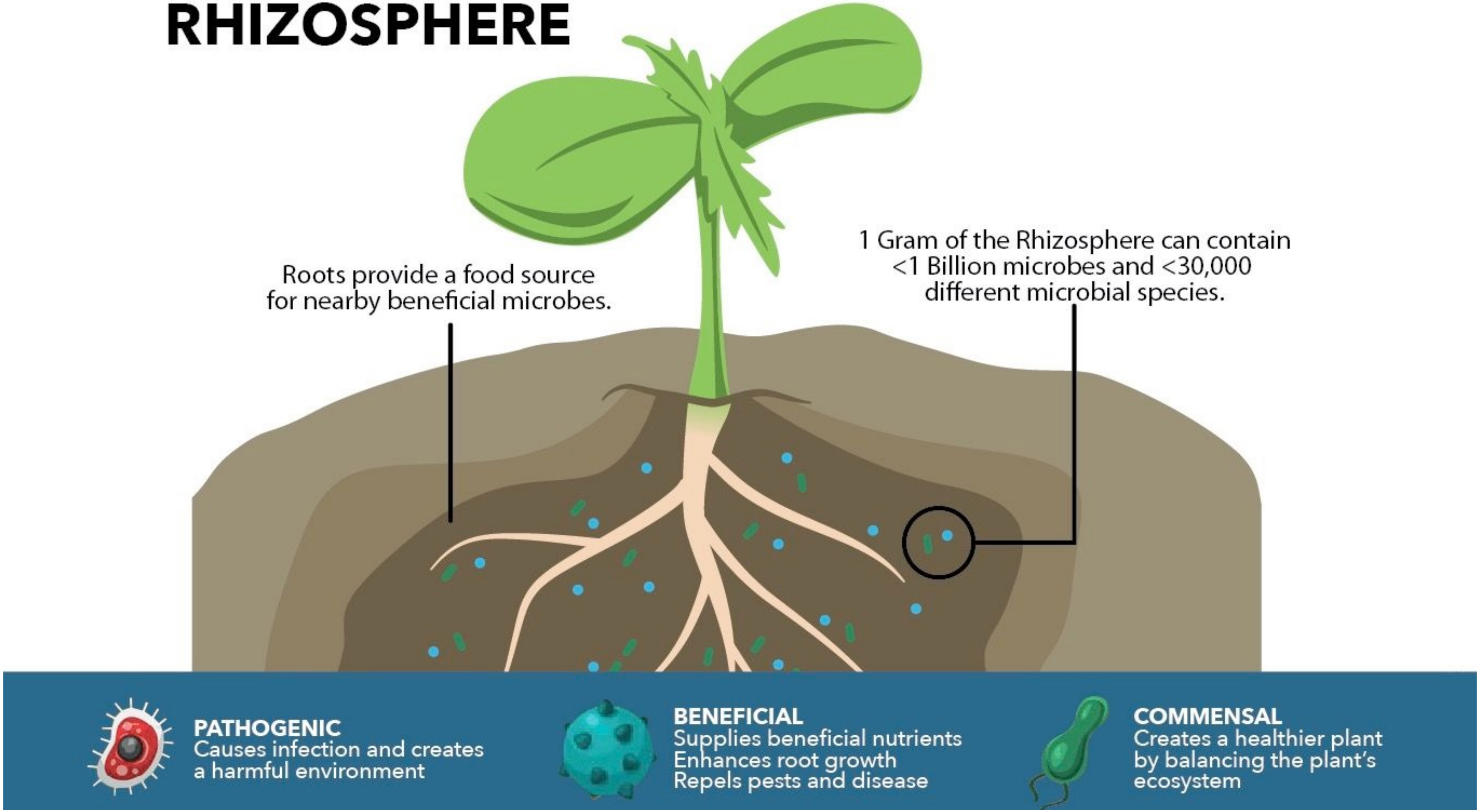
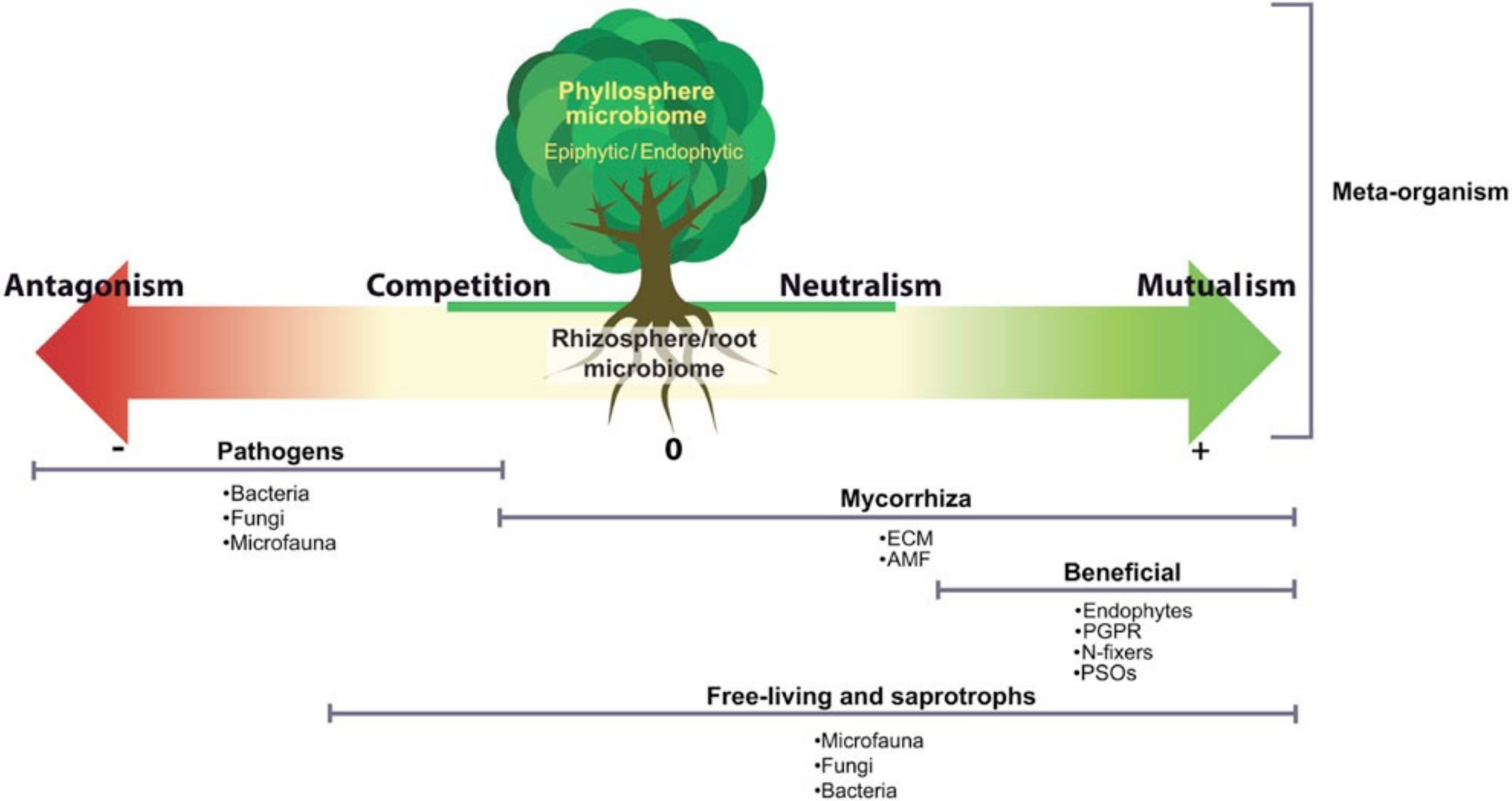
Why do we need **biofertilizers**?



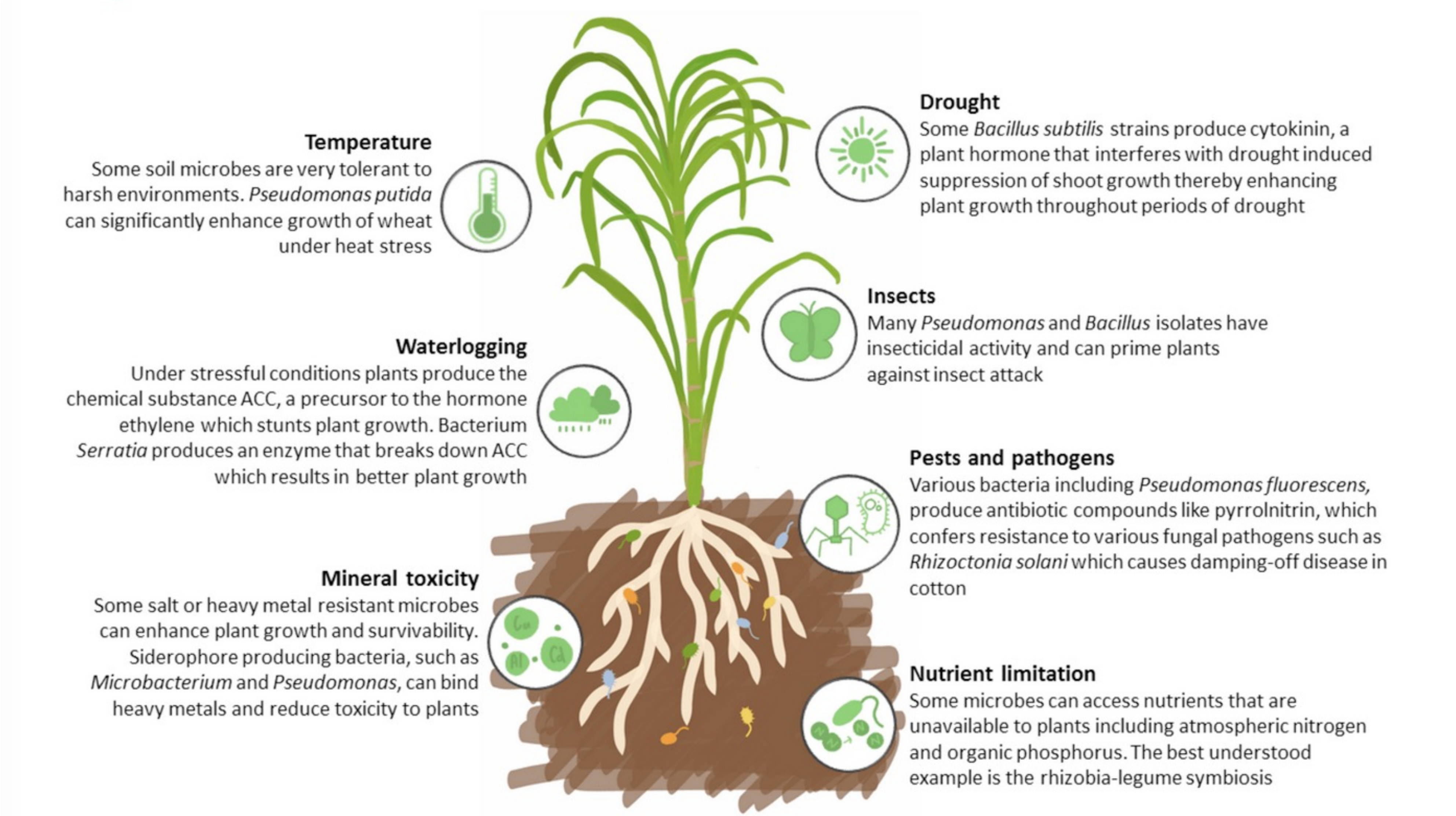
A

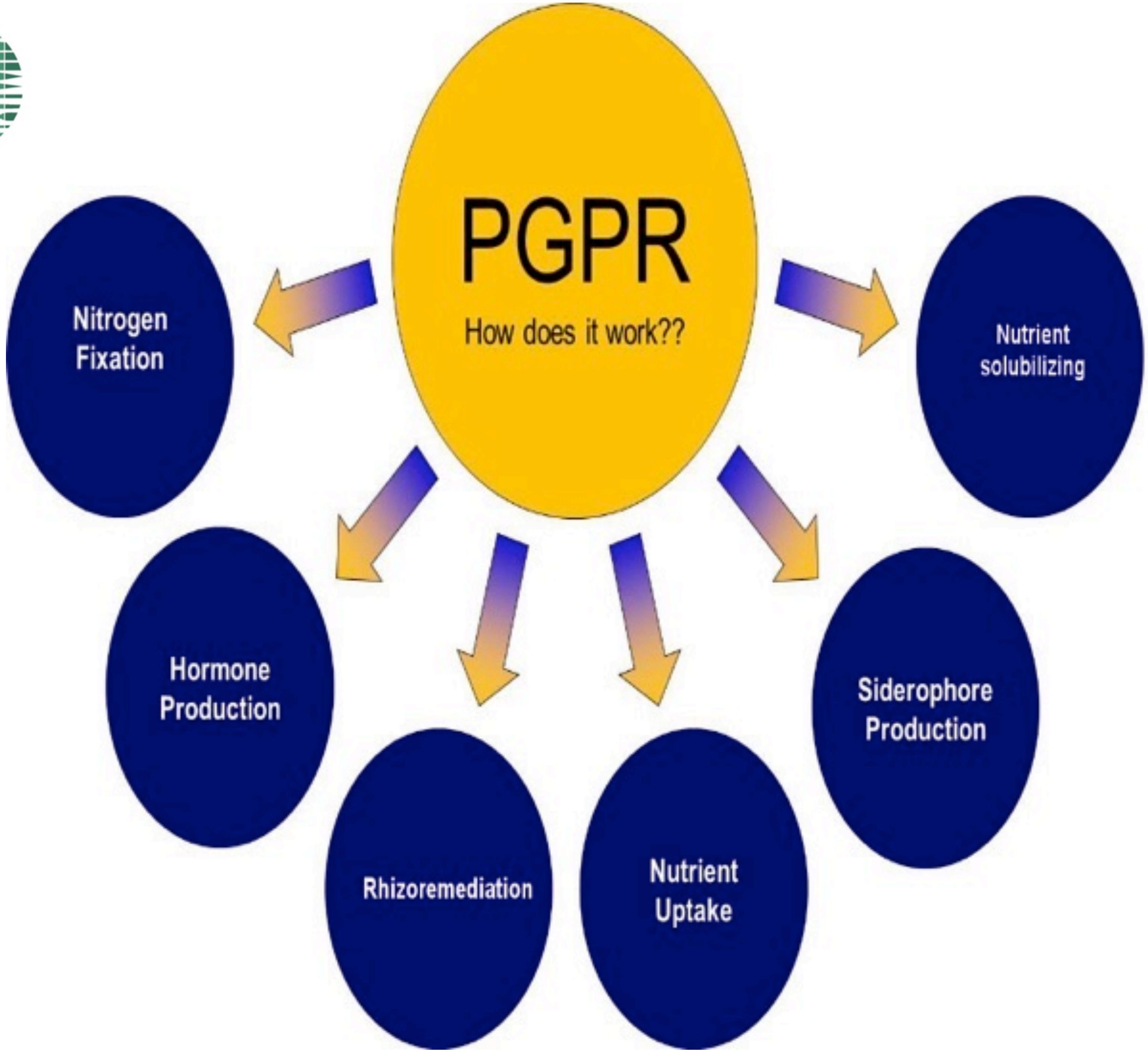
RHIZOSPHERE




Phyllosphere microbiome
Epiphytic/Endophytic
Meta-organism
Antagonism
Competition
Neutralism
Mutualism
Rhizosphere/root microbiome
-
0
+
Pathogens
•Bacteria
•Fungi
•Microfauna
Mycorrhiza
•ECM
•AMF
Beneficial
•Endophytes
•PGPR
•N-fixers
•PSOs
Free-living and saprotrophs
•Microfauna
•Fungi
•Bacteria

Efeitos benéficos dos microrganismos




PGPR
How does it work??
Nitrogen Fixation
Nutrient solubilizing
Hormone Production
Siderophore Production
Rhizoremediation
Nutrient Uptake

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

modalidades	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

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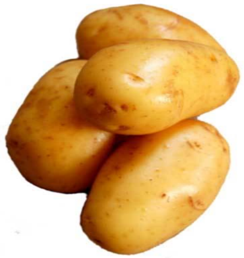
Why do we need **biofertilizers**?

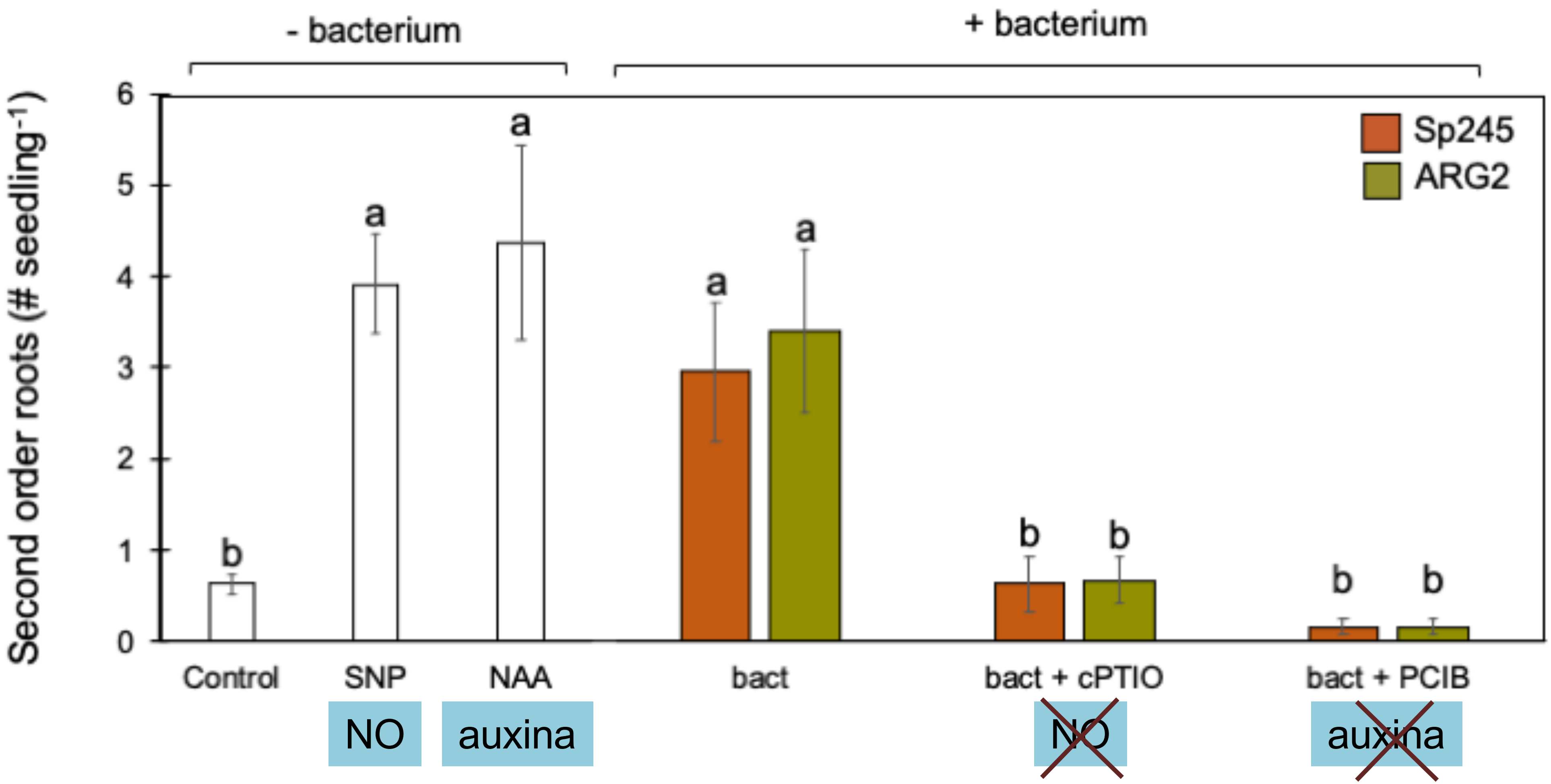


BATATA. Montijo. 2005.
Agricultor: Rui Afonso.
Solo: Areno-franco. pH: 6,1. MO: 1,3%
P_2O_5: 632 ppm K_2O: 84 ppm
Dose NPK: 1000 kg/ha de 6-20-18

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

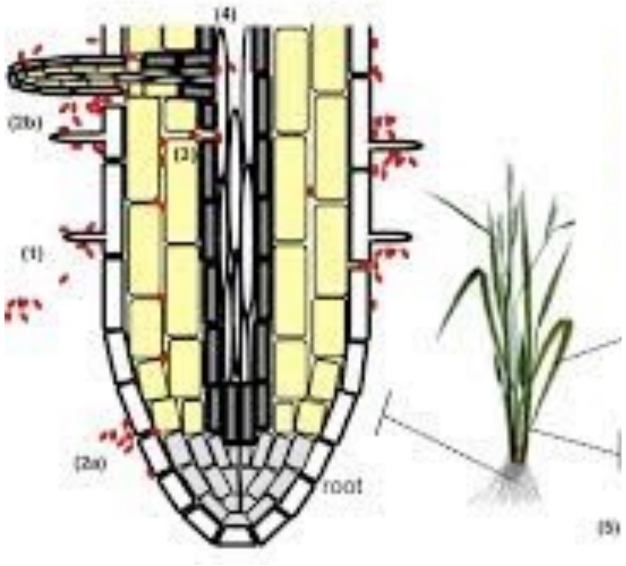
Exemplo da produção de fitohormonas



Plântulas de trigo inoculadas com 2 estirpes bacterianas (*Azospirillum brasilense*)

Ferreira, 2018

Exemplo do aumento de aquisição de nutrientes



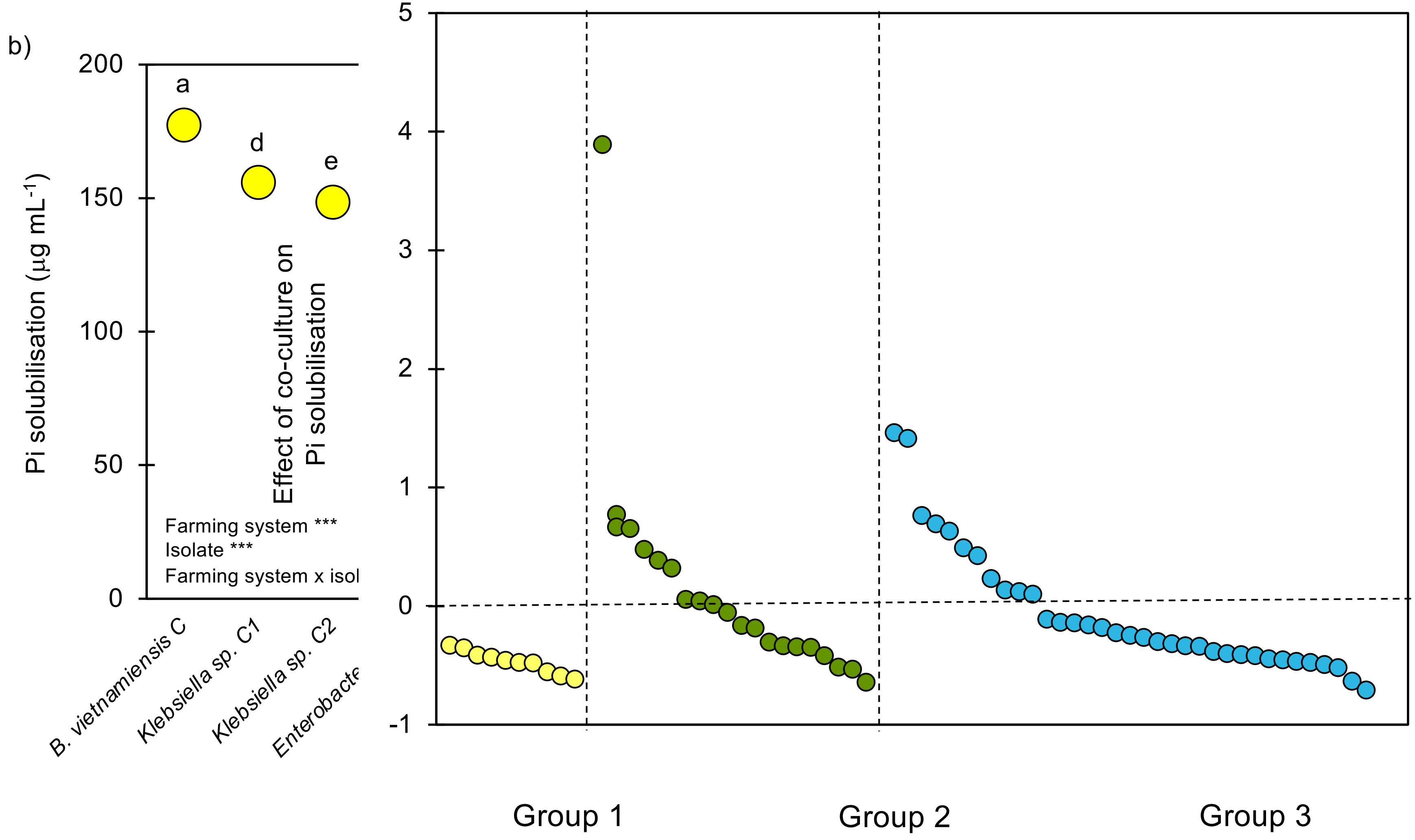
Plântulas de arroz inoculadas com uma estirpe bacteriana endofítica (*Herbaspirillum seropedicae*)

Table 1 Effect of *H. seropedicae* inoculation on rice shoot mineral contents and isotopic N signature ($\partial^{15}N$)

	Non-inoculated	Inoculated	Inoculation effect
Macronutrients (mg shoot^{-1})			
N*	15±1	33±1	+120%
P*	1±0	6±1	+350%
K*	14±1	77±1	+430%
Ca*	4±1	11±1	+150%
Mg*	3±0	6±1	+110%
S*	2±0	6±1	+300%
Micronutrients (µg shoot^{-1})			
Fe*	323±12	576±19	+80%
B*	15±1	50±2	+230%
Cu*	10±1	39±0	+280%
Mn*	682±28	465±17	− 30%
Mo*	0±0	2±0	+1020%
Ni*	11±0	50±1	+340%
Zn*	95±13	3385±193	+3460%
$\partial^{15}N$*	− 2.7±0.3	5.7±0.5	Na

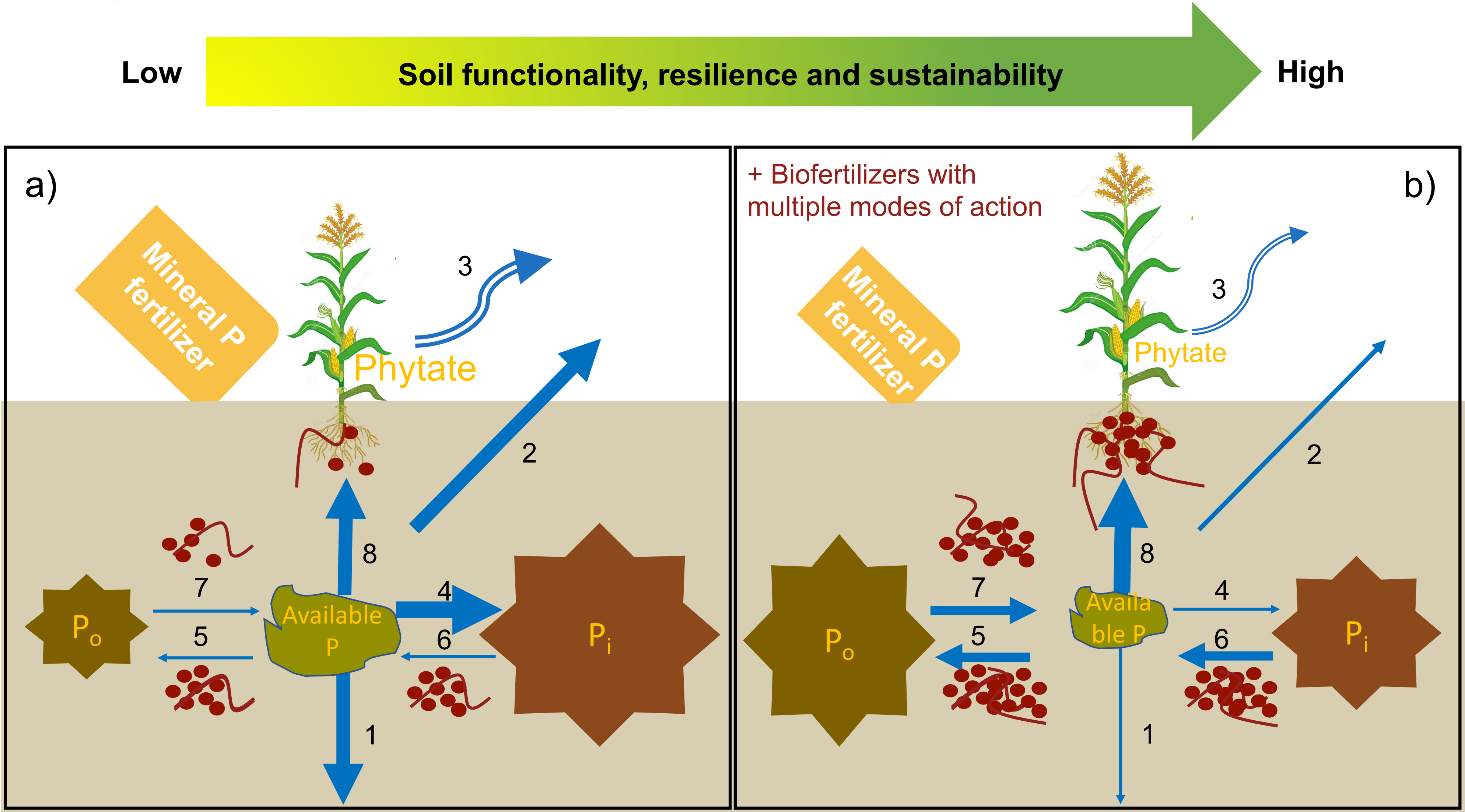
Ramos et al 2020

Exemplo do aumento de solubilização de P



Melo et al 2018

Exemplo dos biofertilizantes na gestão do P



Basílio et al, submetido

Biofertilizers

Increase crop productivity

+

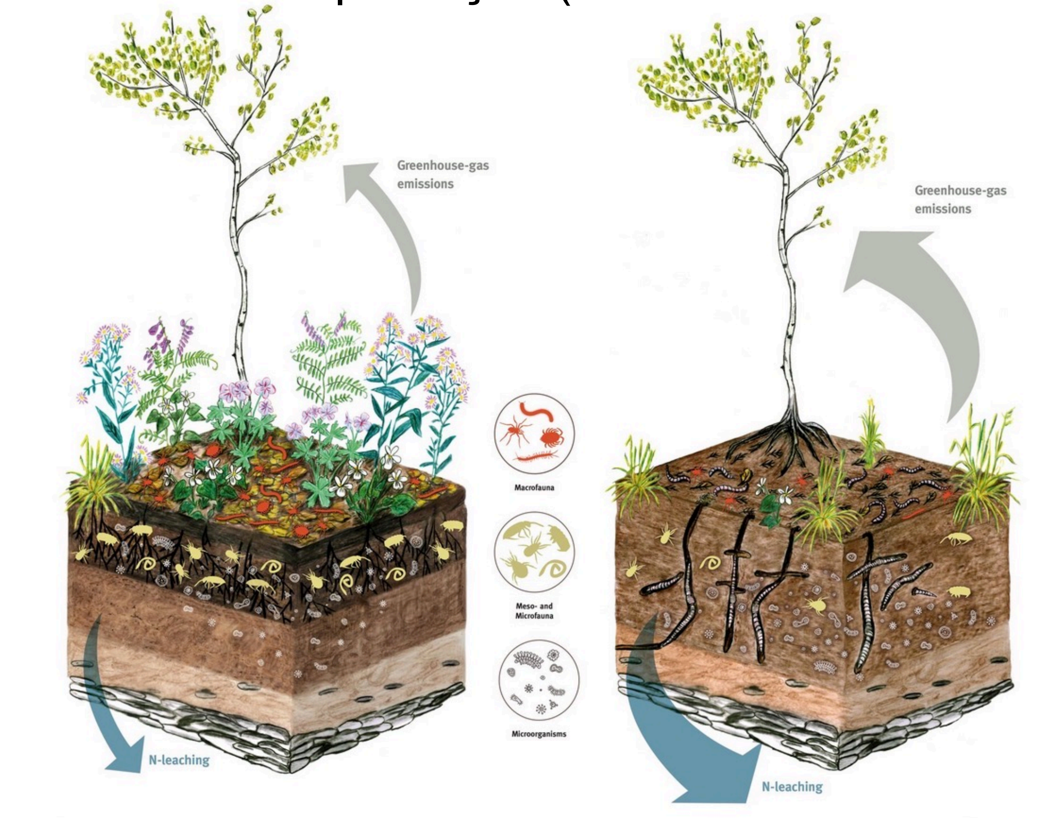
Reduction in the amount of synthetic fertilizers

Reduction of the Ecological Footprint

FV- nutrição

Objetivo da aula prática de Nutrição

Realçar a importância no modo de produção (**convencional** versus **orgânico**):



1. No solo (cromatografia circular do solo)
2. Nas respostas fisiológicas da planta (SPAD) e consequentemente na qualidade alimentar (grau Brix e concentração de nitrato)

CROMATOGRAFIA CIRCULAR DO SOLO

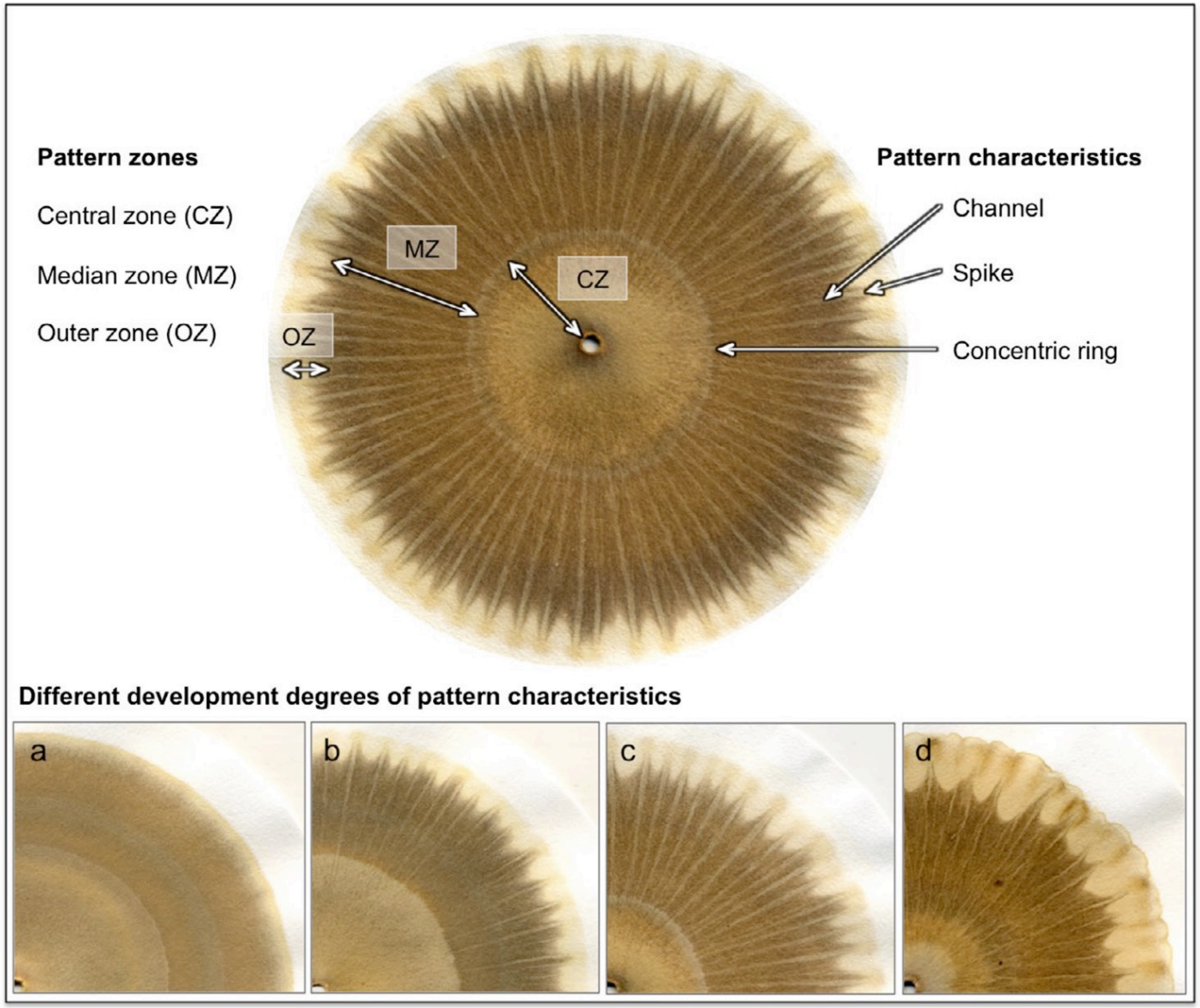
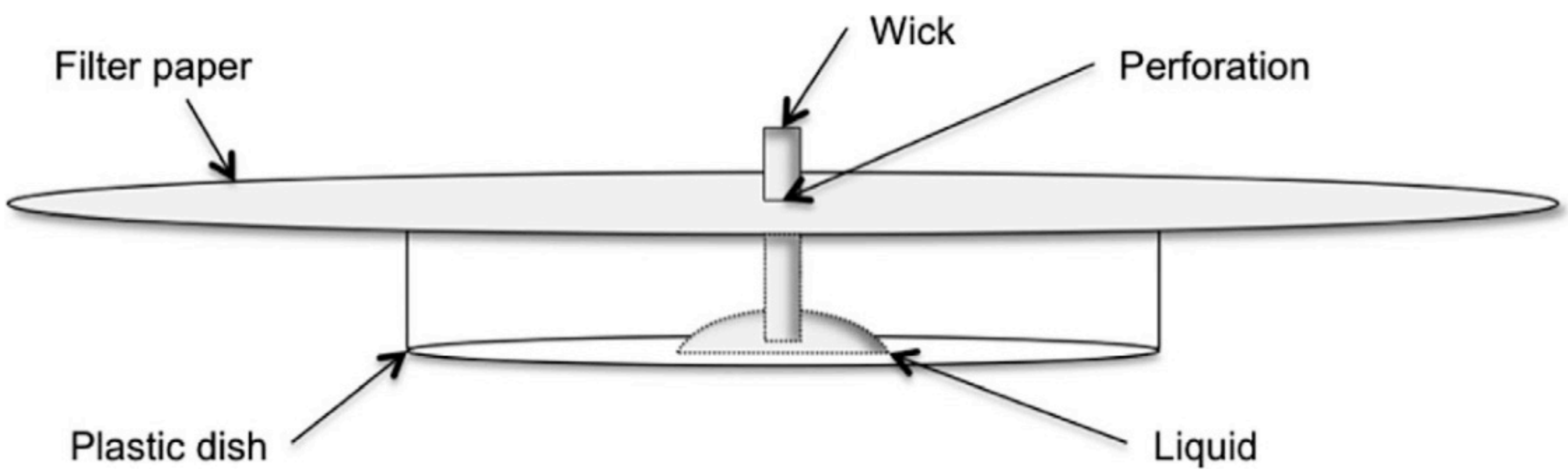


Figure 1. Exemplo de uma Cromatografia Circular, com indicação das várias zonas e padrões formados (no topo) e secções dos padrões (em baixo) ilustrando, de (a) a (d), um aumento no desenvolvimento de padrões radiais (isto é: canais e espigas), e intensidade da cor, e uma diminuição dos padrões concêntricos (isto é: anéis concêntricos). *From: Kokornaczyk et al., 2017*

CROMATOGRAFIA CIRCULAR DO SOLO



Parâmetro fisiológico não destrutivo

Soil Plant Analysis Development (*SPAD*)

The meter works by emitting two frequencies of light, one at a wavelength of 660 nm (red) and one at 940 nm (infrared).
Leaf chlorophyll absorbs red light but not infrared, the difference in absorption is measured by the meter and termed "**Optical Density Difference**," ODD. Therefore, the unit of measurement is ODD, a ratio that is provided by the meter. The value does not give an actual chlorophyll or nitrate content.

SPAD

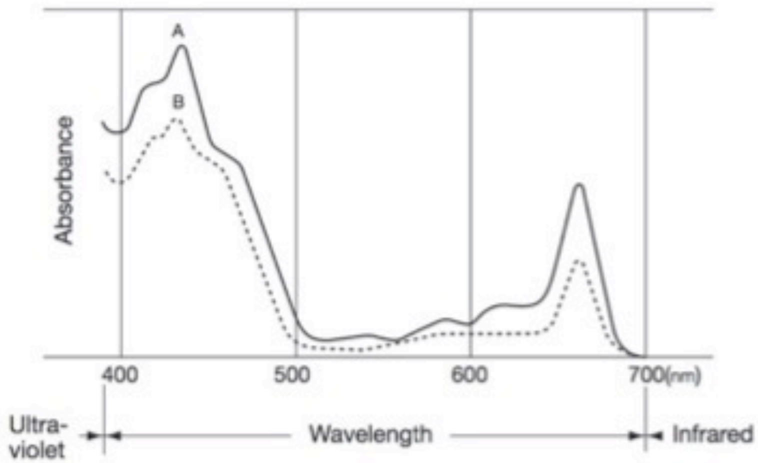
Theory

The SPAD-502Plus determines the relative amount of chlorophyll present by measuring the absorbance of the leaf in two wavelength regions.

The graph below shows the spectral absorbance of chlorophyll extracted from two leaf samples using 80% acetone.

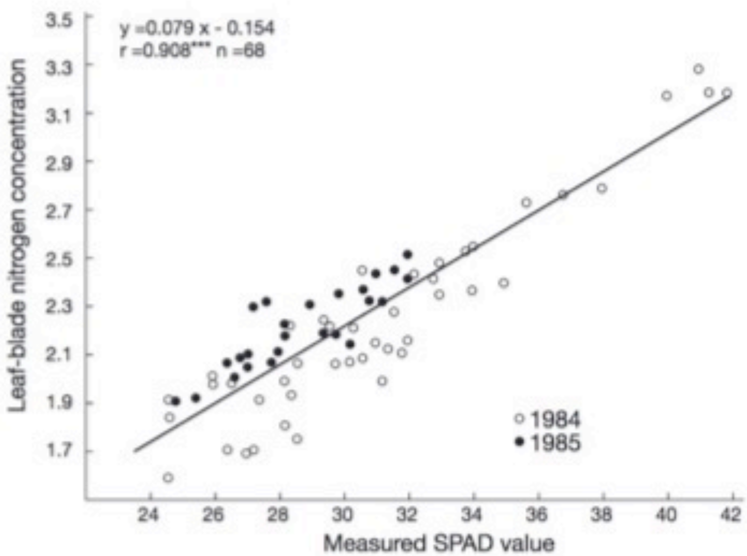
From the diagram, it can be seen that chlorophyll has absorbance peaks in the blue (400-500 nm) and red (600-700 nm) regions, with no absorbance in the near-infrared region.

To take advantage of this characteristic of chlorophyll, the SPAD-502Plus measures the absorbances of the leaf in the red and near-infrared regions. Using these two absorbances, the meter calculates a numerical SPAD value which is proportional to the amount of chlorophyll present in the leaf.

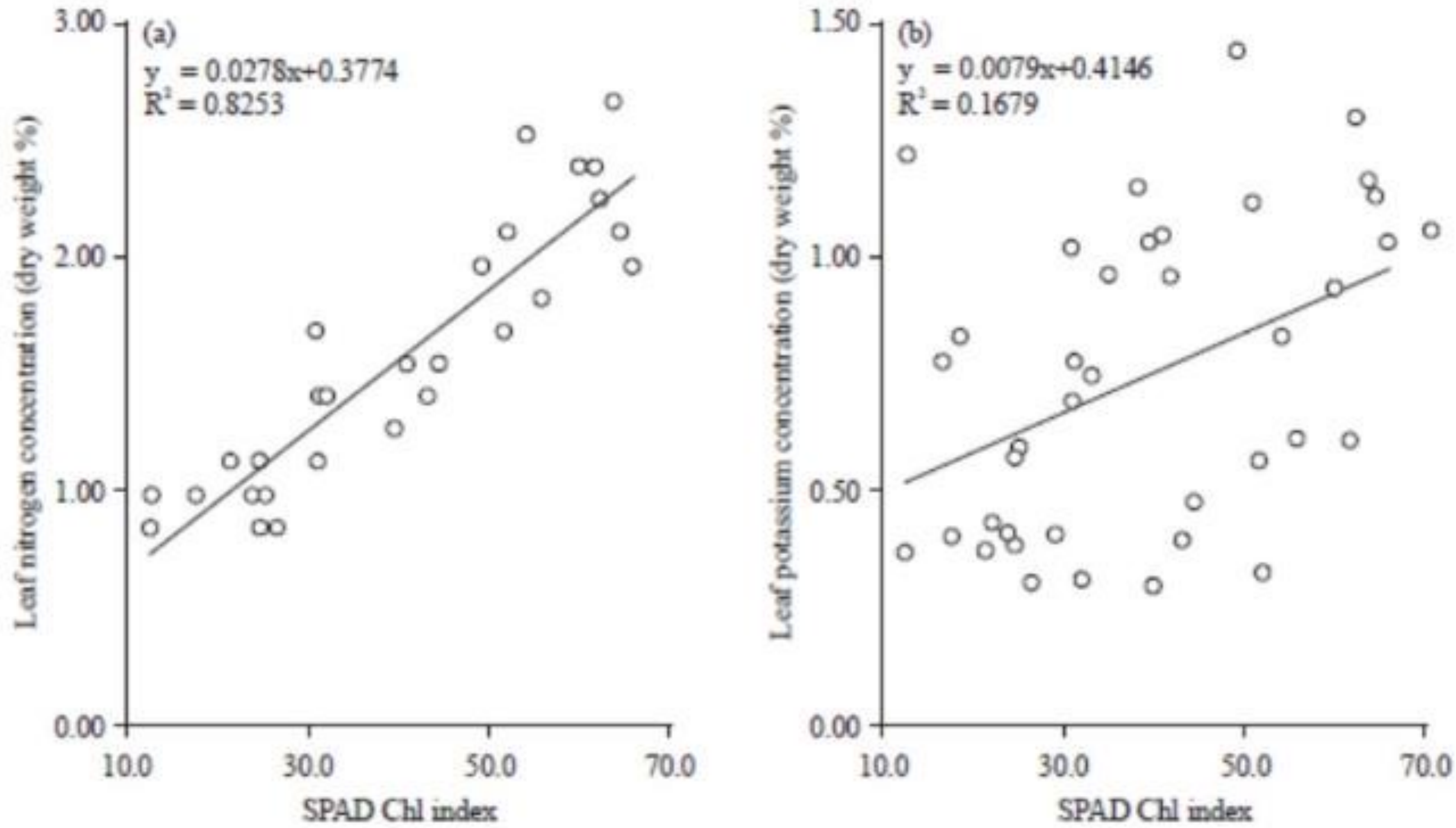


Checking the nutritional condition of plants

The chlorophyll present in the plant leaves is closely related to the nutritional condition of the plant. As can be seen from the graph below, the chlorophyll content (represented by the measured SPAD value) will increase in proportion to the amount of nitrogen (an important plant nutrient) present in the leaf. For a particular plant species, a higher SPAD value indicates a healthier plant.

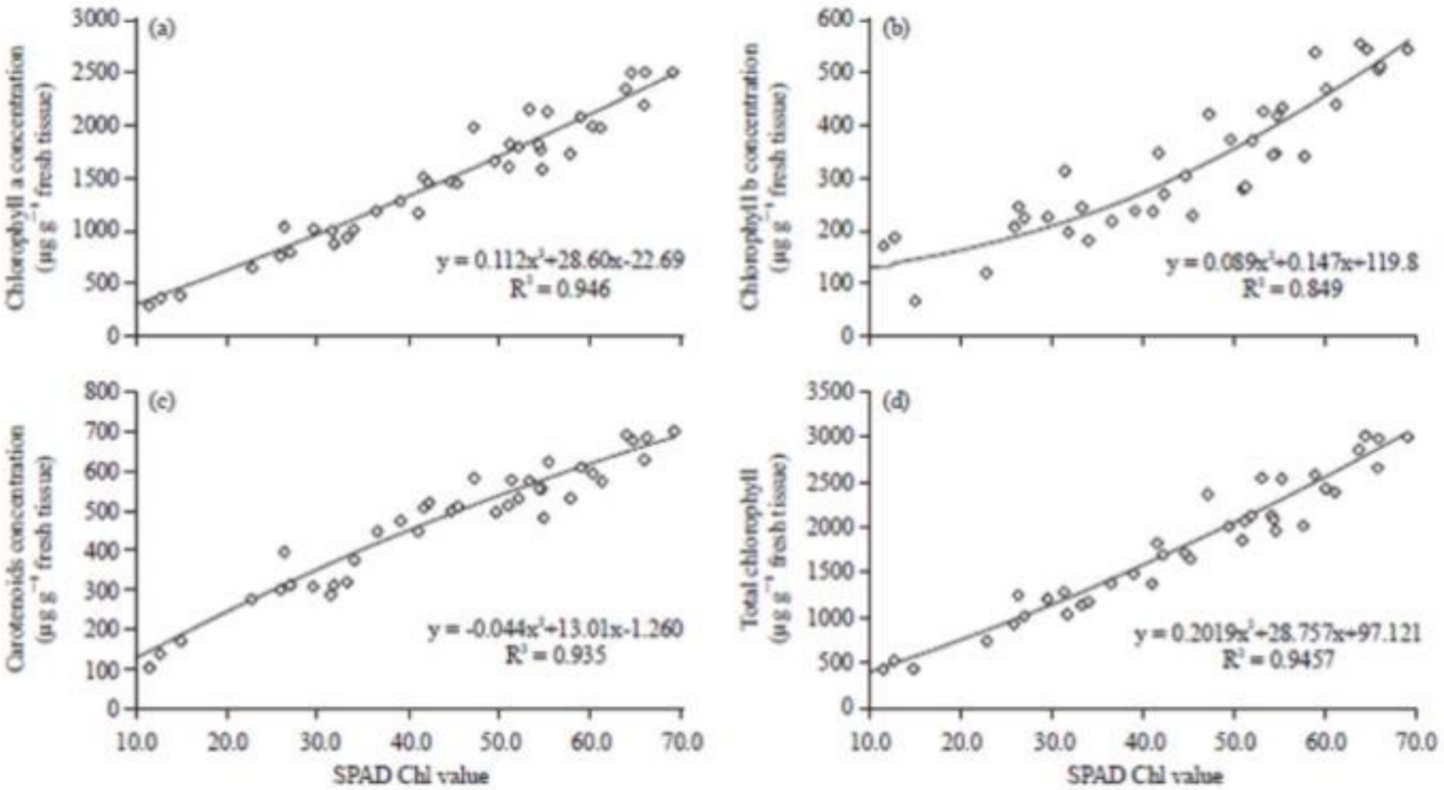


SPAD



O SPAD relaciona-se com o N mas não com o K.

SPAD



Se esta curva representar a relação entre o valor de SPAD e a concentração de N na folha de alface (*Lactuca sativa*), qual será a concentração de N das folhas nos distintos tratamentos experimentais da aula Prática?

Há diferenças entre os tratamentos?
Será necessário proceder a fertilização?
Será um valor de alerta para nitratos?

Parâmetro de qualidade alimentar destrutivo: grau Brix

Brix (Sólidos totais solúveis)

É um refratómetro (ideal para medições quer em laboratório, quer em campo).

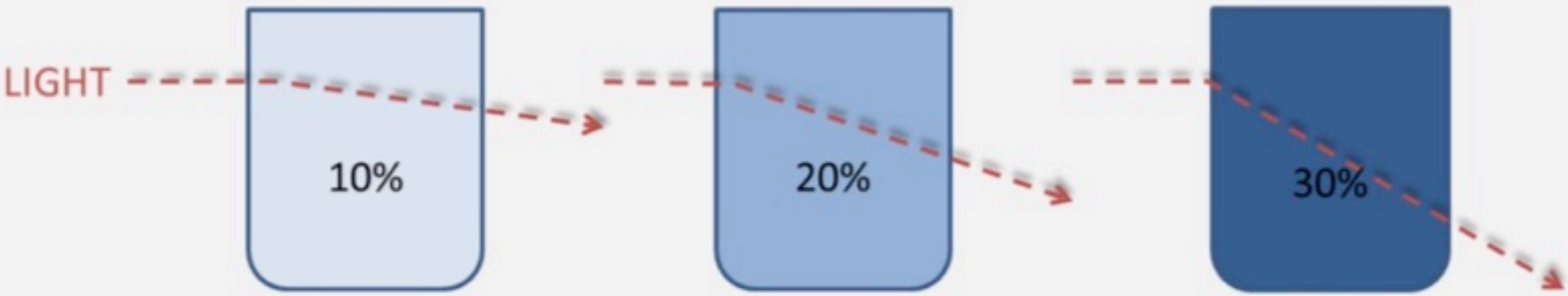
É um instrumento ótico que utiliza a medição do índice de refração para determinar o conteúdo de açúcar de soluções aquosas em % Brix.

Grau Brix

What is Brix (Sólidos totais solúveis)?

Refractive Index

Refractive Index (RI) is the tendency of light to bend as it passes through a liquid. A beaker of pure water will bend light that passes through it. As solids are dissolved in a beaker of water, light will increasingly bend as the concentration increases.



BRIX: History and Application

BRIX is a unit of measurement of refractive index, in the same way Fahrenheit or Celsius is a measurement of temperature. In both circumstances the properties of real world materials were used to devise a continuous scale of measurement. In the case of Fahrenheit, the properties of water were used to come up with a scale based on its thermal behavior. The two ends of the scale were divided by 180°F, yielding 32°F for water�s freezing point and 212°F for its boiling point.

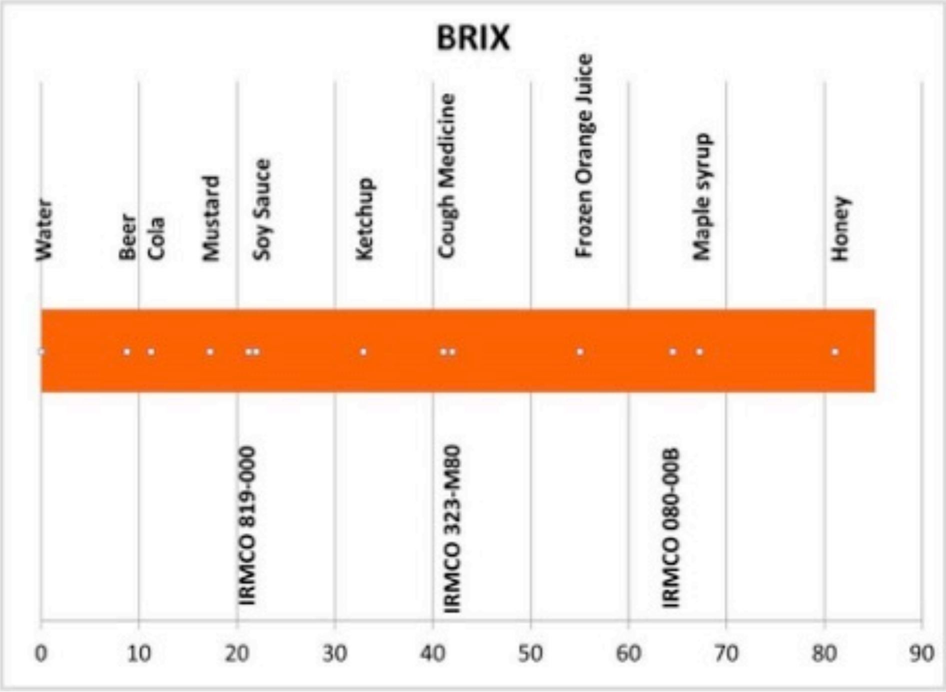
In the case of BRIX, sugar (sucrose) solutions were used to develop the scale. Arbitrarily, the refractive index of pure water (RI=1.333) was simply defined as "0" BRIX. The rest of the scale was calibrated to be read directly as percent Sucrose (i.e. BRIX). This was a convenient reference, as it was used to monitor when fruit had ripened and was ready for harvesting. Today, the BRIX scale is commonly used in the food industry for measuring the approximate amount of sugars in fruits, vegetables, juices, wine and soft drinks. It also finds use in the metalworking industry as a convenient way to check water-based lubricant concentration.

Grau Brix

Measurement

Because of the widespread availability of handheld refractometers, measuring the BRIX value of a fluid is easy. However, not all solids bend light to the same degree. The actual concentration of a given fluid must be calibrated to relate to BRIX by the manufacturer. A conversion factor or Brix table should be provided for each product.

The first major deadline was December 1, 2013. All Employers that handle chemicals were required to train their employees about the upcoming changes being made to the 29 CFR 1910.1200 Hazard Communication Standard. MSDSs and labels were not required to change at this time. It is expected to take approximately 18 months after the initial training deadline for chemical manufacturers and distributors to fully reformat their current product labels and MSDSs to the GHS format.



Interpretation

Not all solids are equal! In metalworking, BRIX is quite handy for monitoring dilutions but it is less useful for comparing two different fluids. Depicted to the right are several fluids and their BRIX values. It is important to understand that although BRIX can be related to concentration, it says nothing about the nature of the solids. Put another way, a 64 BRIX could be a highly additized synthetic lubricant concentrate - or, it could be maple syrup. A 32 BRIX could be a 1:1 mixture of that same lubricant - or it could be ketchup. One would be suitable for working metal - and the other would crash your die.

Parâmetro de qualidade alimentar destrutivo: concentração de nitrato

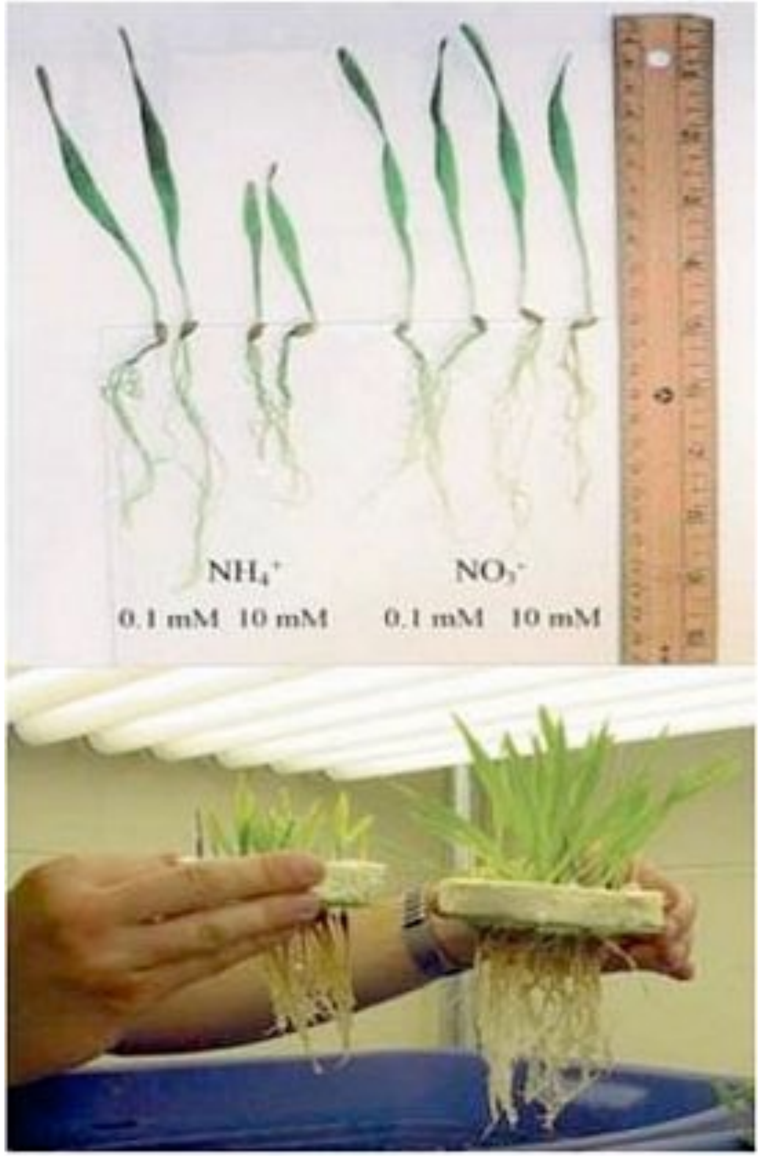
$[NO_3^-]$: Eléctrodo selectivo de NO_3^-

Concentração de nitrato

$[NO_3^-]$: Eléctrodo selectivo de NO_3^-

N is essential for good growth and high yields, especially in a plants early growth stage. It is therefore very important to be able to accurately measure how much nitrogen you need for your soil, your fertilizers, in the leaves of your plant.

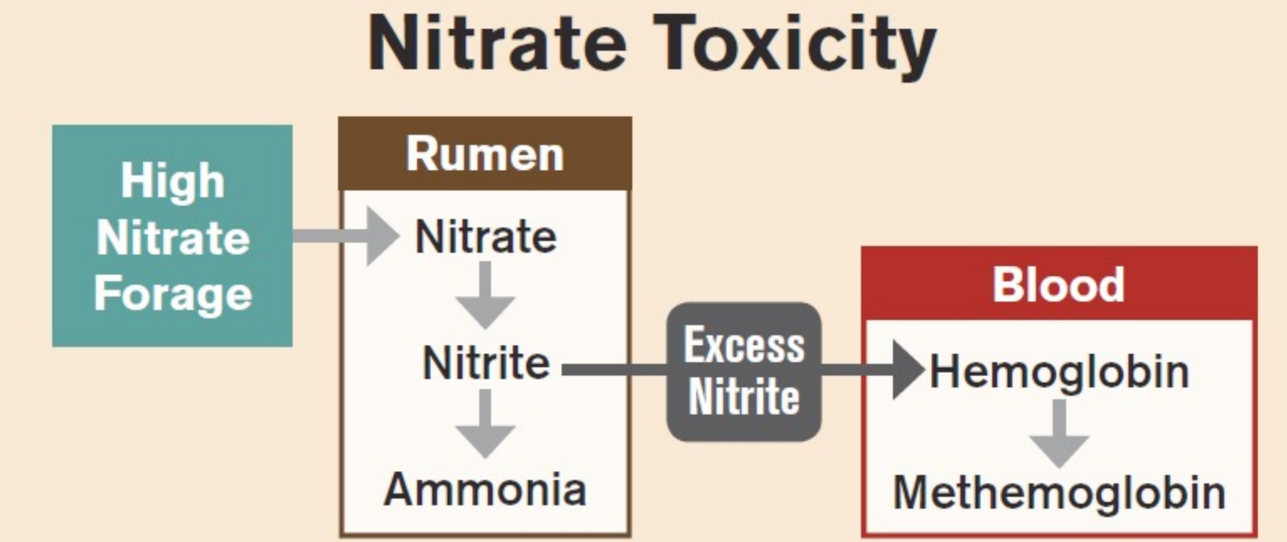
Main forms of N taken up by plants: NH_4^+ and NO_3^-



Concentração de nitrato

$[NO_3^-]$: Eléctrodo selectivo de NO_3^-

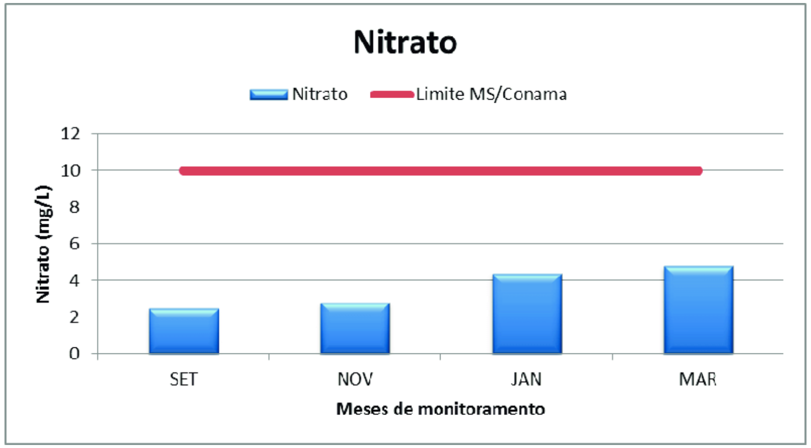
However, too much N in human and animal feed can cause NO_3^- poisoning and has been associated with cancer, so it is also important for health purposes to be able to measure NO_3^- content of your foods.



A build-up of nitrates in the rumen can lead to methemoglobin, a form of hemoglobin that lacks oxygen-carrying ability.

Concentração de nitrato

$[NO_3^-]$: Eléctrodo selectivo de NO_3^-



Muito baixo (< 200)	Baixo (200-500)	Médio (500-1000)	Alto (1000-2500)	Muito alto (>2500)
Alcachofra	Abóbora	Couve	Aipo vermelho	Agrião
Alho	Bróculos	Couve-Sabóia	Alho francês	Aipo
Batata	Cenoura	Endro	Endívias	Alface
Cebola	Couve-flôr	Nabo	Funcho	Espinafre
Cogumelos	Pepino		Rábano	Rabanete
Ervilha			Salsa	
Espargos				

Directiva água: **10 ppm**

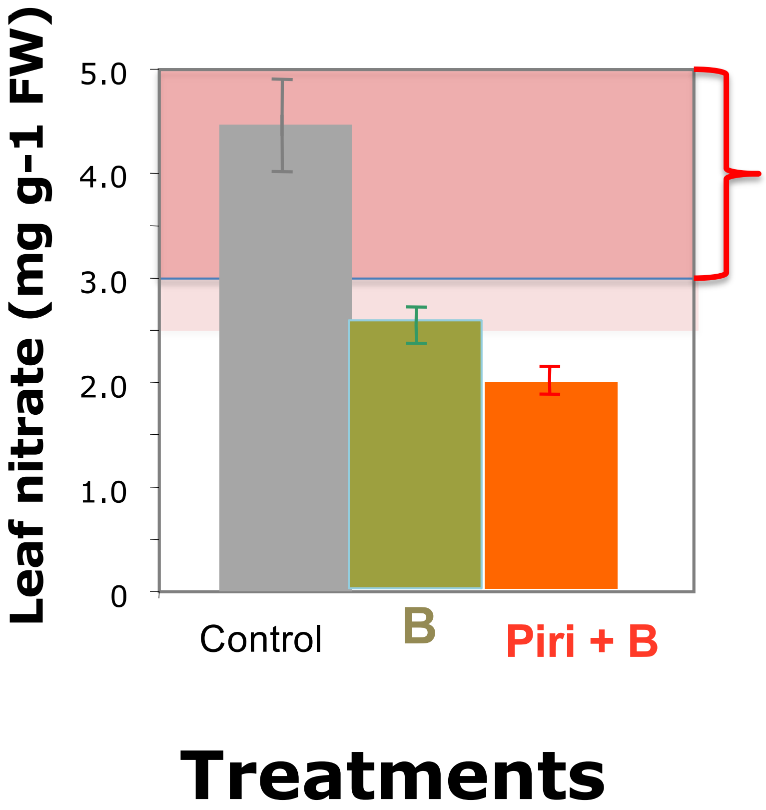
Produtos hortícolas: varia

Máx. 5000 ppm

Concentração de nitrato

response of spinach to soil inoculant

Leaf nitrate



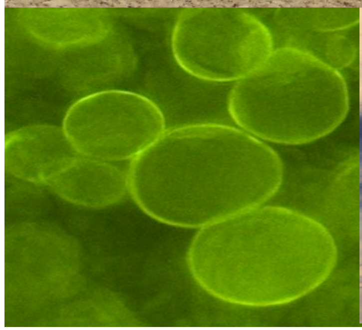
Not for sale = money lost

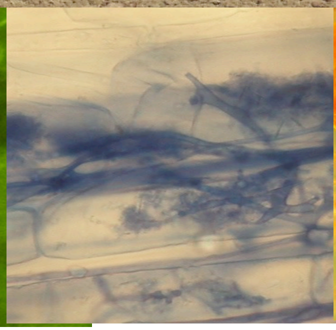
Regulation CE nº1881/2006

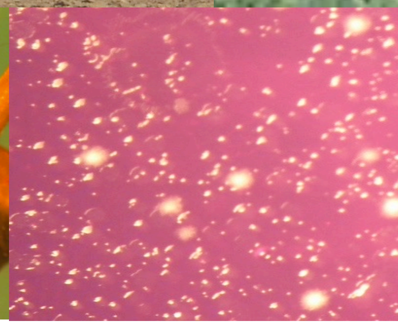
Nitrate is a normal component of the human diet (average daily intake 75 mg.
Upon ingestion, ±5% of the nitrate is reduced to nitrite by bacteria
When the pH of the gastric fluid is high (>5) nitrate-reducing bacteria increase and more N-nitroso compounds can be formed.

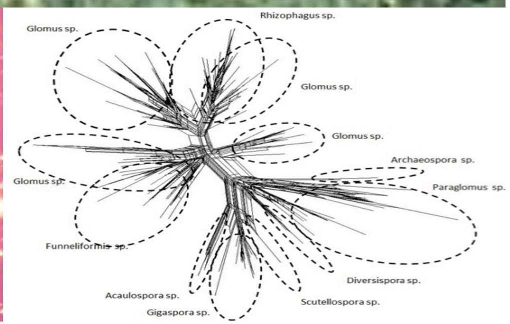
FV- nutrição

Applied soil ecology may help filling the productivity gap









BIG PICTURE

★ RANCH ★