# Soil biology and Rhizosphere biology

By: Pius Floris.
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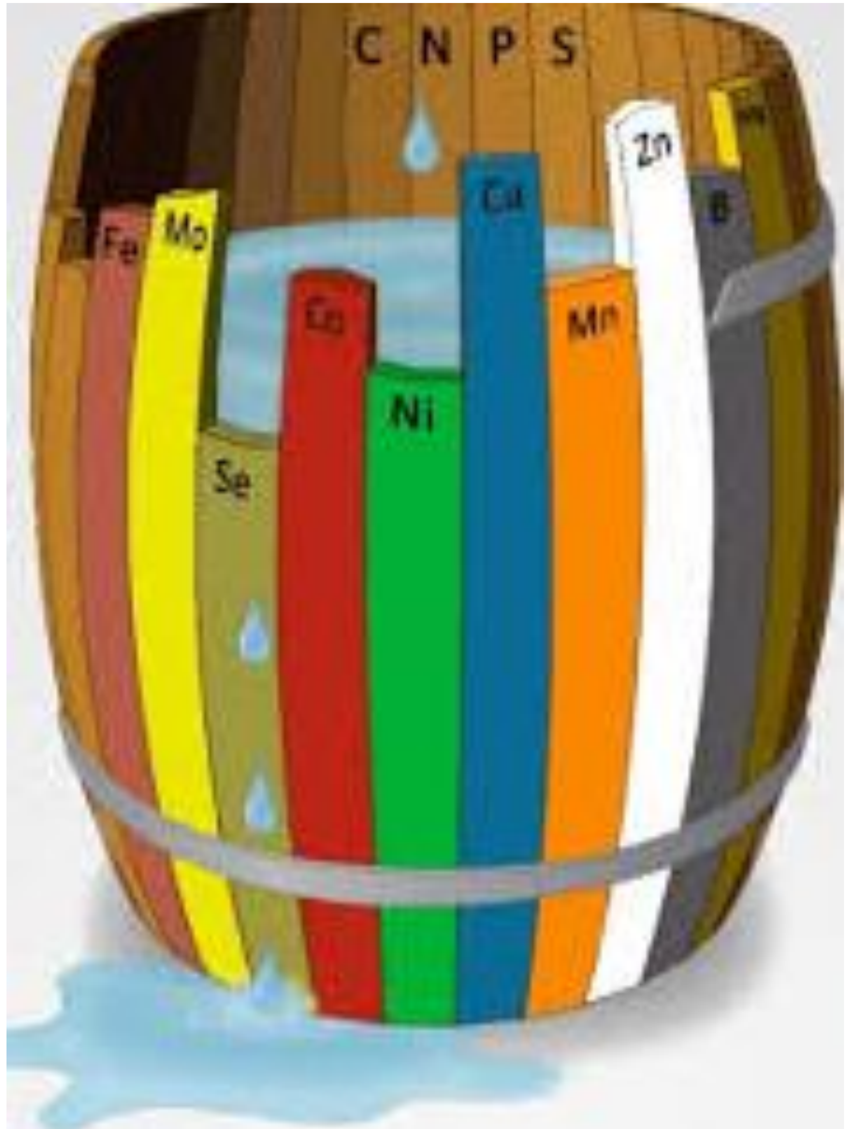
# Plants can grow anywhere

Vancouver Canada

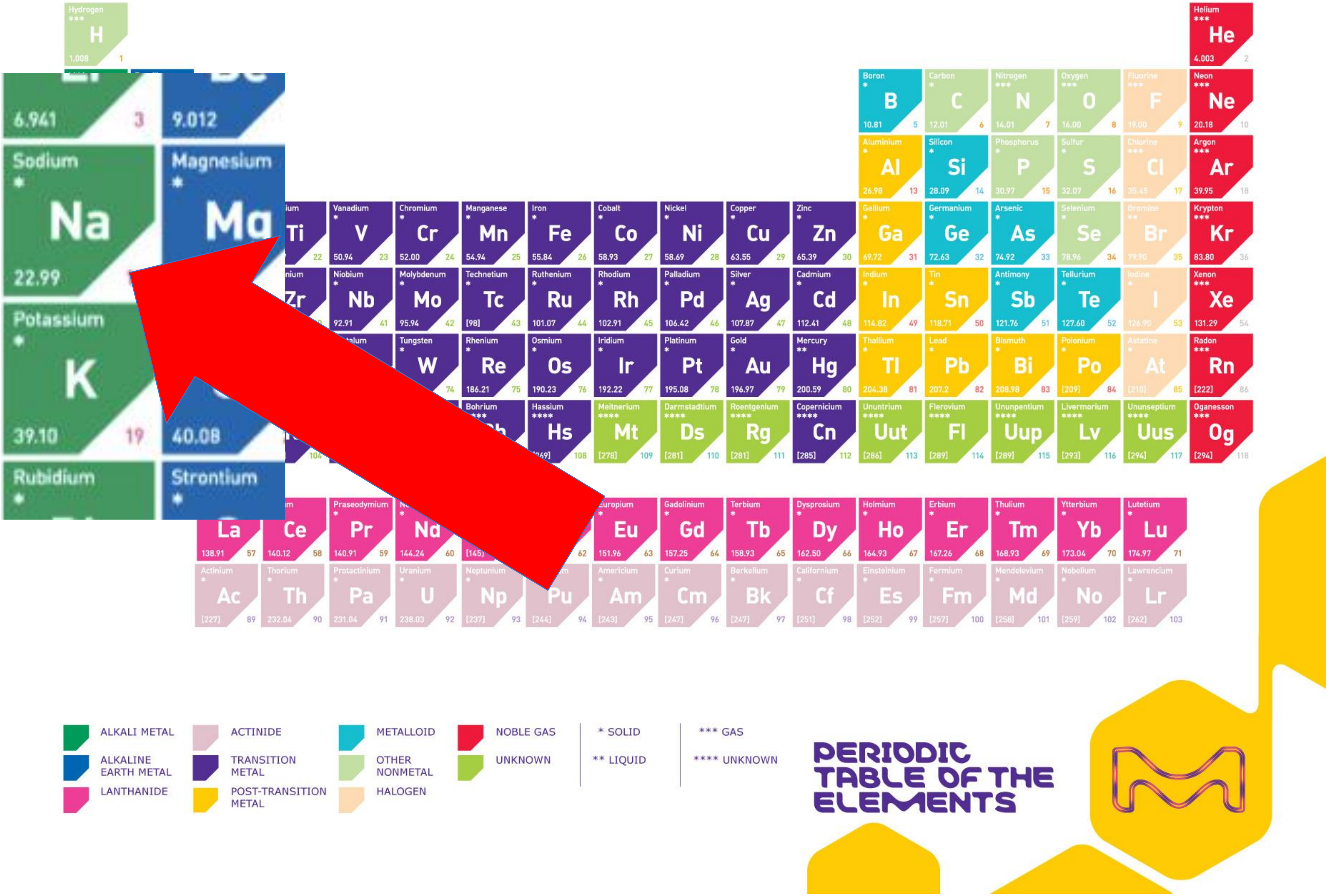
Figure 1.3 Liebig's Laboratory in Giessen (Drawing by Carl Friedrich Wilhelm Trautshold in 1842.)

This is the place where **"Law of the minimum"** was created.
160 years ago people had no idea from bacteria or fungi

Today the laboratory in Giesen (D) is a museum
sponsor: Merck Pharmaceuticals




**Von Liebig's "LAW OF THE MINIMUM" is 160 years old!**


6.941
9.012
Sodium
Na
22.99
Magnesium
Mg
Potassium
K
39.10
40.08
Rubidium
Strontium
ALKALI METAL
ALKALINE EARTH METAL
LANTHANIDE
ACTINIDE
TRANSITION METAL
POST-TRANSITION METAL
METALLOID
OTHER NONMETAL
HALOGEN
NOBLE GAS
UNKNOWN
* SOLID
** LIQUID
*** GAS
**** UNKNOWN
PERIODIC TABLE OF THE ELEMENTS


# Kalium is NOT the same as potassium.

Brick in pure Kalium (Kali60) after 6 months.

**The true price of Nitrogen.**

The production of synthetic nitrogen takes the average of 36 Megajoule per kilo N.

36 megajoule = 1 liter of dieseloil or 1,2$m^3$ natural gas.

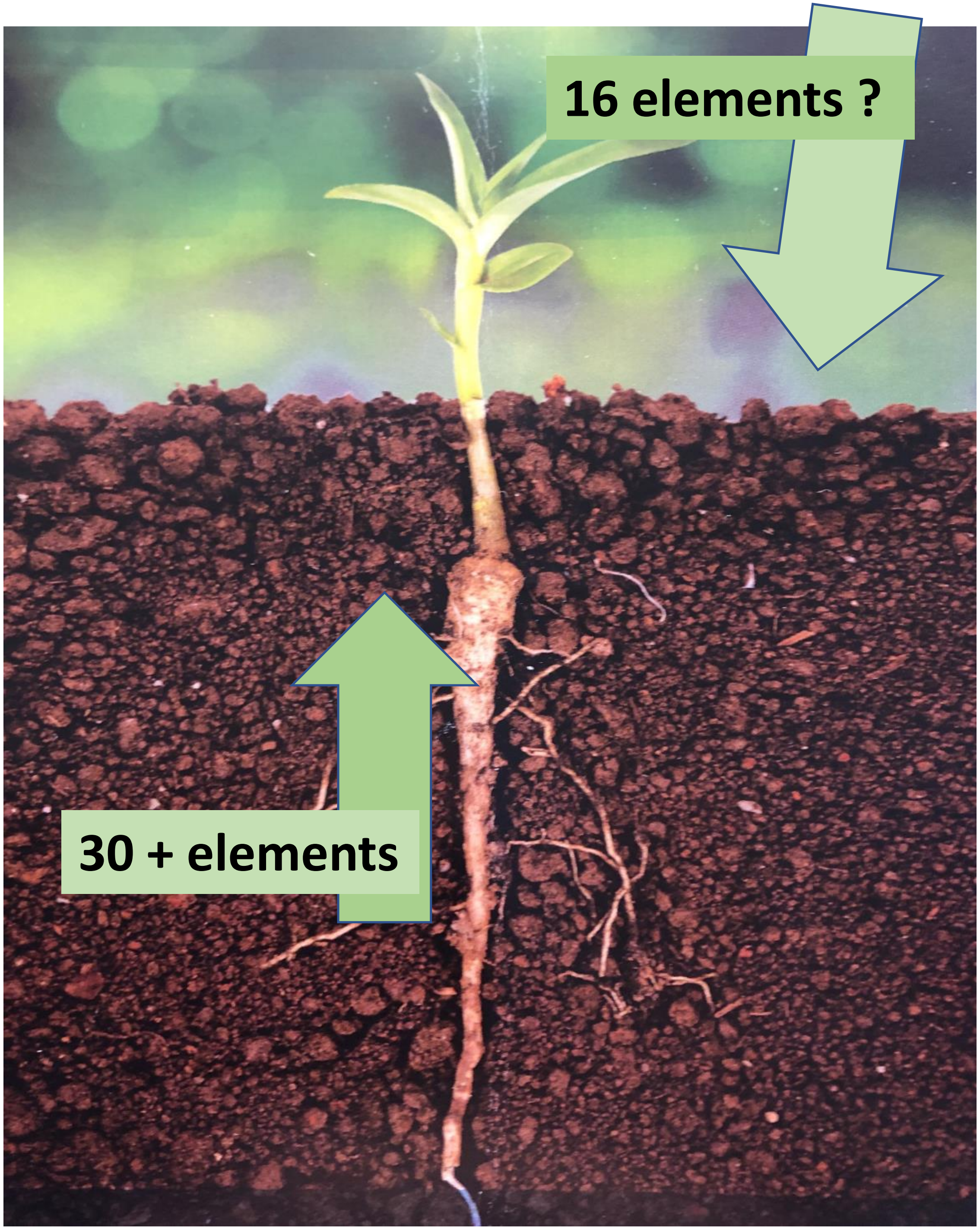
That equals the exhaust of 3,5 kilo $CO_2$ per kilo N.

**When applied to the soil it will consume carbon and exhaust NOX**

**That makes the total exhaust of 8,8 ton of $CO_2$ equivalent per Ha.**


Sutton,Erisman, Howard, Erisman, Billen, Bleeker, Grennfelt, VanGrinsven, Grizetti.

We have come a long way since the “Dust Bowls” in the ‘30 in canada and USA


16 elements ?
30 + elements

**Some Trace elements in woodash:**

As: Arsenic
Ba: Barium
B : Boron
Cd: Cadmium
Cu: Copper
Cr : Chromium
Ag : Silver
Mo: Molybdenum
Hg : Mercury
Ni : Nickel
V :Vanadium
Zn : Zinc
Ce: Cerium
La: Lanthanum
**And many more.**

the major components of wood ash are:
Calcium (Ca), potassium (K), (Mg), silicon (Si) and phosphorus (P)

# Studies on contents of wood ash


1. Andersson, S., Karltun,E. et al. Wood ash - properties and ecological consequences of recycling to forest.

2. Werkelin,J. 2002. Distribution of ash-forming elements in four trees of different species.

3. Hjalmarsson, A. et al. 1999. Handbok för restprodukter från förbränning.

4. Nilsson, J., Timm, B. 1983. Environmental effects of wood and peat combustion. Summary and conclusions.

5. Kofman, P. 1987. Wood-ashes from chip fuelled heating plants: Chemical composition, possibilities of application.

6. Eriksson, J., Börjesson, P. 1991. Wood ash in forests.

7. Holmroos, S. 1993. Karaktärisering av vedaska.

8. Steenari, BM. et al. 1999. Evaluation of the leaching characteristics of wood ash and the influence of ash agglomeration

9. Booth, C. et al. 1990. Changes to forest management and silvicultural techniques necessitated by forest energy production.


Wood ash contains up to 60 elements

nutrition Security Institute

## Eighty-Year Decline in Mineral Content of One Medium Apple

*Raw, With Skin*

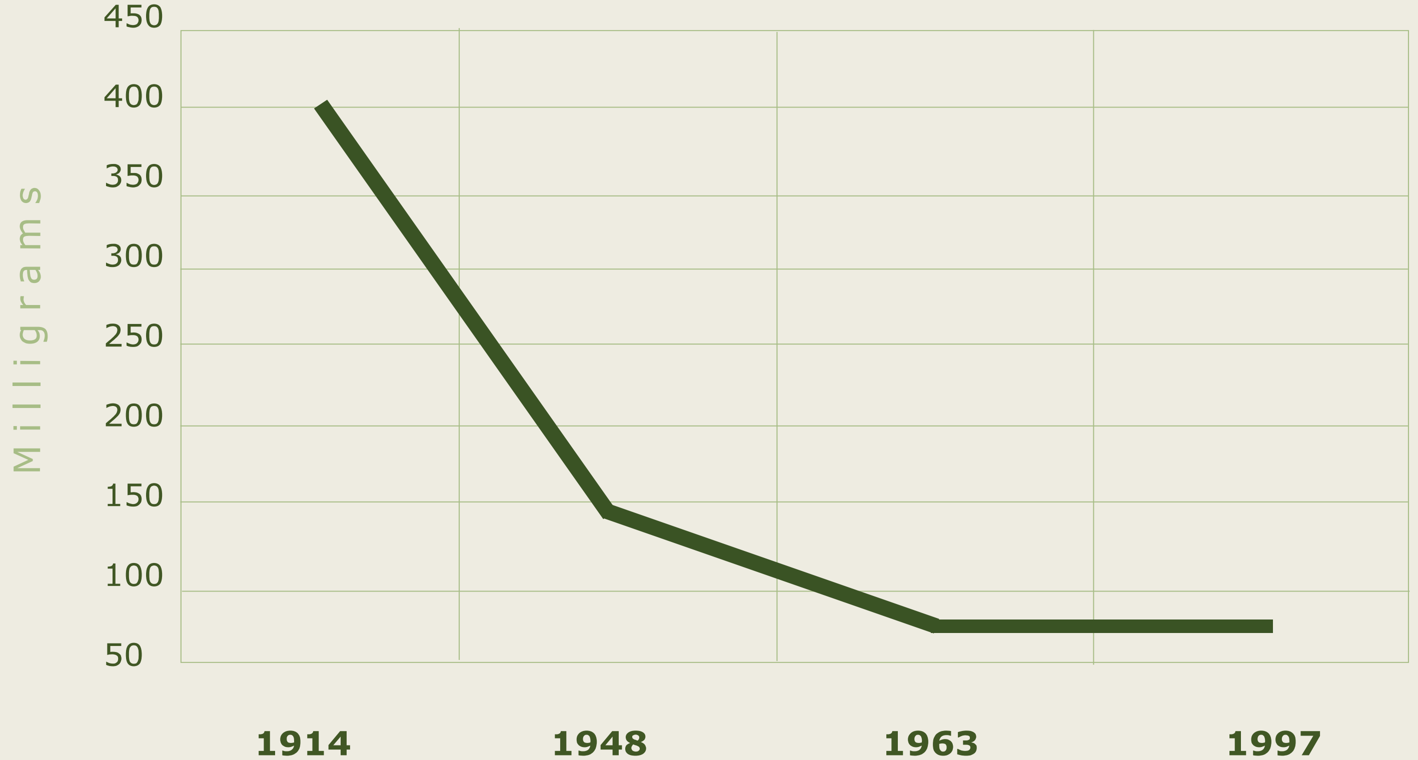
| Mineral | 1914 | 1963 | 1992 | %Change (1914-1992) |
|---|---|---|---|---|
| Calcium | 13.5mg | 7.0mg | 7.0mg | -48.15 |
| Phosphorus | 45.2mg | 10.0mg | 7.0mg | -84.51 |
| Iron | 4.6mg | 0.3mg | 0.18mg | - 96.09 |
| Potassium | 117.0mg | 110.0mg | 115.0mg | -1.71 |
| Magnesium | 28.9mg | 8.0mg | 5.0mg | -82.70 |

*Source: Lindlaar, 1914; USDA, 1963 and 1997*

Nutrition Security Institute

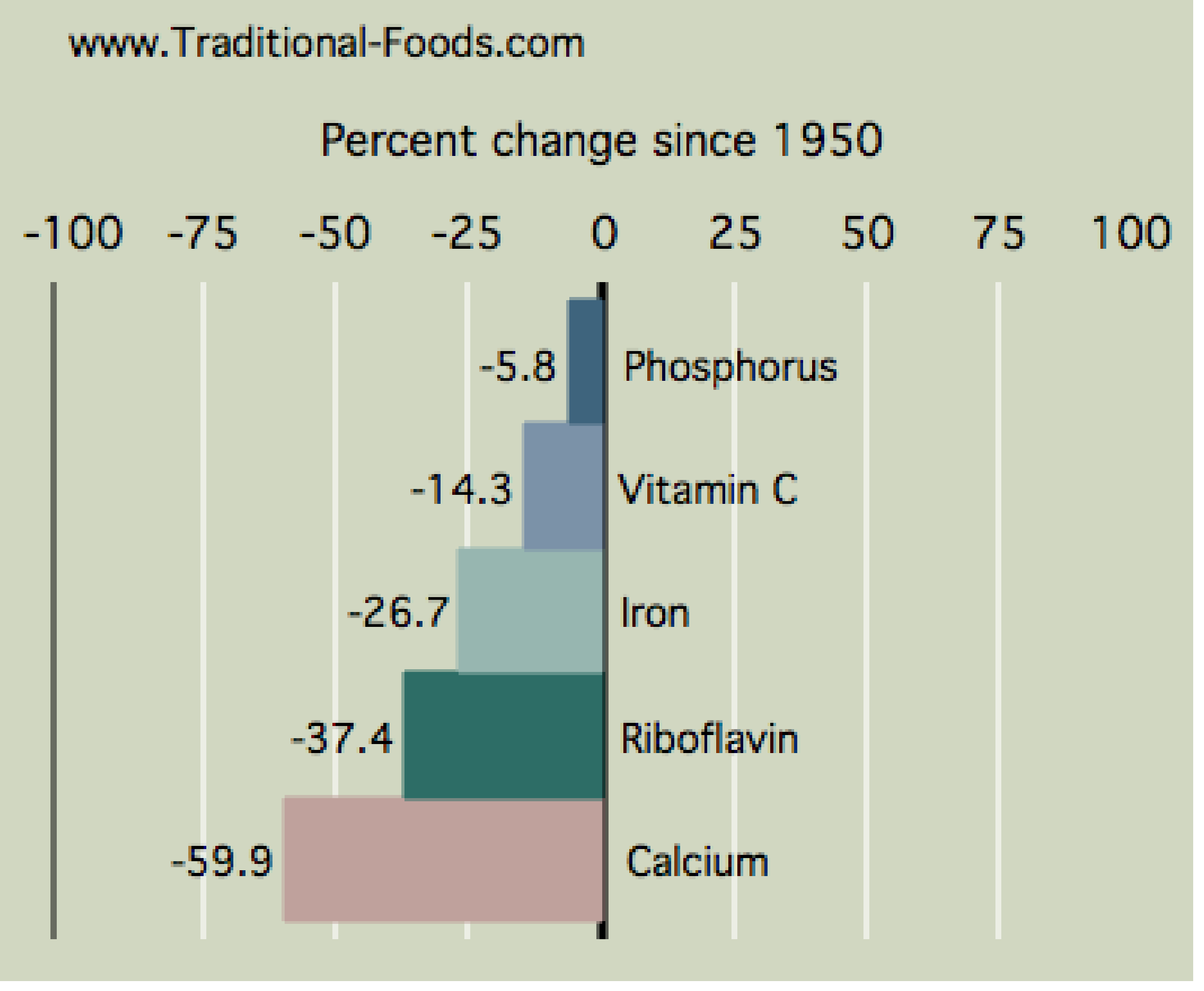
## Average Mineral Content in Selected Vegetables, 1914 -1997

### Sums of averages of calcium, magnesium and iron in cabbage, lettuce, tomatoes and spinach




*Source: Lindlahr, 1914; Hamaker, 1982; U.S. Department of Agriculture, 1963 and 1997*

# Broccoli: Decline in Nutrients Percent Change, 1950-2010



# Supplements – Optimum Daily Allowances

Patrick • 6 Jan 2009 • Reading time 1 min

| Nutrients | RDA | Average Diet | Good Diet | Shortfall | ODA |
|---|---|---|---|---|---|
| Calcium (mg) | 800 | 912.5 | (800:Good Diet) | shortfall 200 | 1000 |
| Iron (mg) | 14 | 12.8 | 15 | shortfall 5 | 20 |
| Magnesium (mg) | 300 | 272 | 350 | shortfall 150 | 500 |
| Zinc (mg) | 15 | 9.3 | 10 | shortfall 10 | 20 |
| Iodine (mcg) | 150 | 193.5 | 240 | shortfall 60 | 300 |
| Selenium* (mcg) | - | 40 | 50 | shortfall 50 | 100 |
| Chromium* (mcg) | - | 50 | 70 | shortfall 30 | 100 |
| Manganese* (mcg) | - | 3 | 6 | shortfall 4 | 10 |

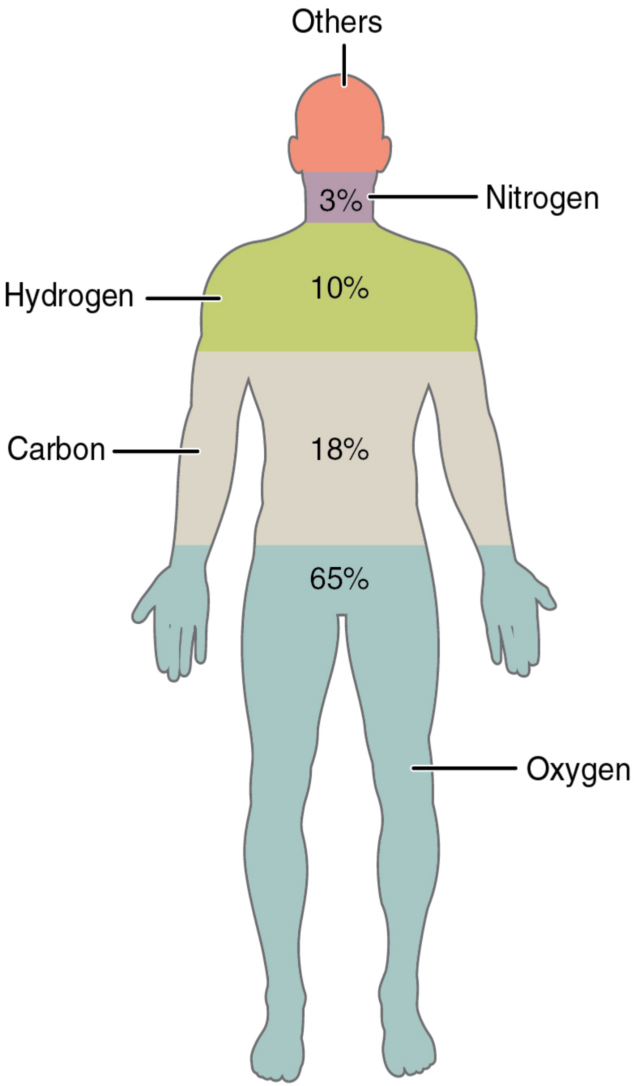
100% RDA

**Key**

- Black: Average Diet
- Grey: Good Diet
- Yellow: Shortfall

RDA = Recommended Daily Allowance

ODA = Optimum Daily Allowance (diet plus supplements)

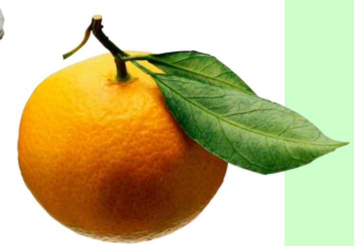



| Element | Symbol | Percentage in Body |
|---|---|---|
| Oxygen | O | 65.0 |
| Carbon | C | 18.5 |
| Hydrogen | H | 9.5 |
| Nitrogen | N | 3.2 |
| Calcium | Ca | 1.5 |
| Phosphorus | P | 1.0 |
| Potassium | K | 0.4 |
| Sulfur | S | 0.3 |
| Sodium | Na | 0.2 |
| Chlorine | Cl | 0.2 |
| Magnesium | Mg | 0.1 |
| Trace elements include boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn). | | less than 1.0 |

At least 15 elements in our bodies count for less than 1% of total.

## Elements comprising the human body.

Oxygen 61%
Carbon 23%
Hydrogen 10%
Calcium 1,4%
**Kalium 0,2%**
Chlorine 12%
Magnesium 0,27%
Zinc 0,0033%
Sulfur 0,20%
Nitrogen 2,6%
Phosphorus 1,1%
Sodium 0,14%
Silicium 0,26%
Iron 0,006%
Fluoride 0,0037%

## <1% "non essential elements"

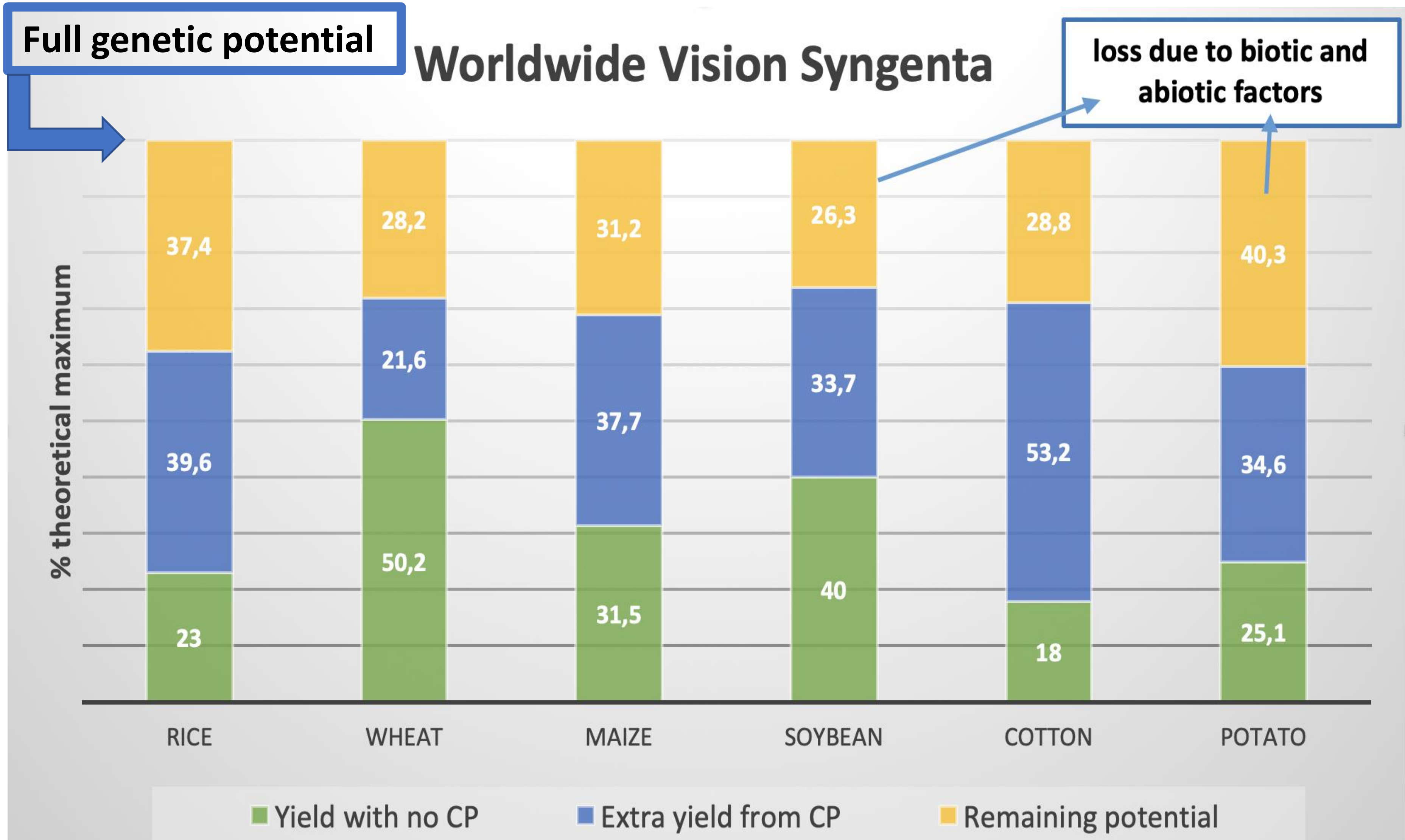
Copper
Cobalt
Iodine
Chromium
Nickel
Vanadium
Germanium
Arsenic
Boron
Tin
Selenium
Rubidum
Manganese
Molybdenum

**Elements comprising the PLANT body.**

Oxygen 35%
Carbon 23%
Hydrogen 10%
Calcium 1,4%
**Kalium 0,2 %**
Chlorine 0,4%
Magnesium 0,27%
Zinc 0,0033%
Sulfur 0,20%
Nitrogen 2,6%
Phosphorus 1,1%
Sodium 0,14%
Silicium 0,26%
Iron 0,006%
Fluoride 0,0037%
Manganese ?
Boron ?

**<1%“non essential elements”**

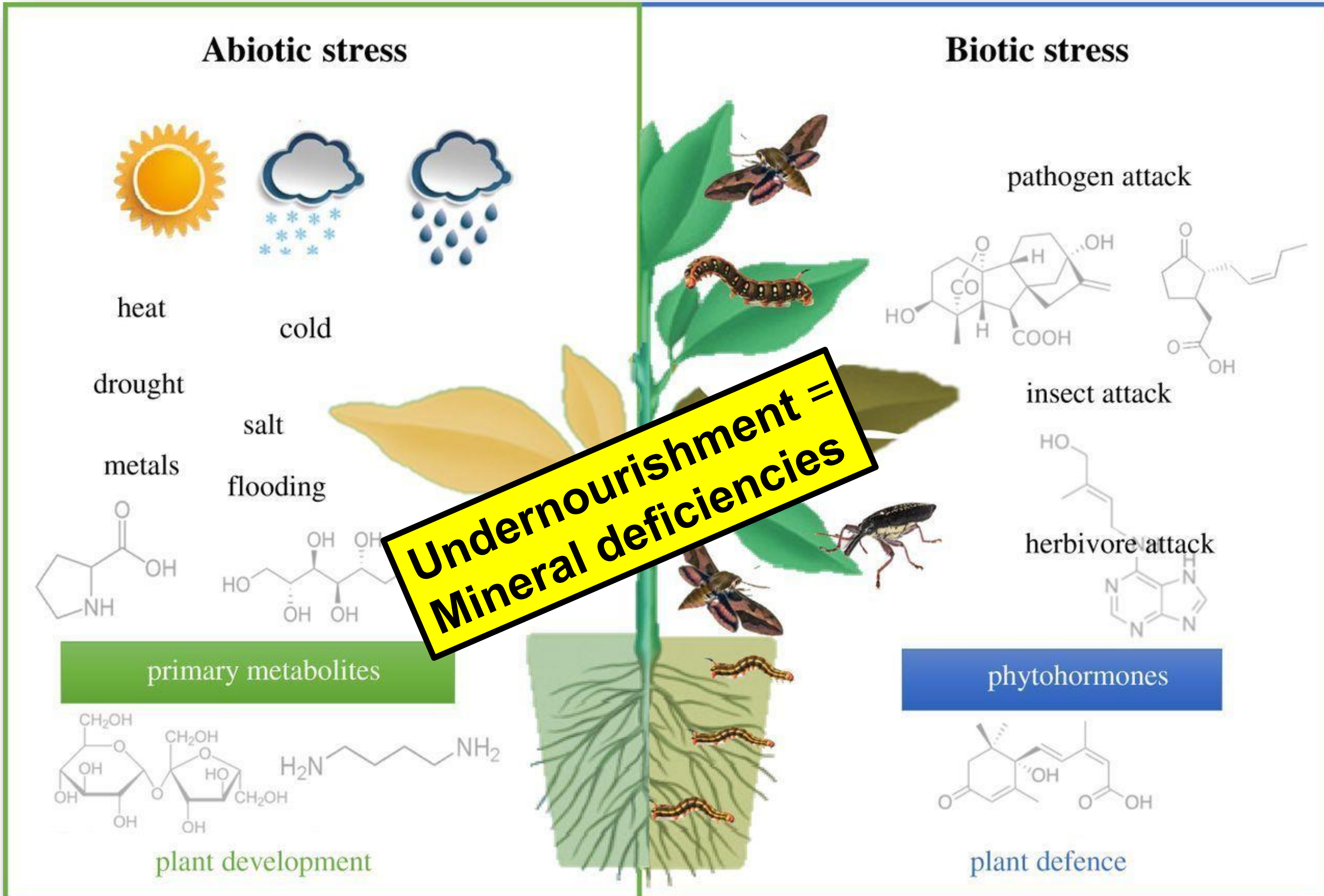
Copper
Cobalt
Iodine
Chromium
Nickel
Vanadium
Germanium
Arsenic
Tin
Selenium
Rubidum
Molybdenum
Lanthanum
Cerium



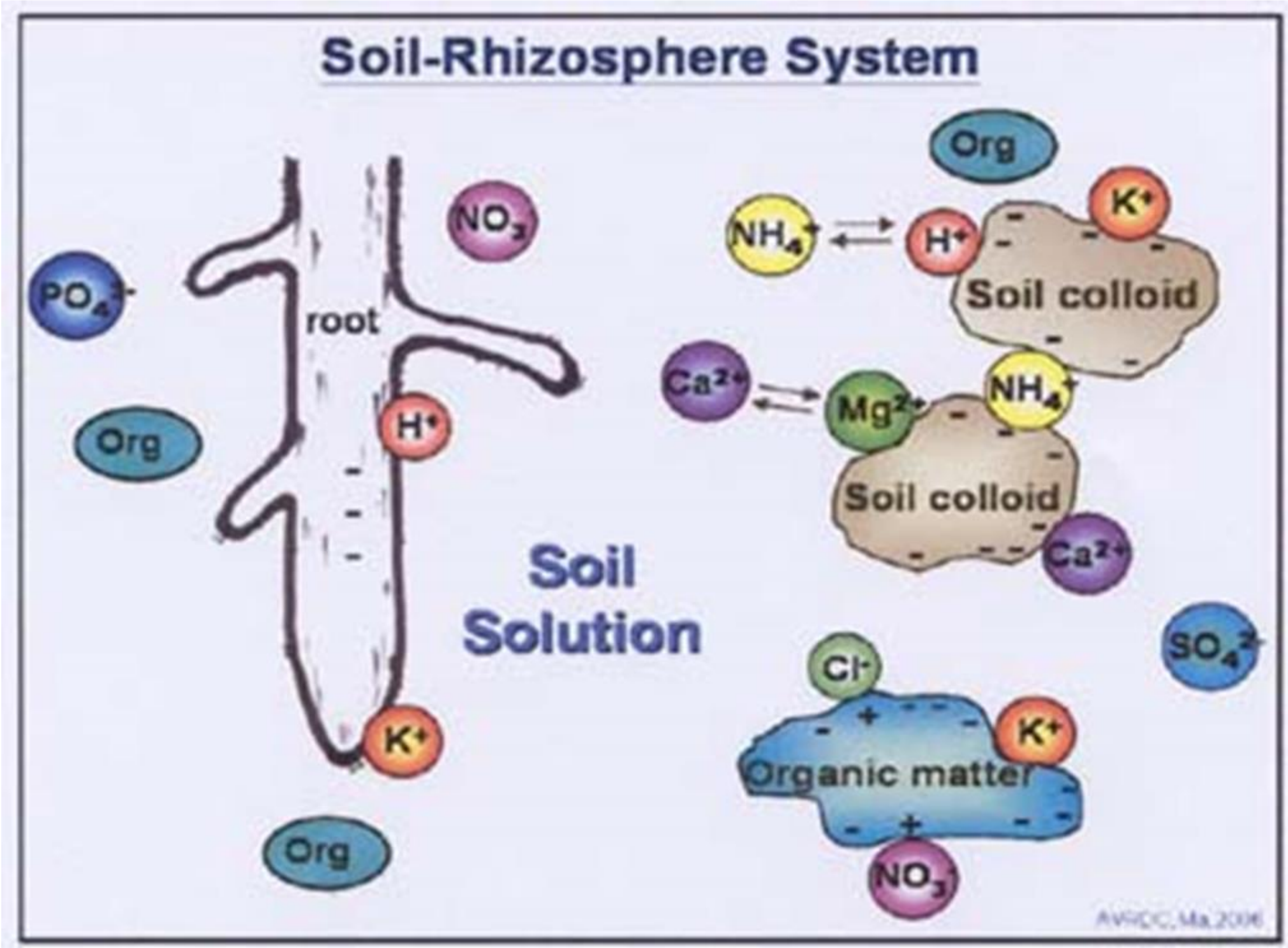

Plants worldwide are under stress because of malnutrition.
PLANTS SUFFER FROM HUNGER!!

The fuses in a car count for <1%.   Essential for safe driving!!

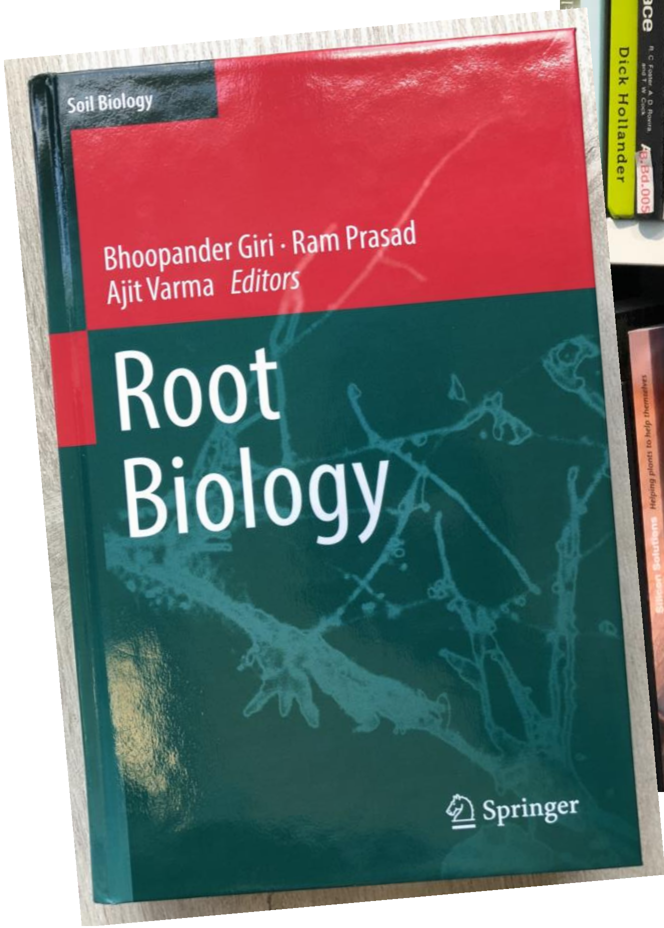

**R**are **E**arth **E**lements (REE's)
play a potential big role in healthy plant growth.
Novel fertilizer concepts could potentially replace many pesticides




The majority of plant diseases are the result of abiotic stress and malnutrition




**This is how the trade looks at roots until today.**



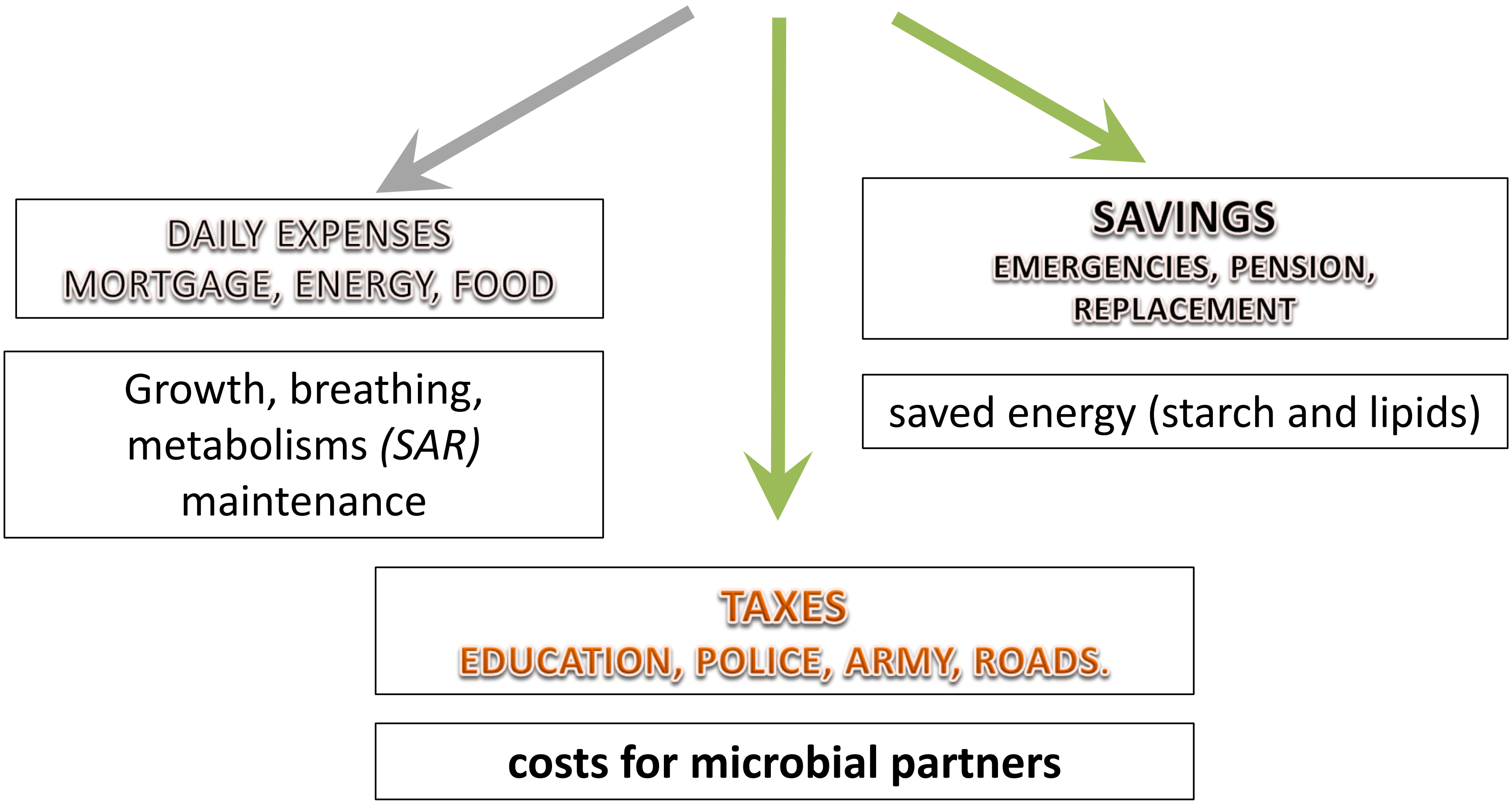


The amount of scientific information is overwhelming but overspecialized.

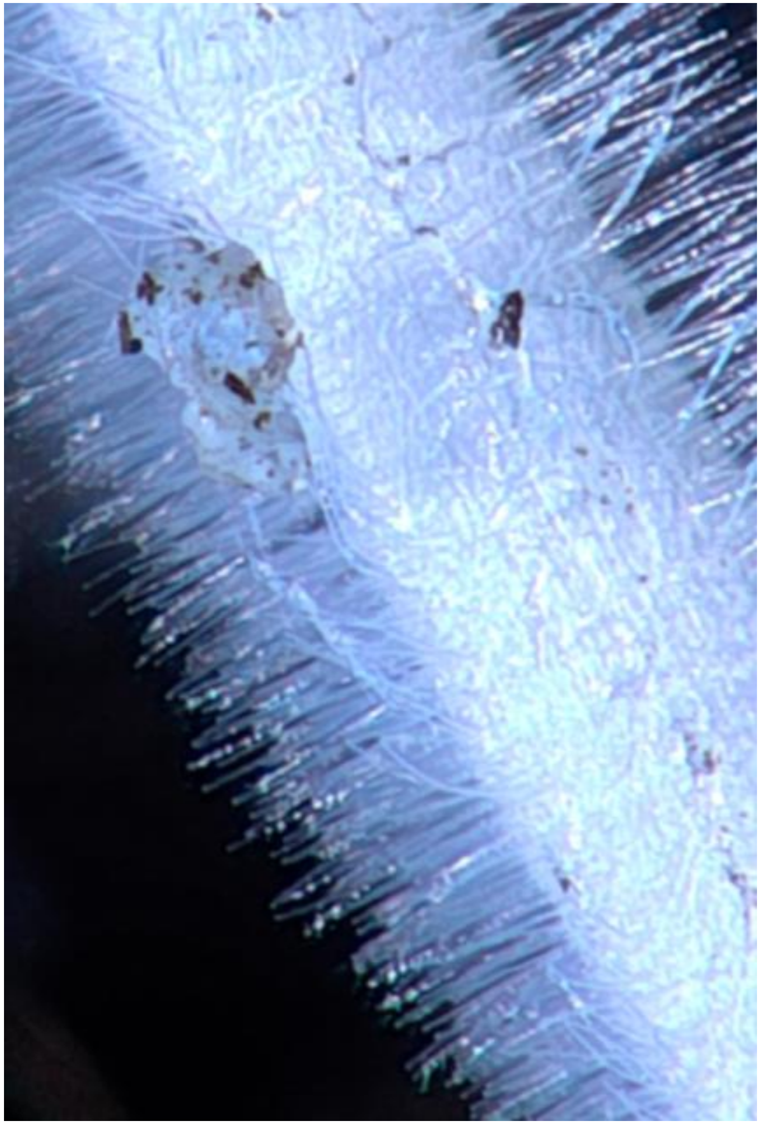
# Plant budget in Carbon (C)

**photosynthesis *(Carbon)* production**

**= foodproduction**

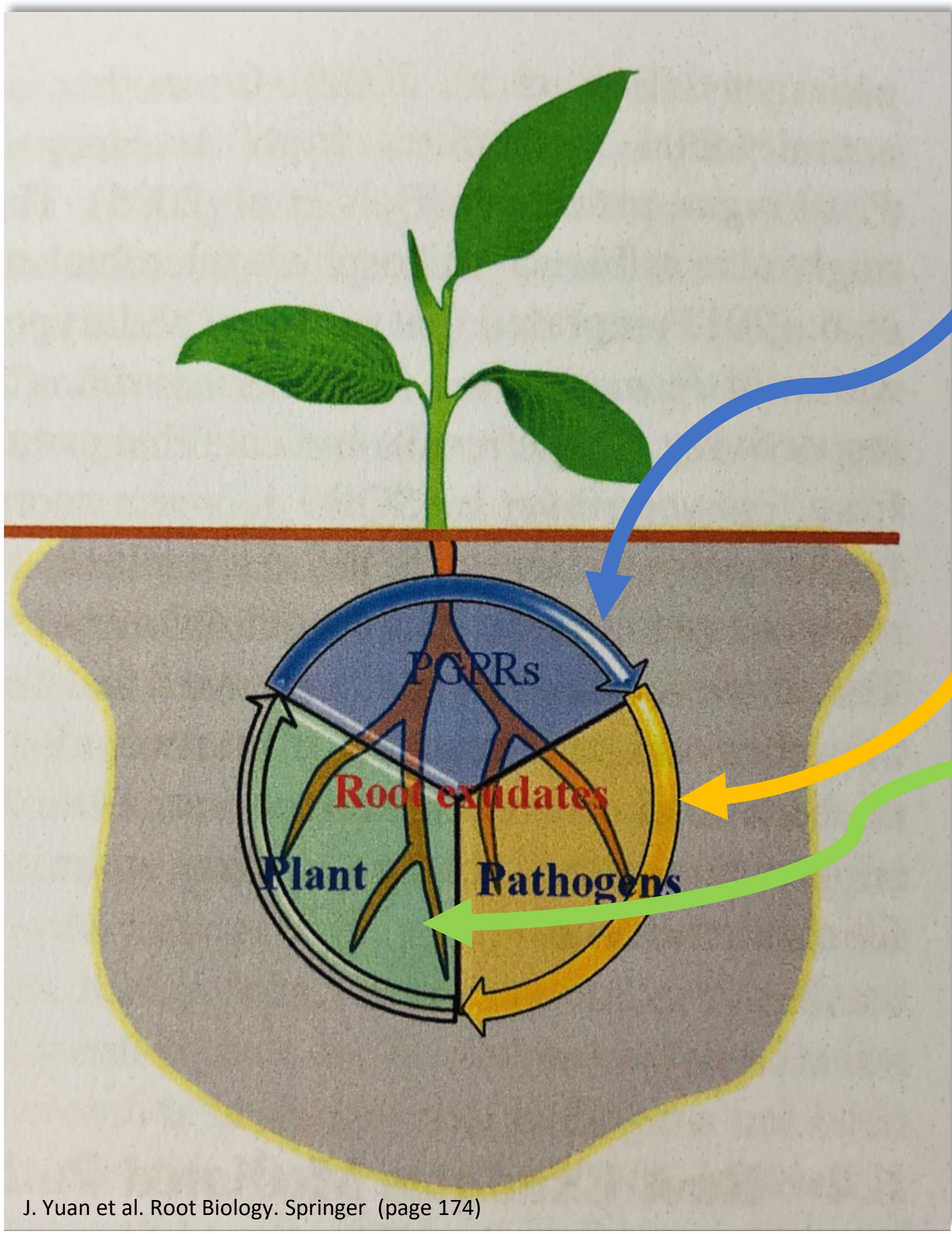


# Root exudates



**Absorbing roots live up to 3 weeks. Root hairs live 3 days.**

# Plant Root exudates



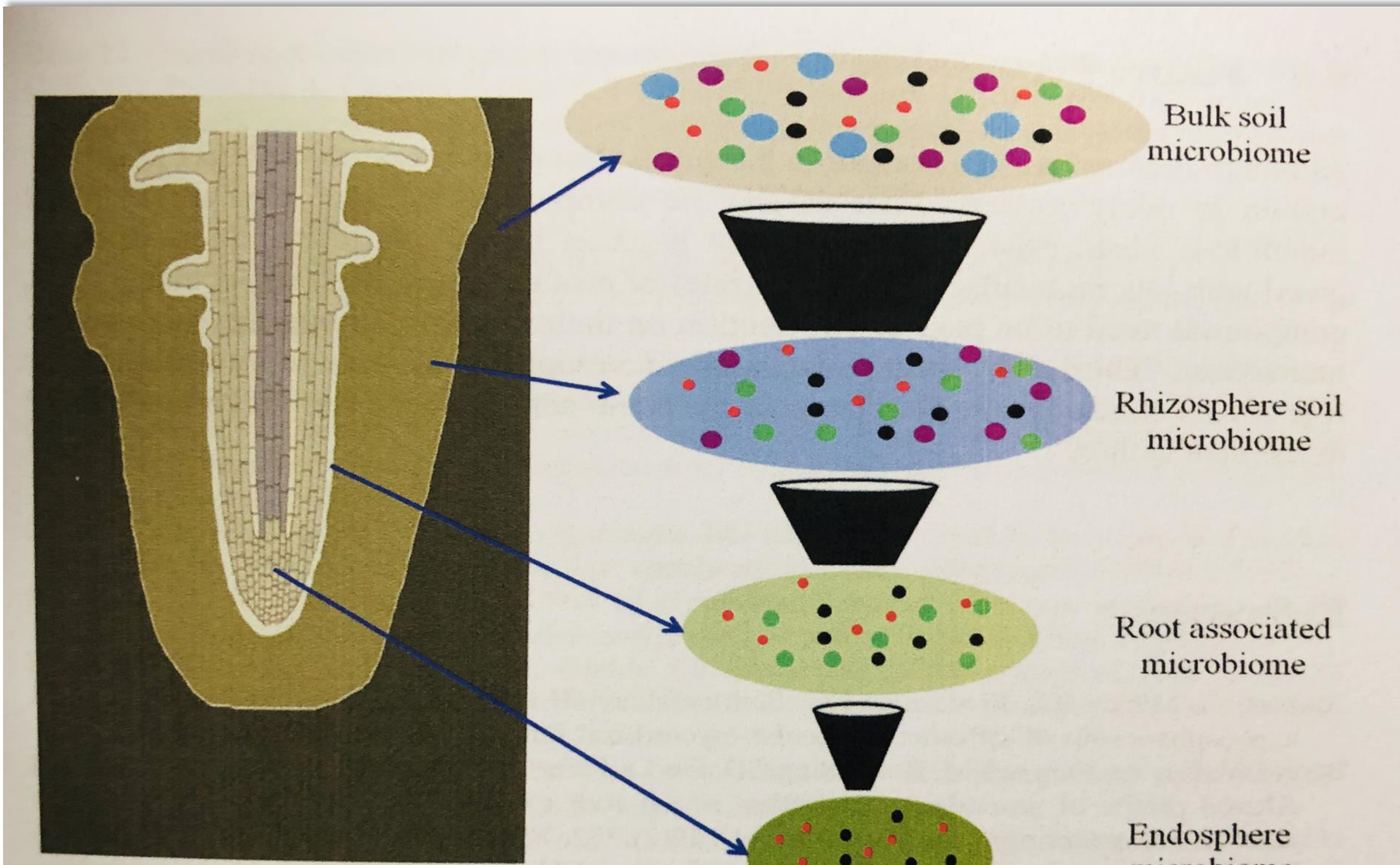

J. Yuan et al. Root Biology. Springer (page 174)

**PGPR's =**
**Plant Growth Promoting Rhizobacteria**

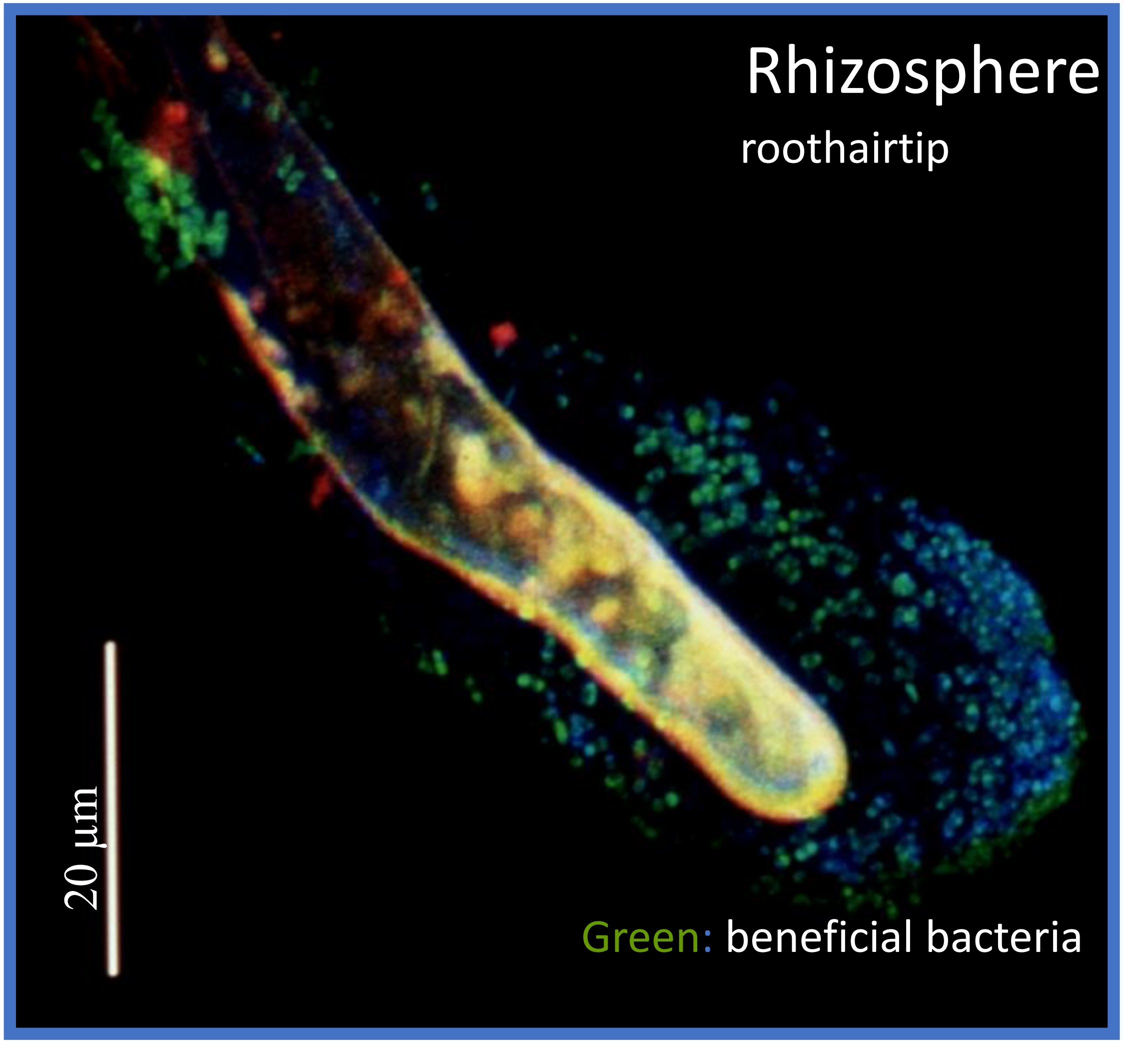
**Pathogens**

**Plant roots**

# The Rizosphere



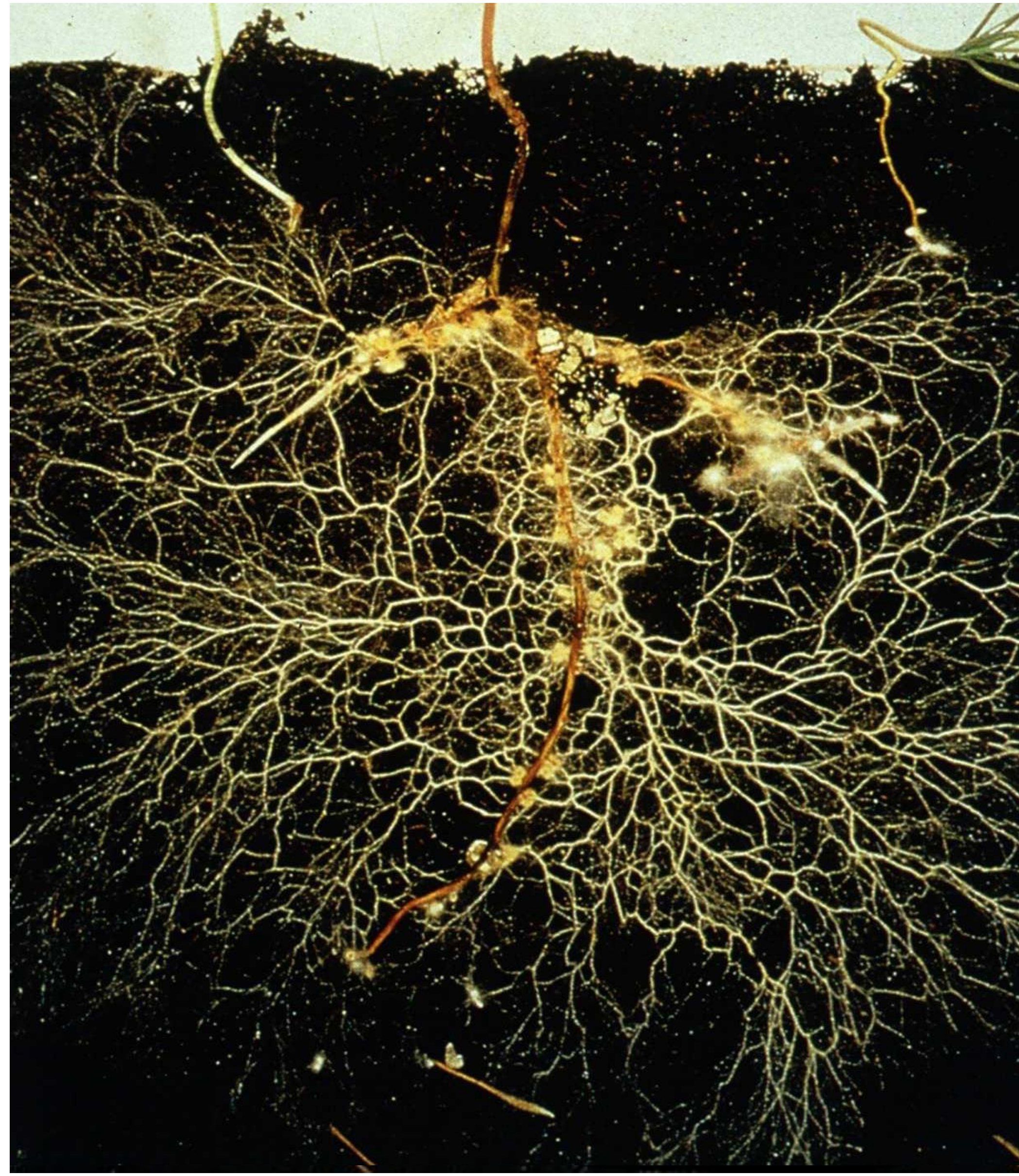

J. Yuan et al. Root Biology. Springer (page 175)




The rhizosphere bacteria Live from the root exudates (complex sugars)

Many salt fertilizers neutralize the rhizospere, disturbing mineralisation by specific rhizbacteria.

Ectomycorrhiza
foto: D.J. Read

Hyphae form a mantle around or in the fine absorbing roots and take care of absorption of water and minerals

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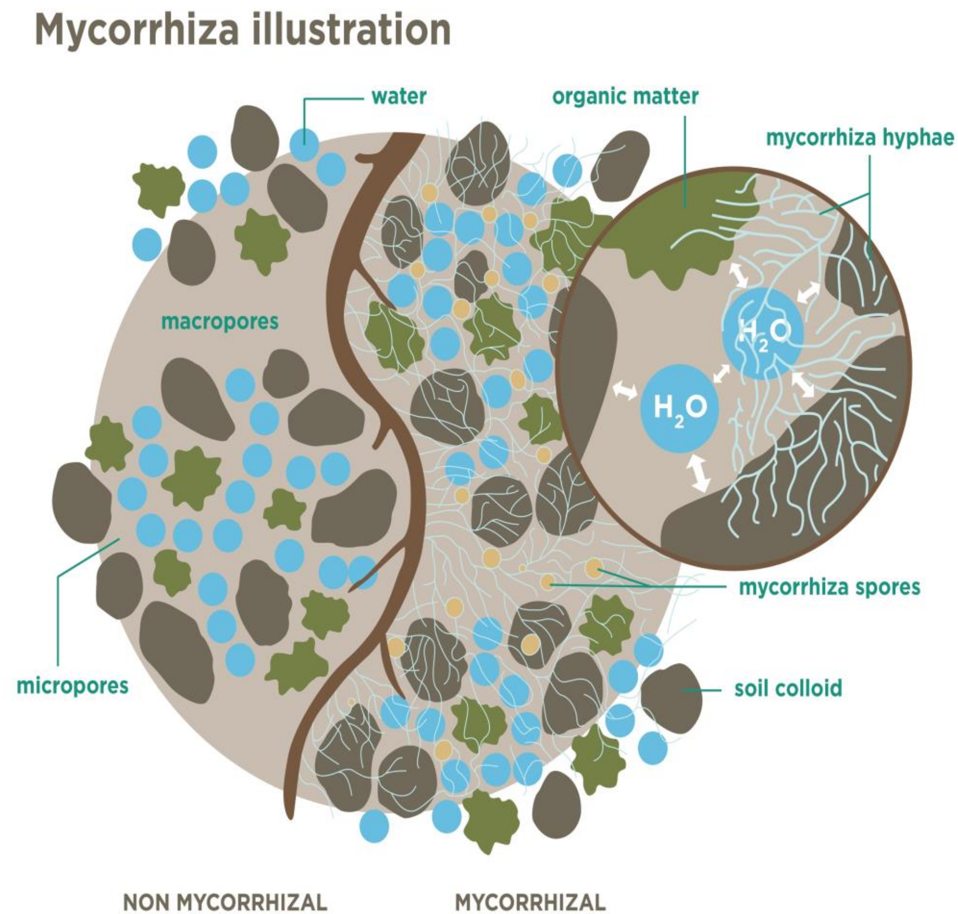
Plant roots grow **IN** the soil but have no contact **WITH** the soil

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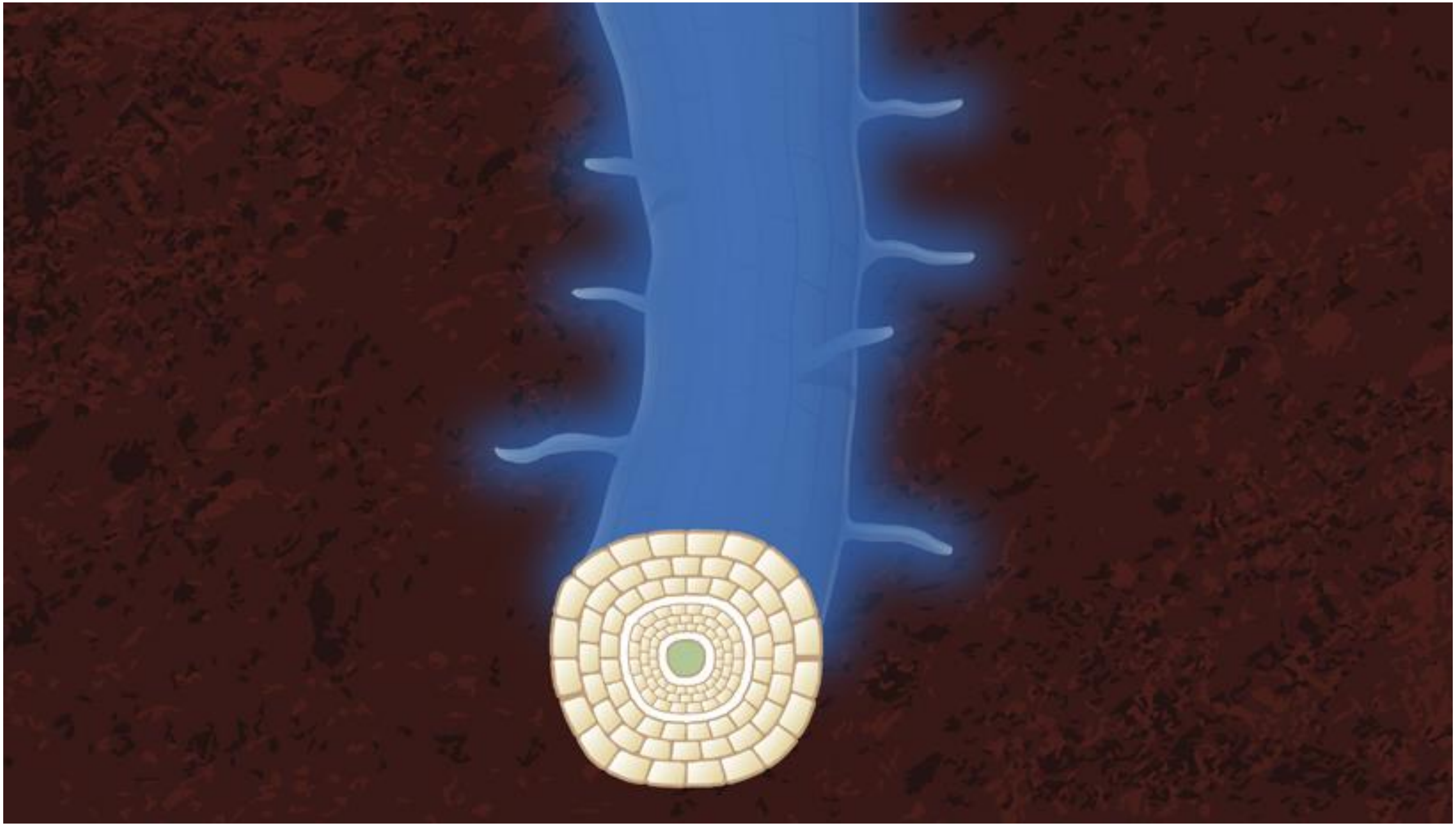
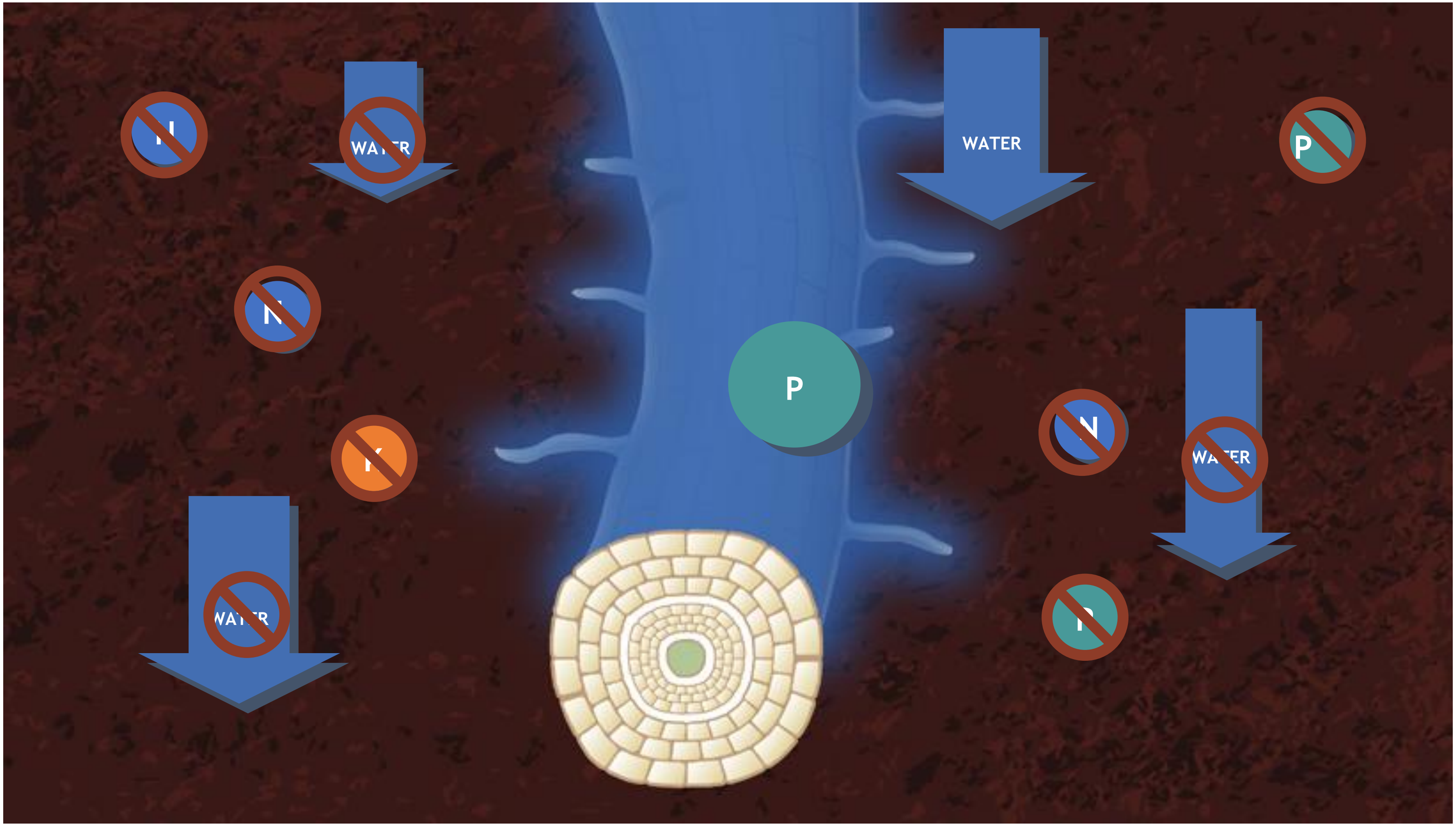
Fine roots only grow in the macropores (elevator shafts)
Fungal hyphae absorb water and minerals from the micropores

# Absorption zone of roots

limited to maximum of 2 mm outside root



# Outside the absorbing zone minerals are not available to the plant.

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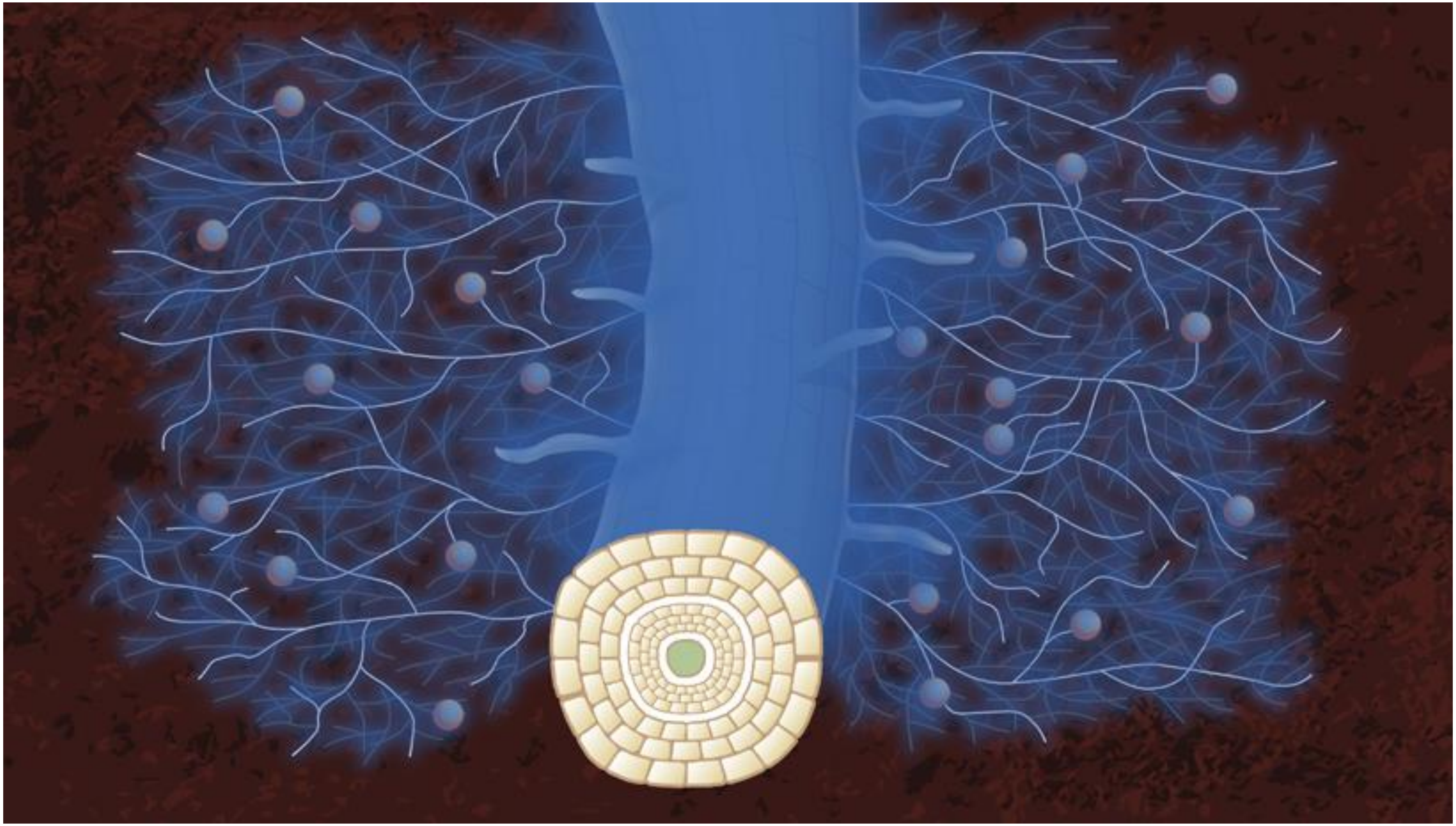
# mycorrhizasystem in absorbing roots

## Schematic presentation of increased absorption capacity.



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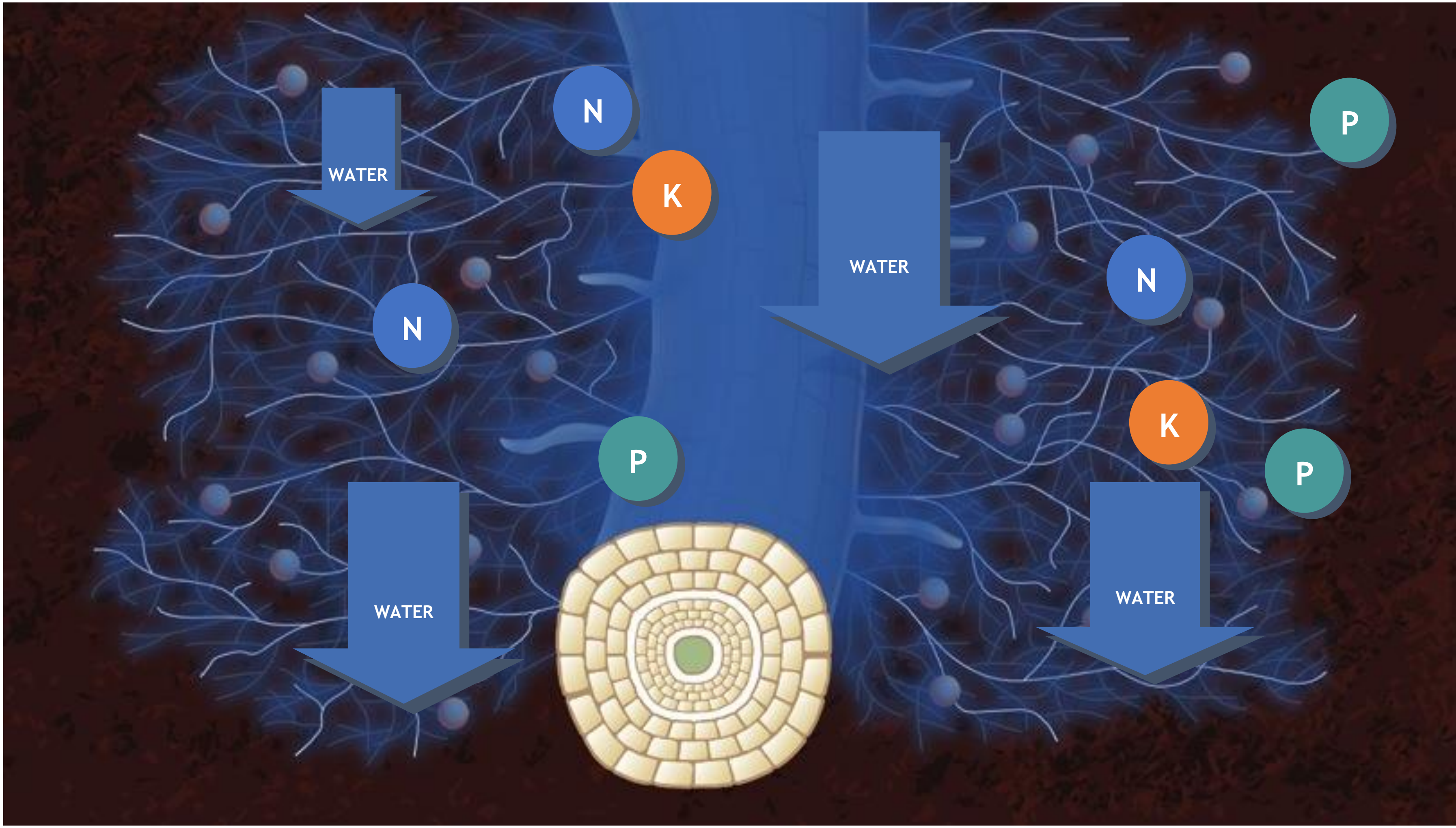
# mycorrhizasystem in absorbing roots




- Average 700% increase of absorption
- Optimal mineral absorption

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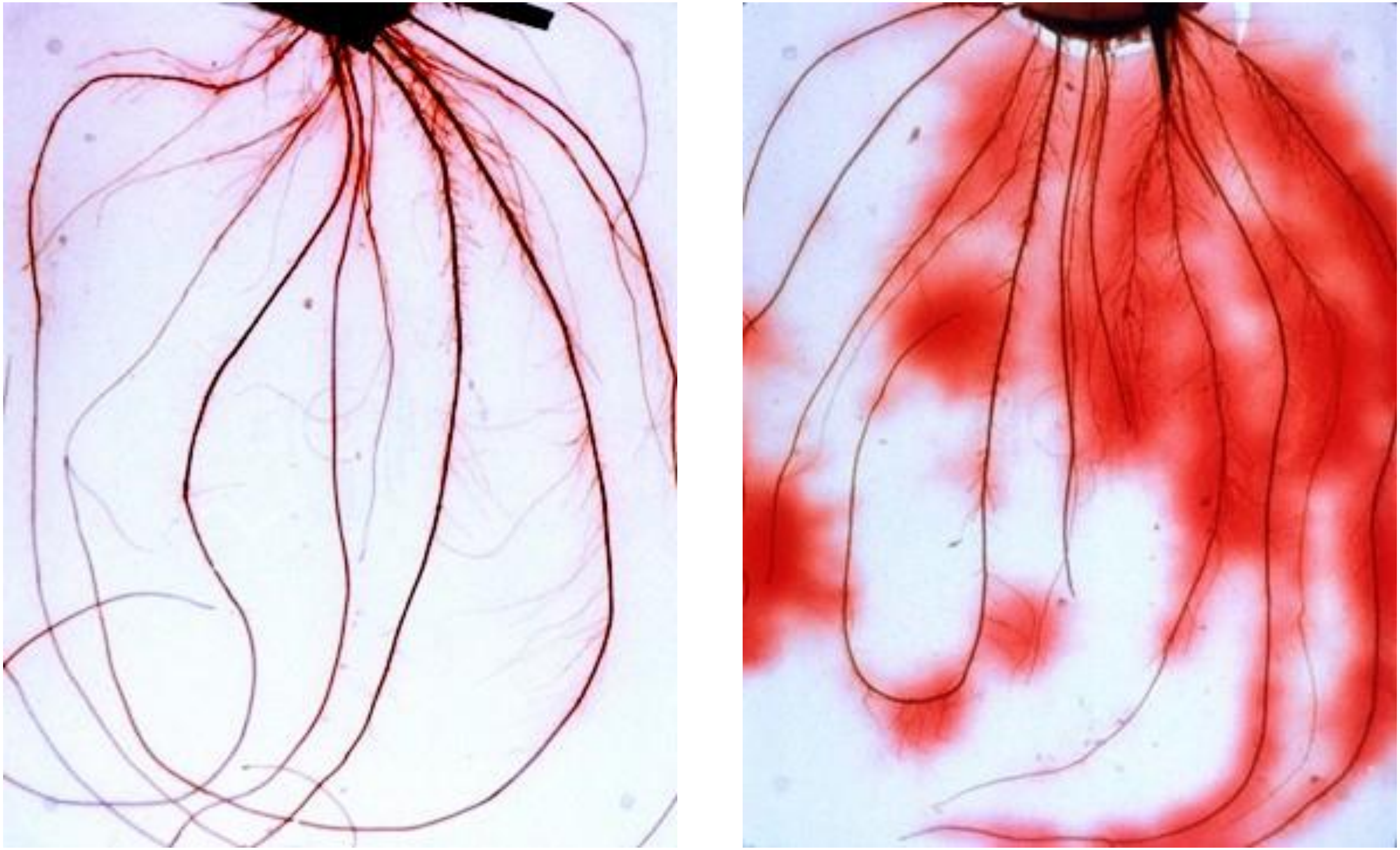
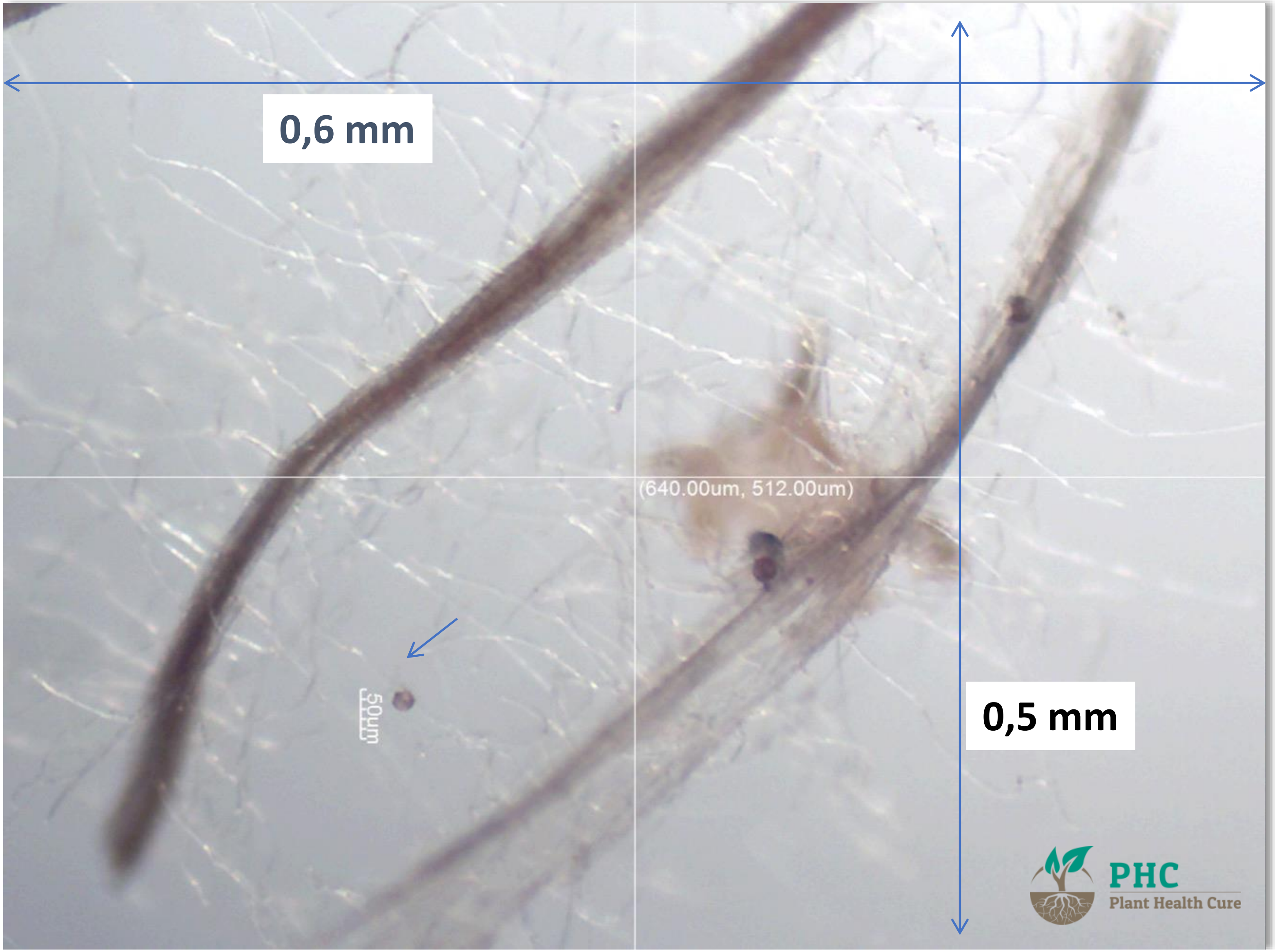


<u>Exudates</u> from roots without mycorrhiza **|** and with mycorrhizal colonisation



Fine absorbing root with mycorrhizal hyphae. See the ultra fine hyphae. Fragile and sensitive to soil compaction, plowing etc,

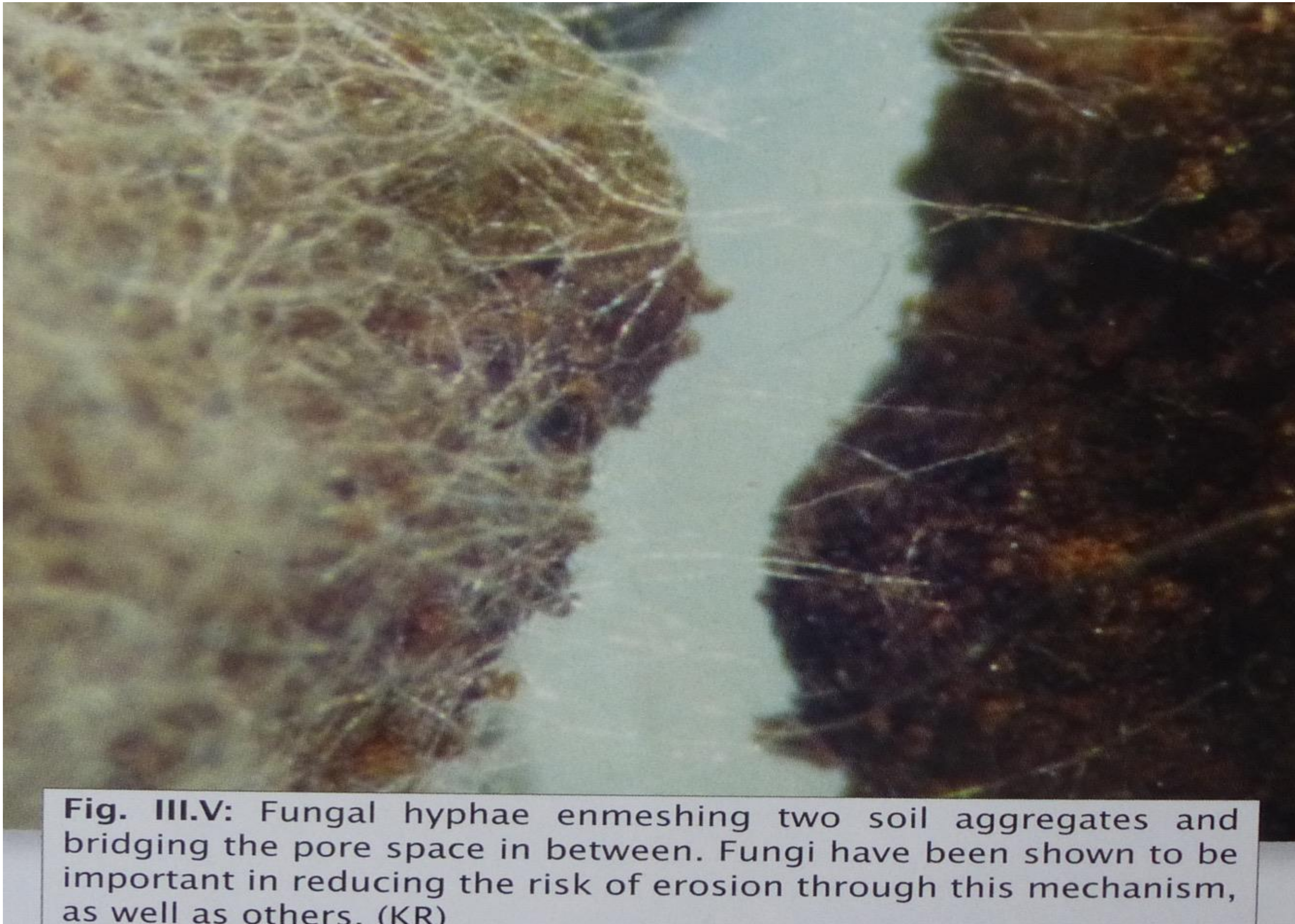
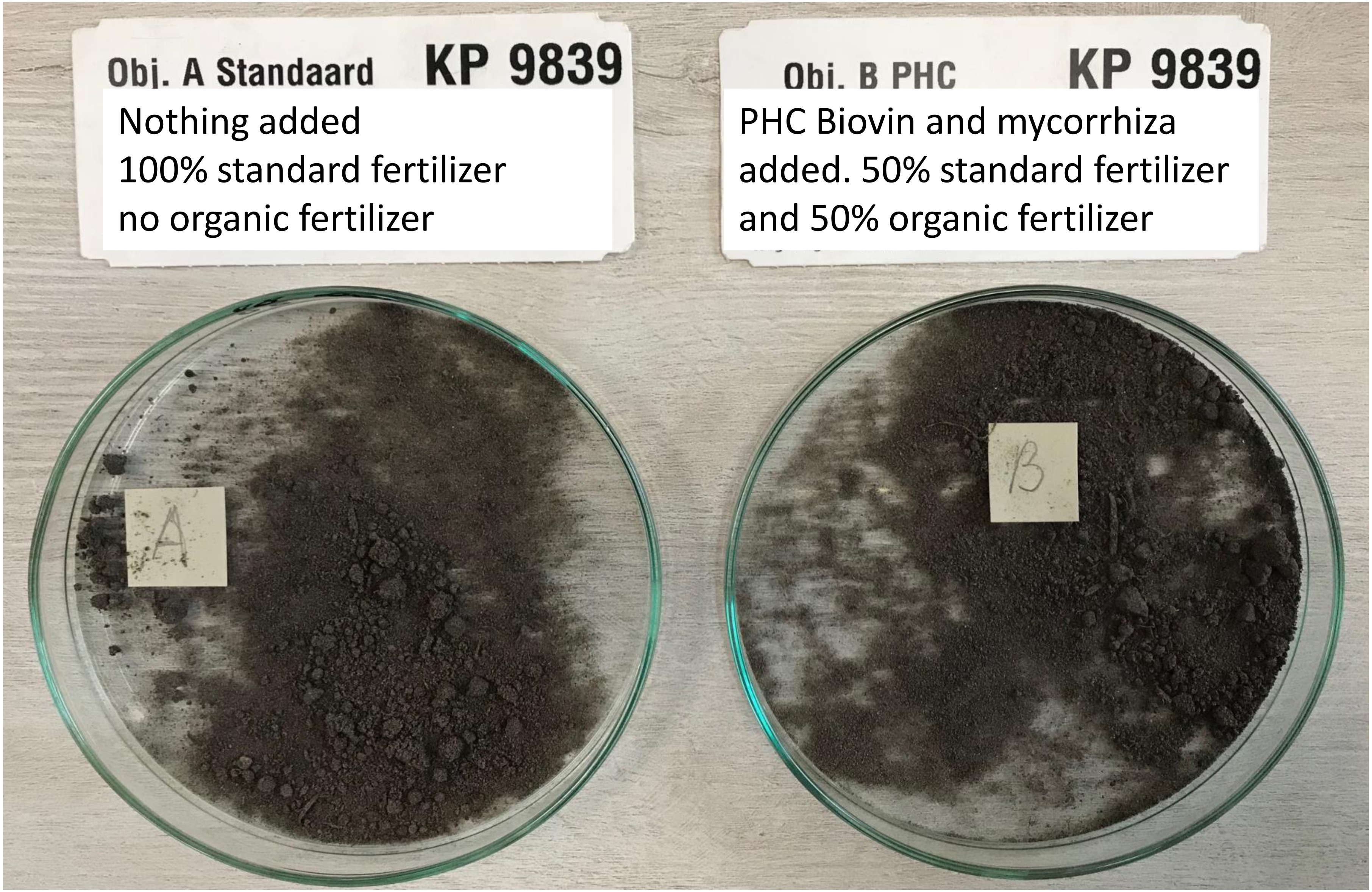


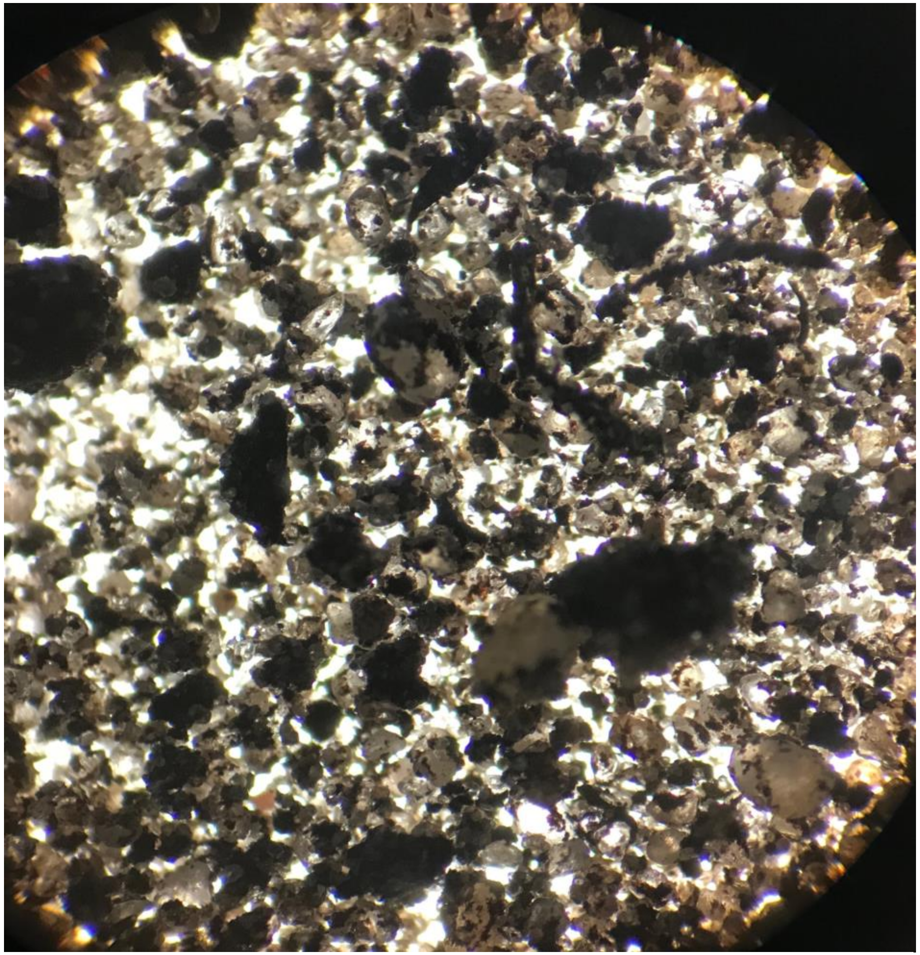
**Fig. III.V:** Fungal hyphae enmeshing two soil aggregates and bridging the pore space in between. Fungi have been shown to be important in reducing the risk of erosion through this mechanism, as well as others. (KR)

Result after change of soil treatment in **one year**!
Left: 50% organic and 50% synthetic fertilizer
Right: 100% synthetic fertilizer

Wageningen University 2017 unpublished




On first sight no difference between soils
Chemical analysis are identical



Mineral sandy soil
Nothing added
100% standard fertilizer

Results 1 year after trial start
Soil particles are not bound (erosion)

Mineral sandy soil
Biovin and mycorrhiza
added. 50% standard fertilizer
and 50% organic fertilizer
Results 1 year after trial start.
Soil is closely bound (Glomalin)

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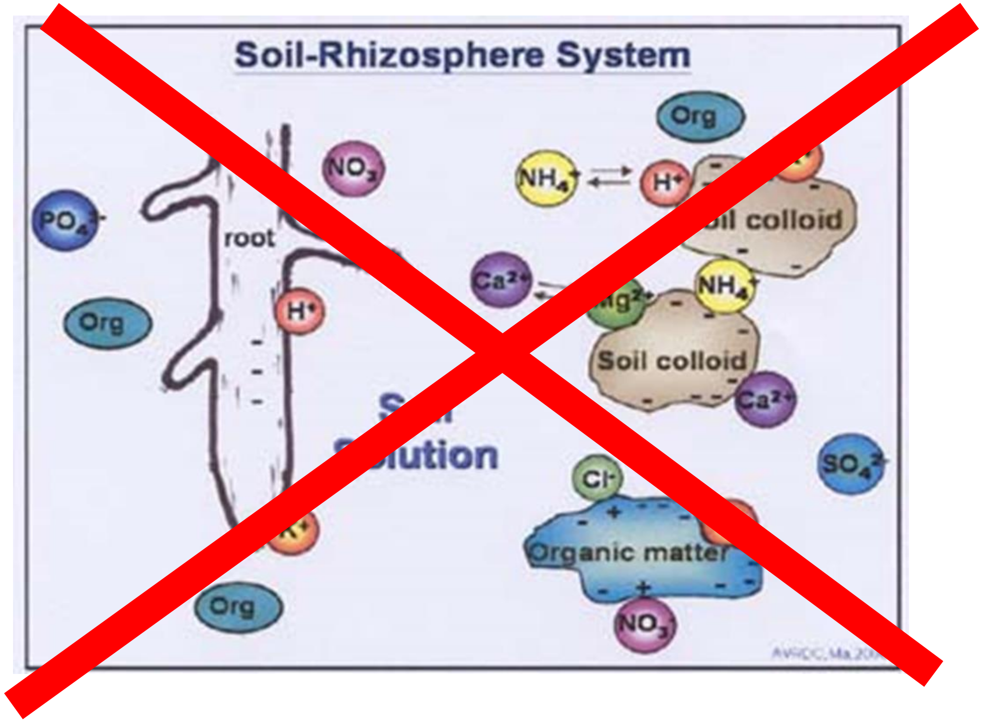


**Let's please step away from the idea that plants only need 16 elements.**

**It is a fantastic opportunity for the fertilizer industry to increase the mineral content of fertilizers to help reduce the need for Nitrogen and the use of fungicides and pesticides.**

# Future agriculture will depend on low N. fertilizers that provide the full mineral spectrum

**Fungicides and herbicides will be used in minimal quantities**


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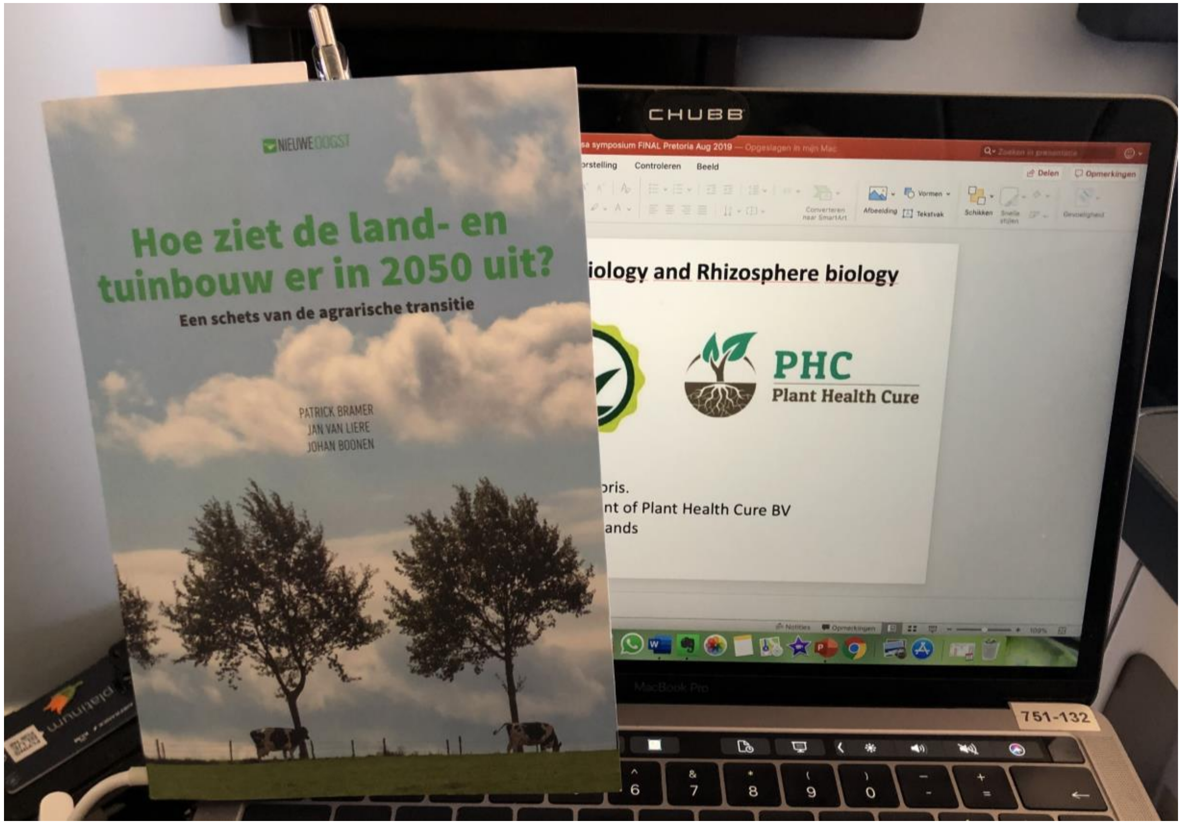
Novel fertilizer concepts could potentially replace many pesticides




What will Agriculture look like in 2050?

- Depleted soils will be used for agriculture in Africa wherever there is acces to water.
- Agriculture will demand lower nitrogen levels and increased mineral levels
- Organic fertilizers will replace many pesticides as plants show defense.
- The combination of organic fertilizers enriched with mineral loading will outcompet the current low content / high nitrogen fertilizers.

- WE ALL NEED EACH OTHER TO GUARANTEE HEALTHY PEOPLE AND HEALTHY SOILS.

# THE WORLD DEPENDS ON YOU AND IS COUNTING ON YOU.

**Thank you for your attention**.

Pius Floris

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