Arbuscular mycorrhizal fungal communities and its impact on GHG emissions

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NUOVI APPROCCI PER LA GESTIONE SOSTENIBILE DEL PINO NERO:
biodiversità e mitigazione
MARTEDÌ 14 MAGGIO 2019 | 9.30 - 16.30
Firenze, Sala Giordano - Palazzo Medici-Riccardi

What is Arbuscular mycorrhiza ?

- MYCORRHIZA: IS AN OBLIGATORY SYMBIOSIS AMONG SOIL BORN FUNGI AND PLANT ROOTS

The plant taxa are from Angiosperms Gymnosperms, Gametophytes, Pteridophytes, and Sporophytes.

While the fungi are from the phylum Glomeromycota.

What is Arbuscular mycorrhiza ?

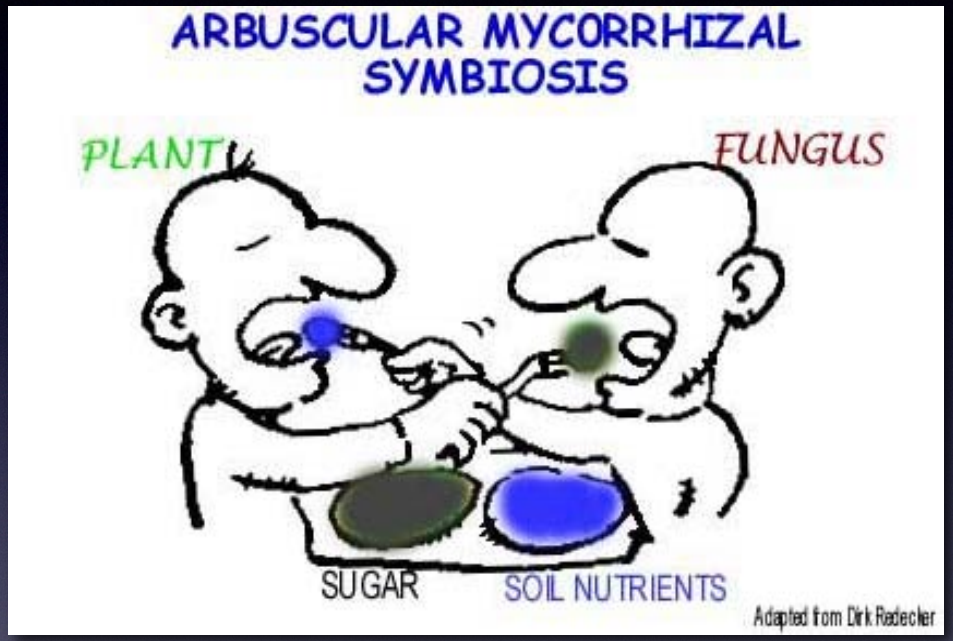
Mycorrhizas, not roots, are the chief organs of nutrient uptake by land plants (Smith and Read 1997)

The study of plants without their mycorrhizas
is the study of artefacts.

The majority of plants, strictly speaking,
do not have roots; they have mycorrhizas.

BEG Committee, 25th May, 1993

What is Arbuscular mycorrhiza ?



Linking belowground biodiversity and ecosystem function in European forests (BioLink)

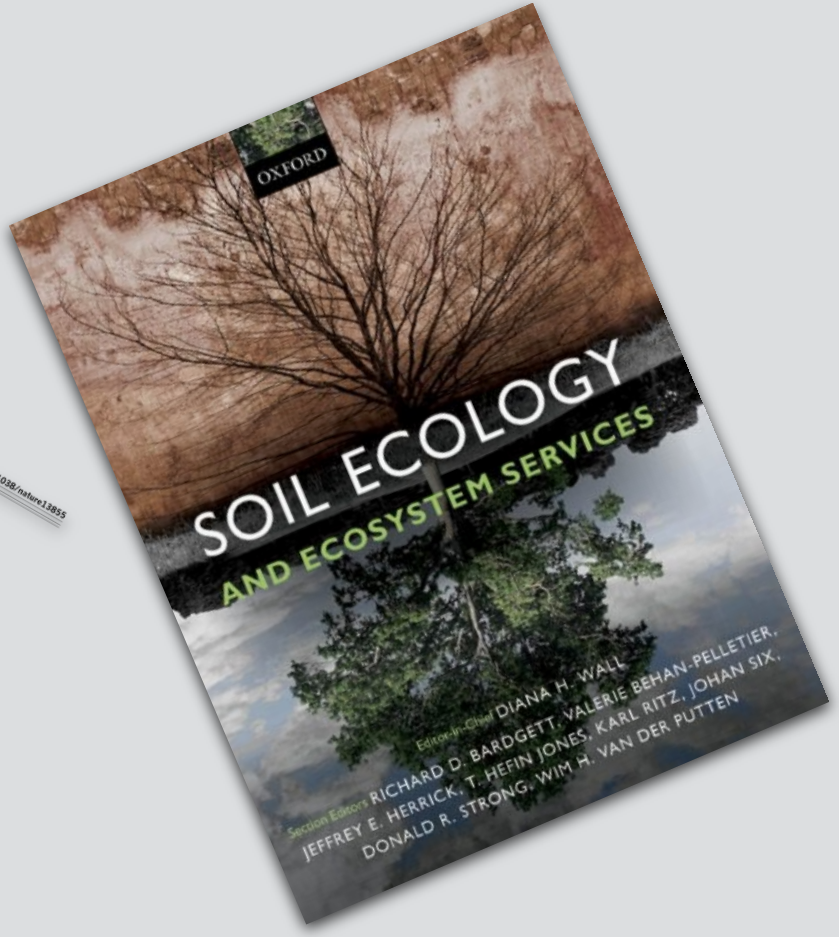

REVIEW

Belowground biodiversity and ecosystem functioning

Richard D. Bardgett[1] & Wim H. van der Putten[2,3]

doi:10.1038/nature13855

Evidence is mounting that the immense diversity of microorganisms and animals that live belowground contributes significantly to shaping aboveground biodiversity and the functioning of terrestrial ecosystems. Our understanding of how this belowground biodiversity is distributed, and how it regulates the structure and functioning of terrestrial ecosystems, is rapidly growing. Existence also points to soil biodiversity as having a key role in determining the ecological and evolutionary responses of terrestrial ecosystems to current and future environmental change. Here we review recent progress and propose avenues for further research in this field.



Going Deep down and .....Dirty ?

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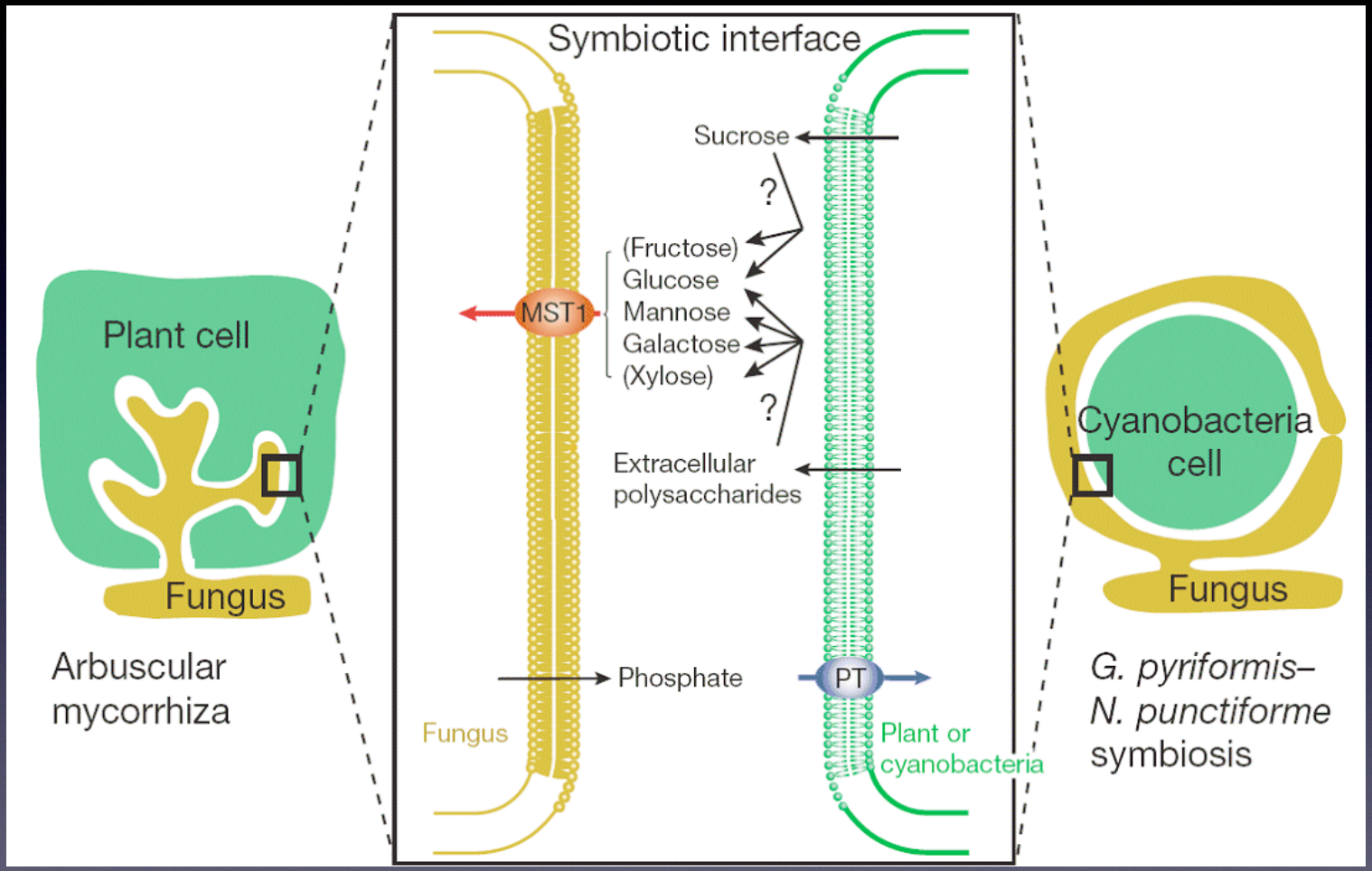
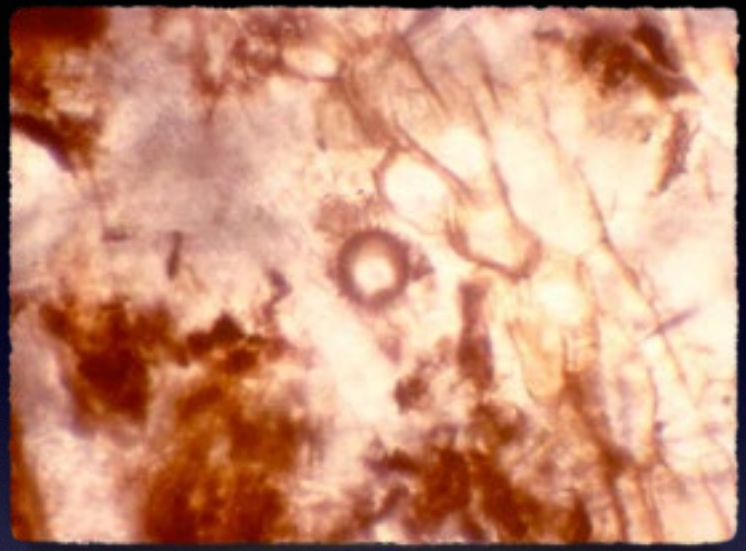
Why it 's so important?

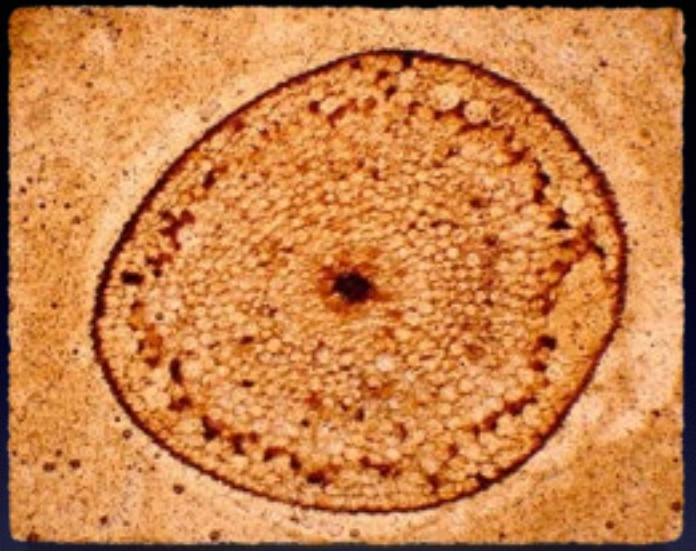
Soil diversity regulates ecosystem functions and the structure of terrestrial ecosystems

Origins

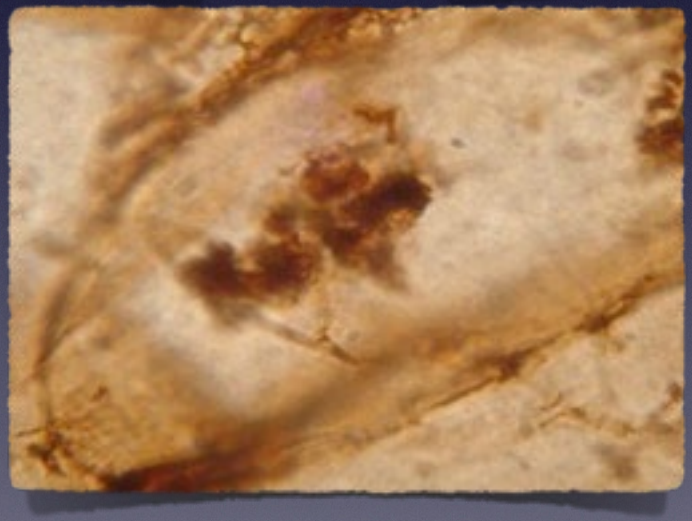

Symbiotic interface
Sucrose
?
(Fructose)
Glucose
Mannose
Galactose
(Xylose)
?
MST1
Extracellular
polysaccharides
Plant cell
Fungus
Arbuscular
mycorrhiza
Phosphate
PT
Fungus
Plant or
cyanobacteria
Cyanobacteria
cell
Fungus
G. pyriformis–
N. punctiforme
symbiosis

Fossils

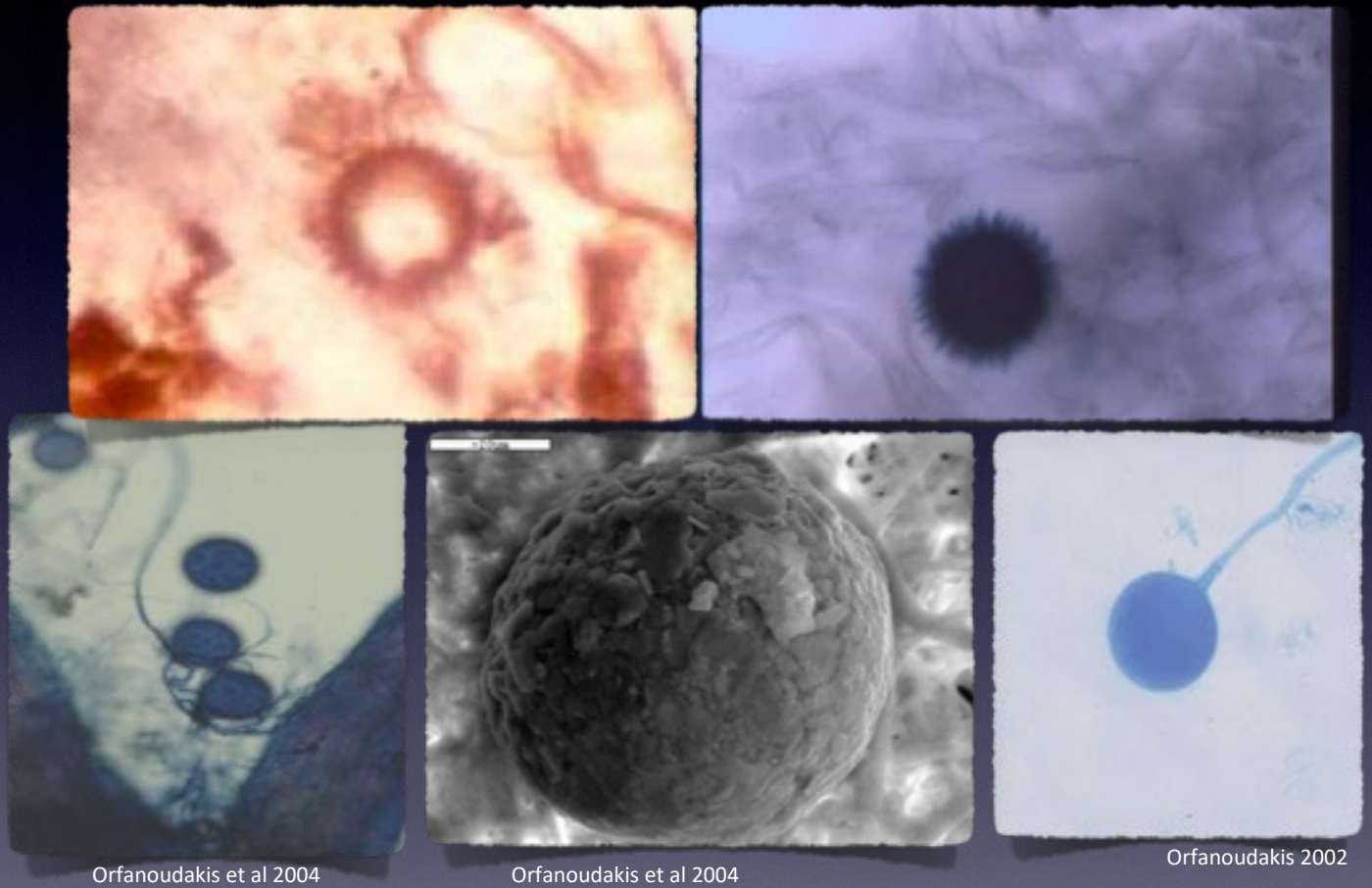




Orfanoudakis et al 2004



Anatomy of the symbiosis: The spores



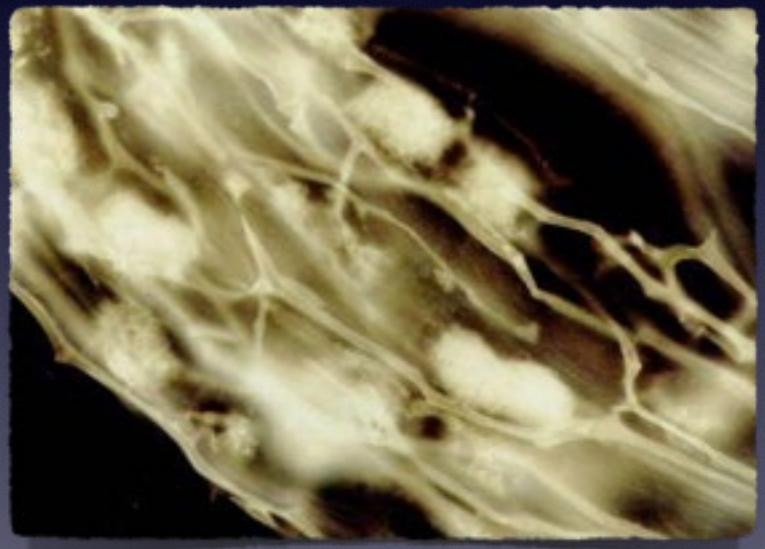
Orfanoudakis et al 2004

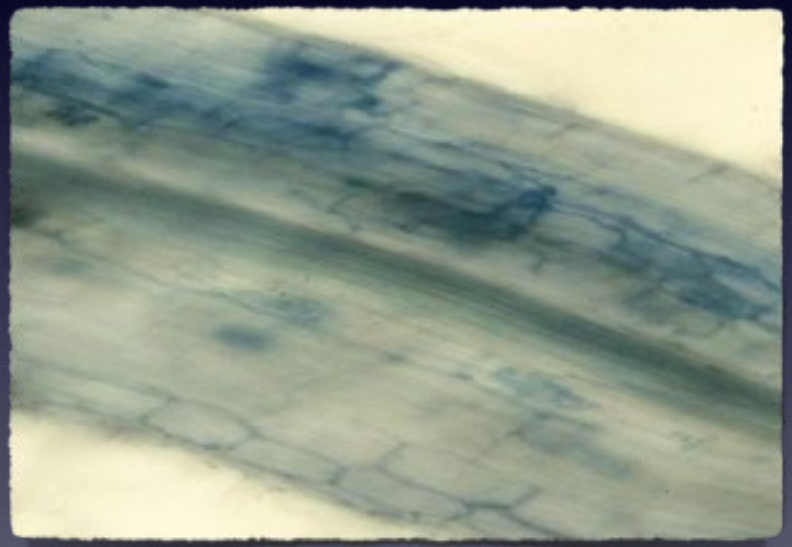
Orfanoudakis et al 2004

Orfanoudakis 2002

clonization

Orfanoudakis 2002



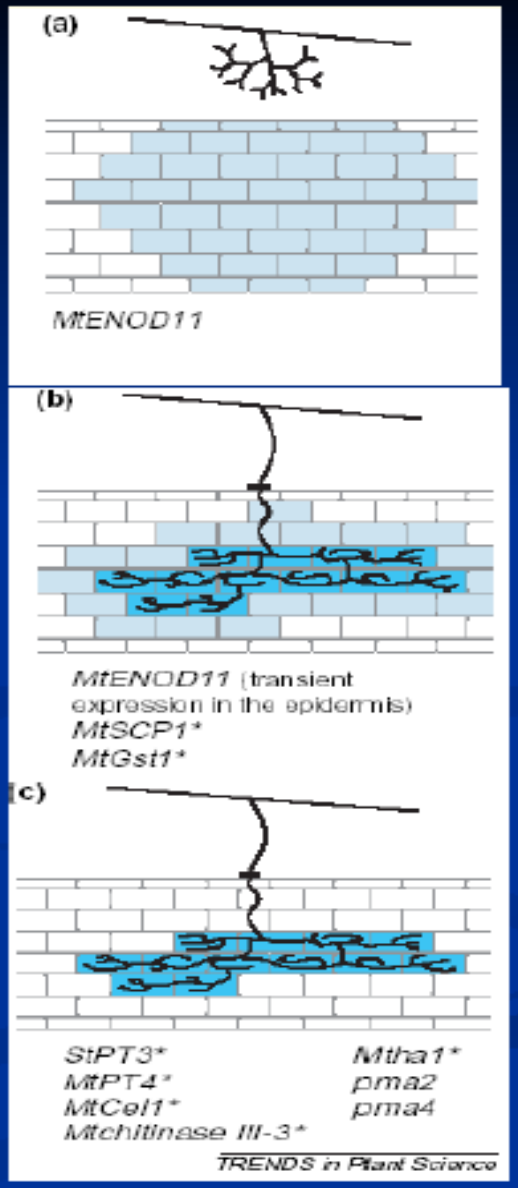


Orfanoudakis 2002

Function

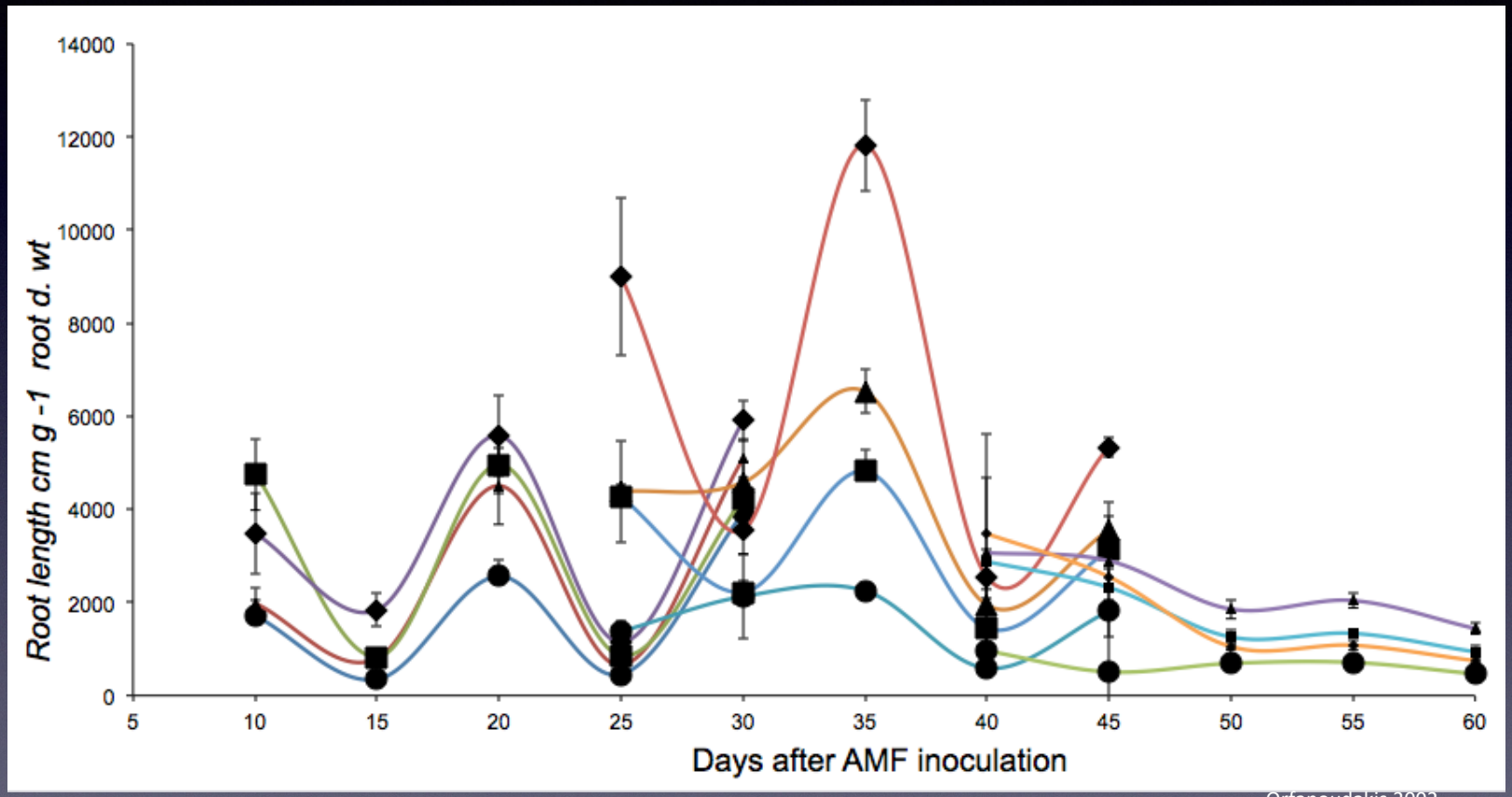
AMF could interact with the plant genome.

They could switch off the expression of gene related to the P transport to the plant



Changes to the plant

specific root length

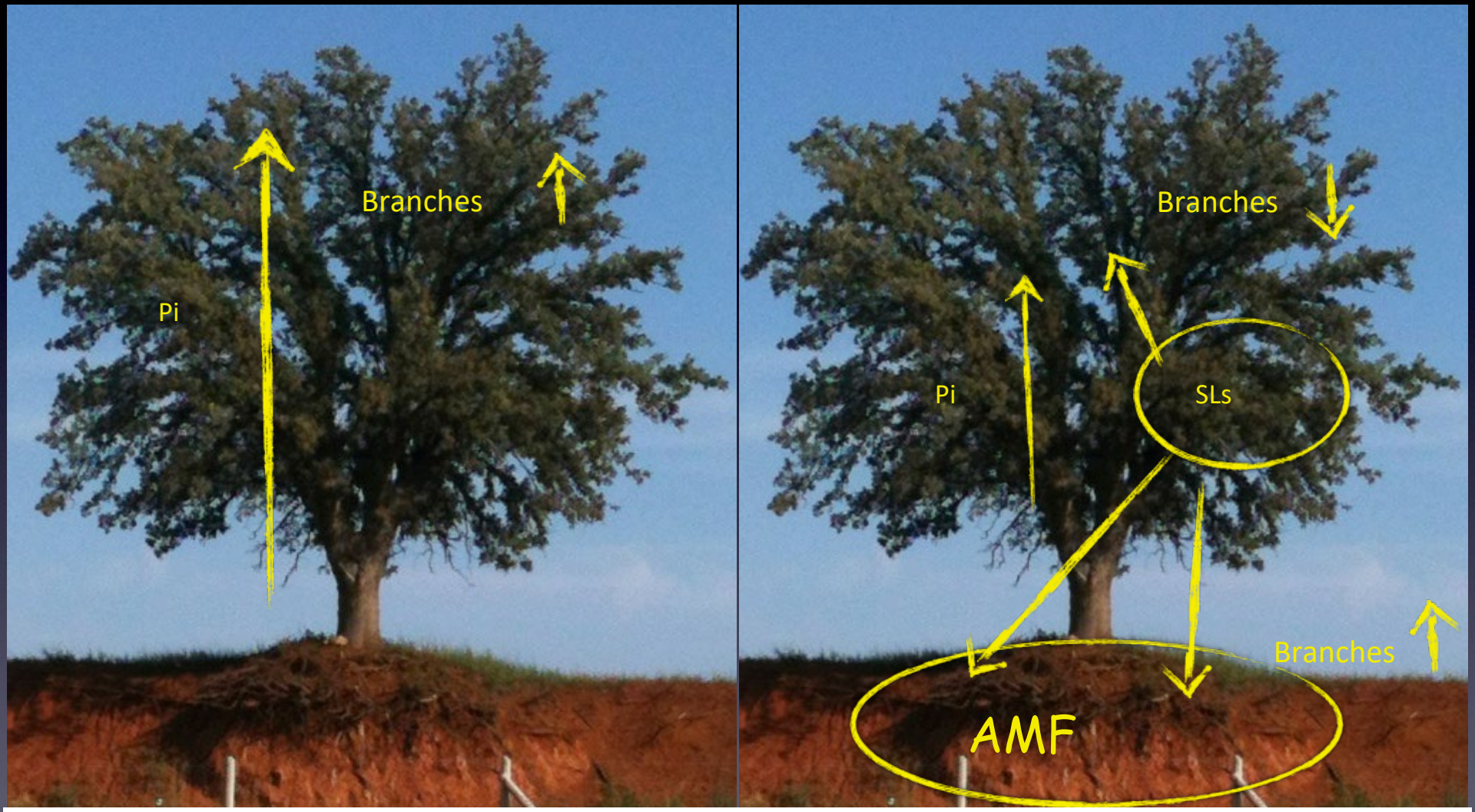


Orfanoudakis 2002

Why do we have such response ?

High P

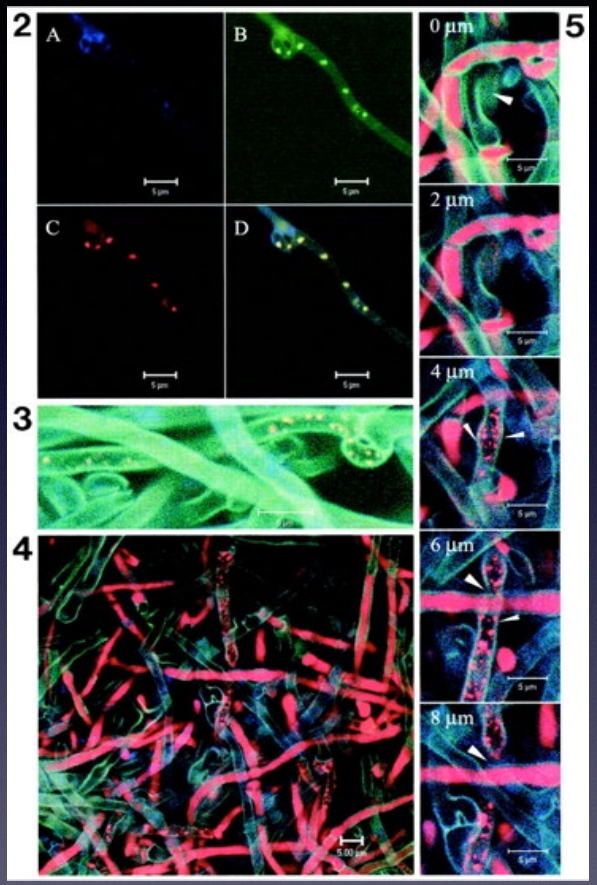
Low P



The increased root volume resulting to an increased root exudation to the mycorrhizosphere.

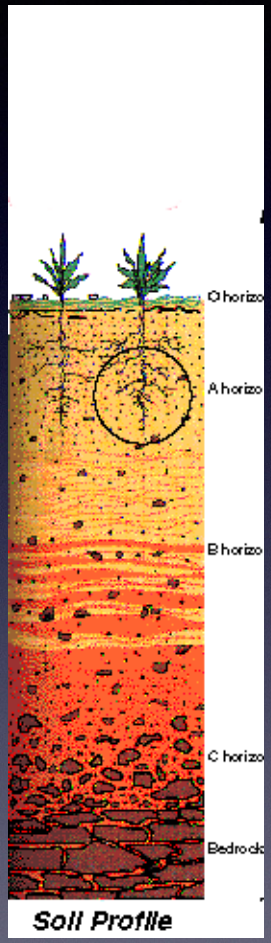
These exudates vary according to AMF species colonizing the root

Therefore the rhizospheric environment could be controlled by the symbiots resulting to a different microfauna at that particular environment.

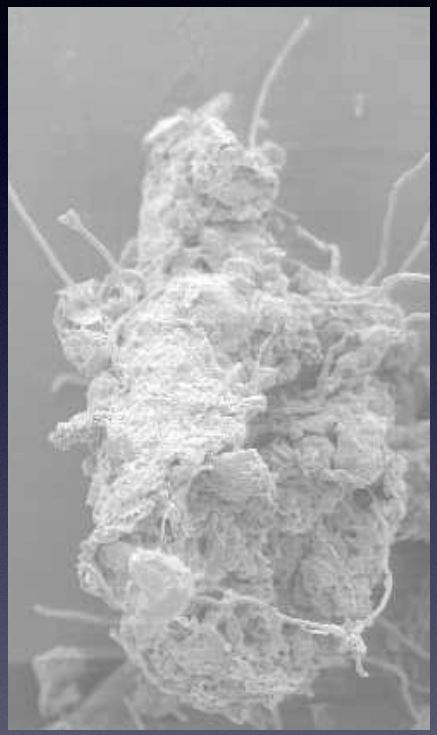


Bertaux et al 2003

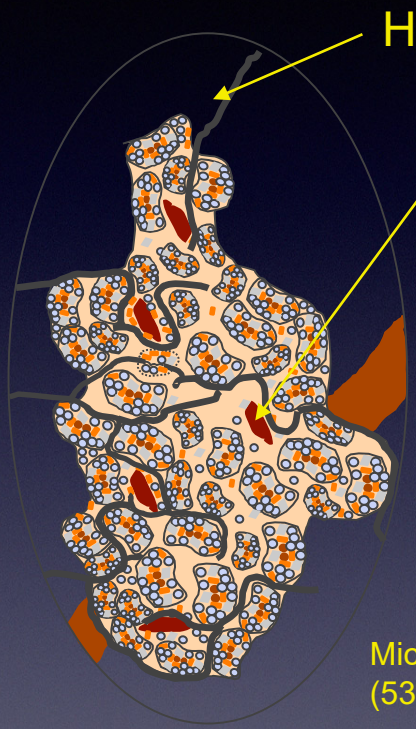
The soil environment



The soil environment



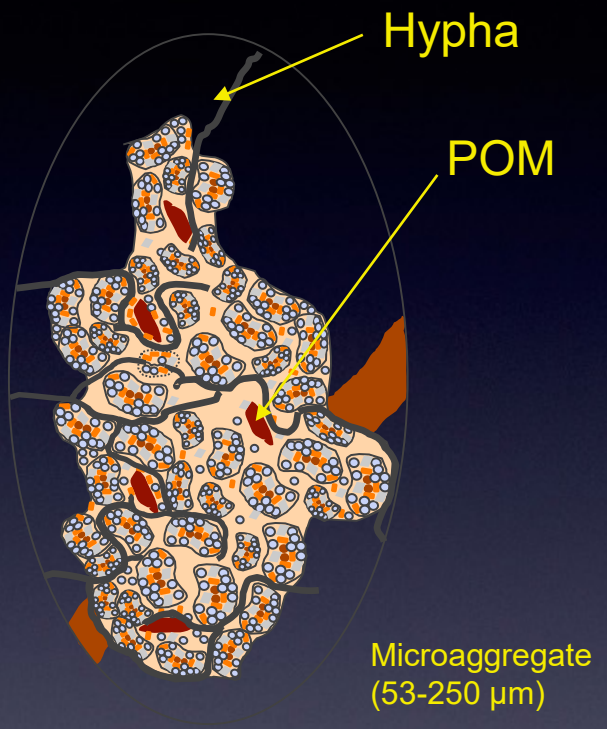
Rillig et al (2004)



Microaggregate
(53-250 µm)

Microaggregates are home for many soil bacteria.

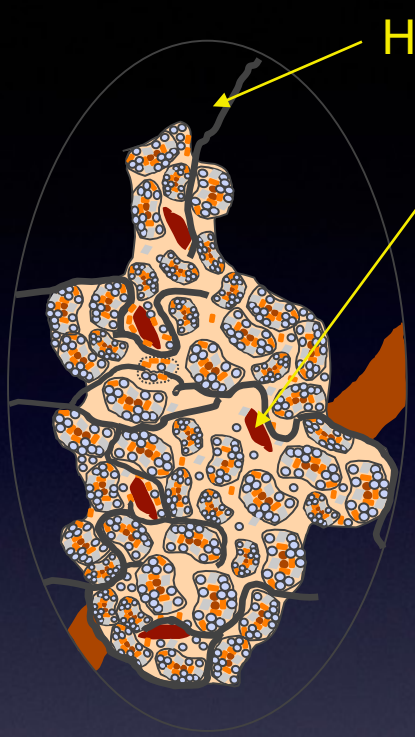
The soil environment



Soil bacteria are the source of many GMC gases

Many of them are at the mycorrhizospheric environment.

The soil environment



Microaggregate
(53-250 µm)

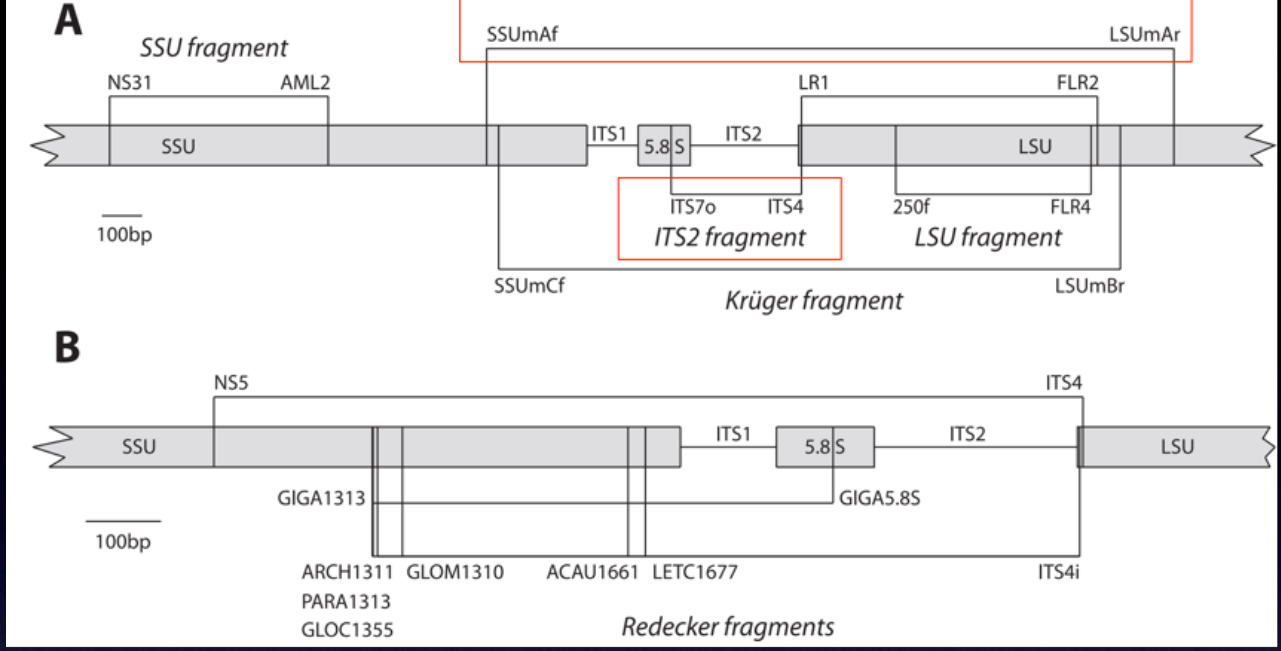
Previous pot experiment studies suggests an effect upon the N_2O emissions

What is happening in Xanthi's soils ?

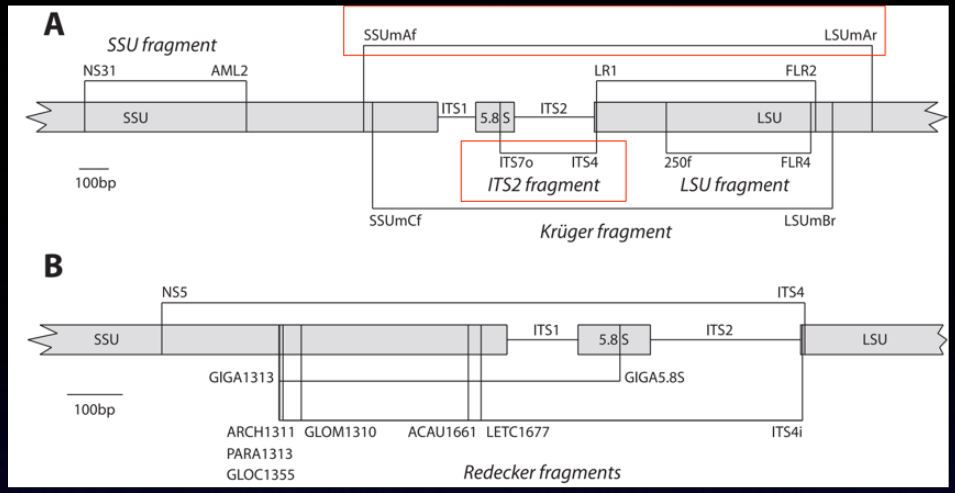
Nested PCR

A set of Specific Glomeromycota Primers was used

For soil-root samples of different soil layers.



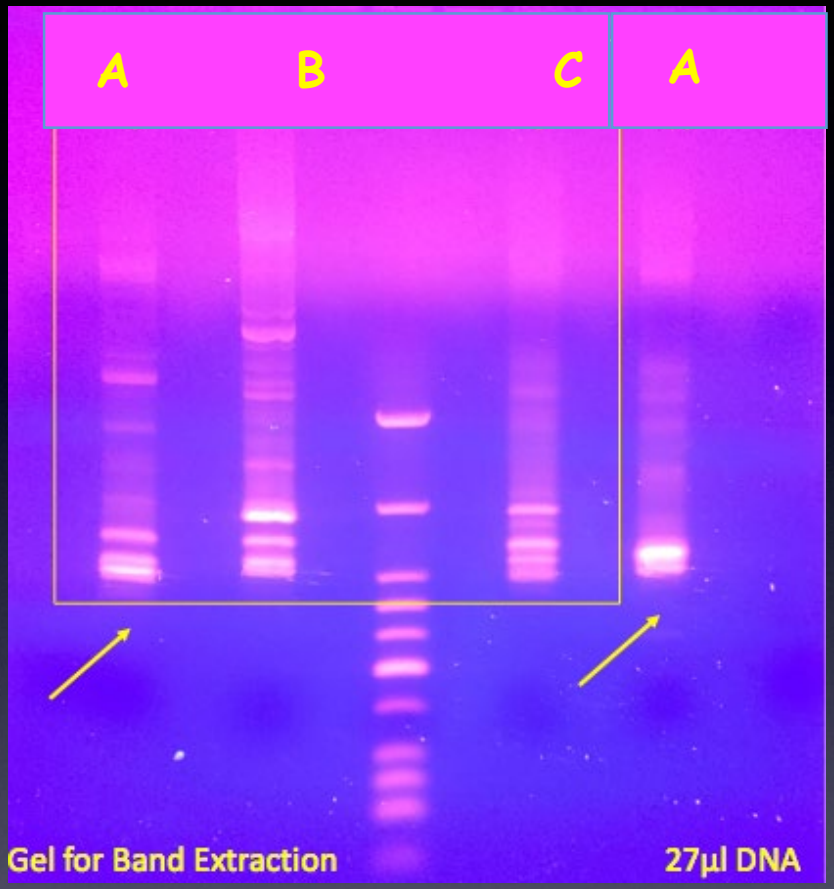
- Soil DNA extraction
- 1st PCR using an AMF specific primer set (Big red box)
- 2nd PCR (nested) using as template the product of the 1st PCR and two primers (Little red box) to improve the specificity and quality of product for the next step
- Cloning and sequencing of the 2nd PCR products for AMF species identification



Kohout et al 2014

- Instead of cloning and sequencing (that could give us) max output 25-50 clones i.e. sequence samples to check for AMF species diversity (so, we could lose some rare species)
- NGS (next generation sequencing) (will give us) min 300.000 sequence reads (max 3.000.000 reads) to check for AMF species diversity (so, we are confident that we will identify all the species) AND an additional ADVANTAGE is (we achieve in the same reaction) quantification of the different species

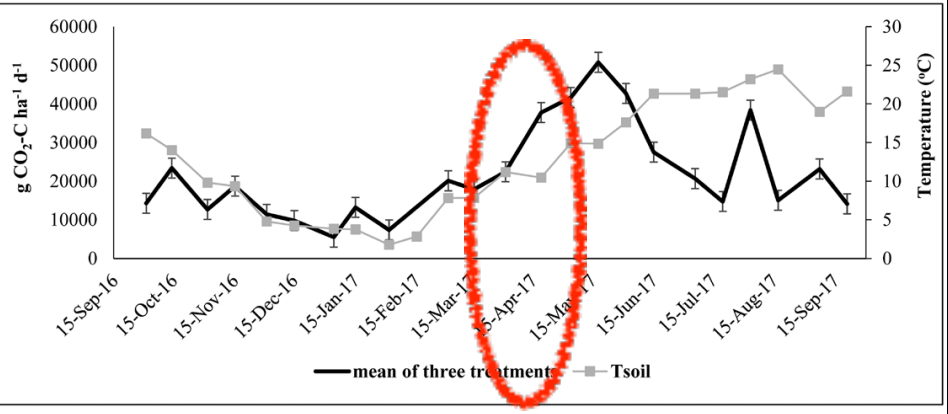
PCR result



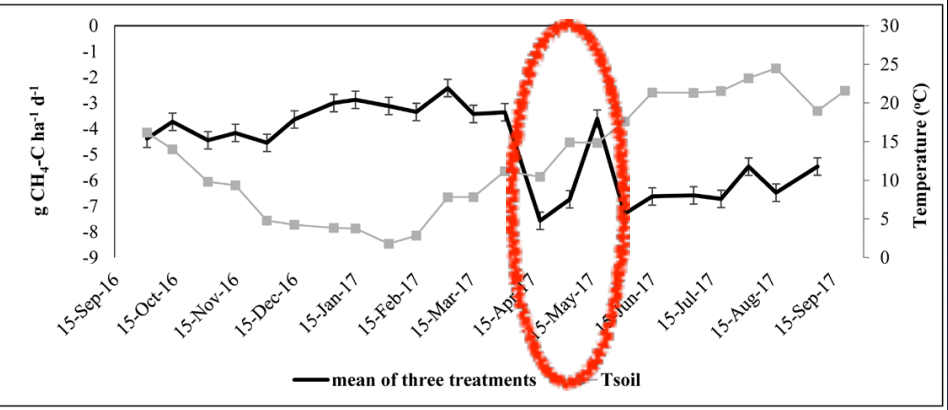
The number of bands is indicative of AMF diversity

1. In the yellow box there are samples from one area at three different sequential depths (A surface – C deepest). In the box the deepest soil sample showed the smallest diversity.
2. There were also differences in the diversity between different areas. The sample from depth A in the box and the sample from depth A outside the box (Control Vs innovative) look different concerning the number of bands present.

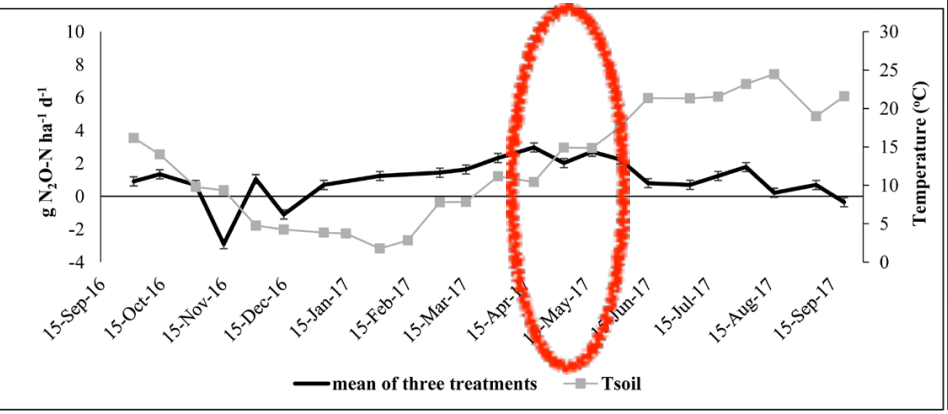
Gas emissions



There is a change at the emission pattern at the end of April to May.



Methane can be both produced and consumed by soils during methanogenesis and oxidation

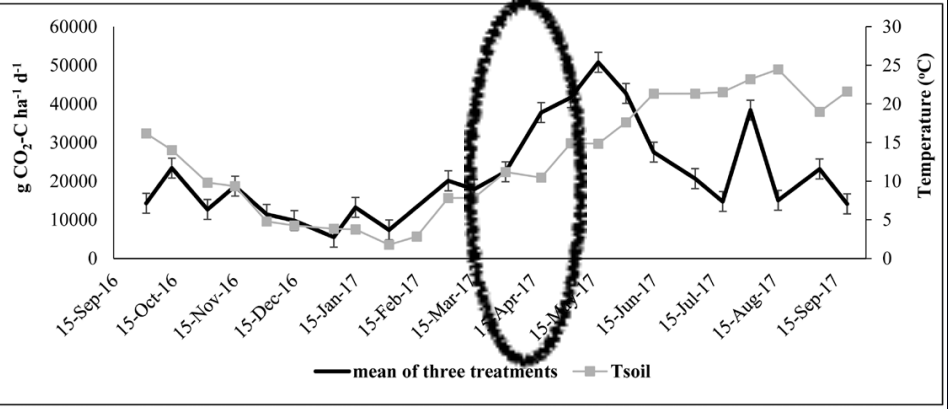


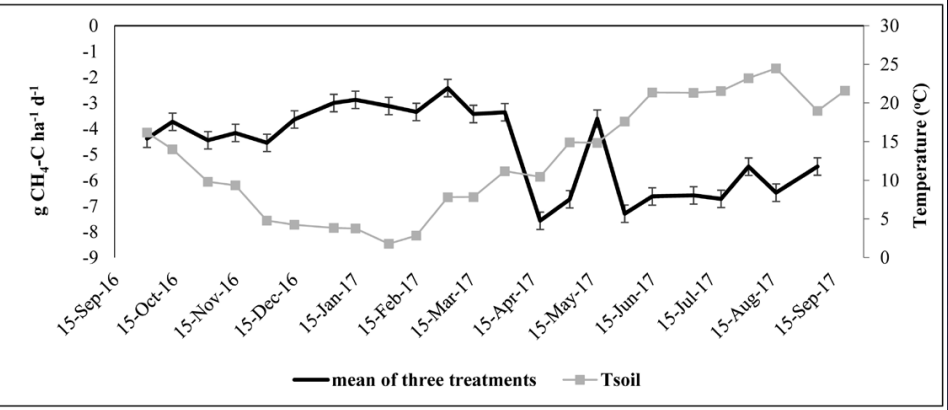
In anaerobic patches …inside micro aggregates

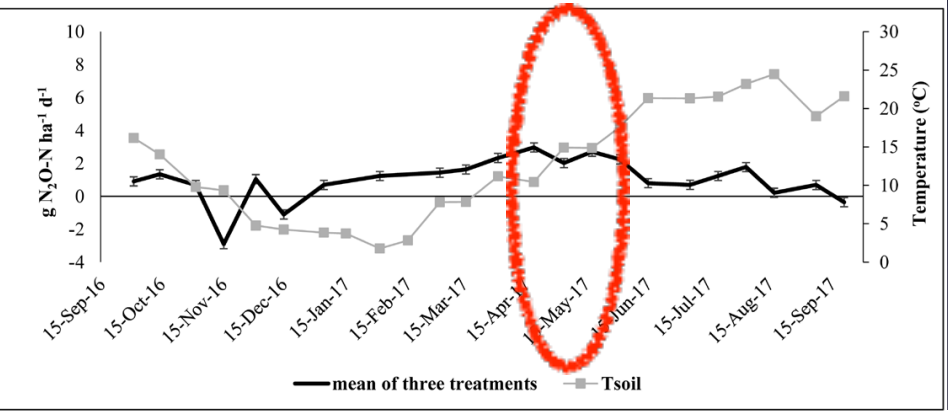
The bacteria responsible for these changes are

methanotrophic bacteria
archaea,
nitrifying bacteria

Their presence has been correlated with external AMF hyphae







It is notable the reduction of N_2O emissions,

coincides with increased AMF activity

Mycorrhizal plants have better water management.

The increased water uptake resulting to enhanced aerobic conditions.

Resulting to increased root respiration …in Spring.

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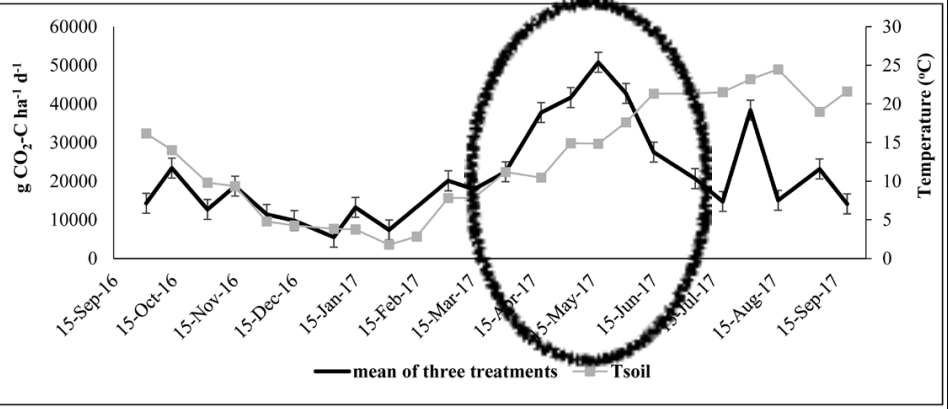

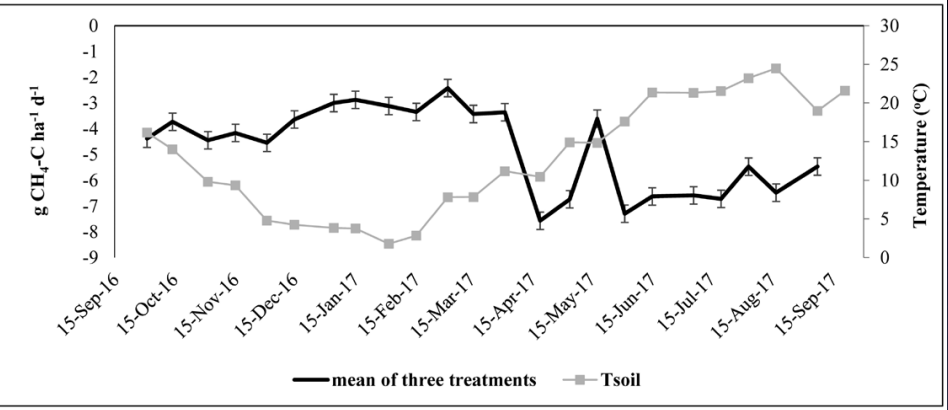

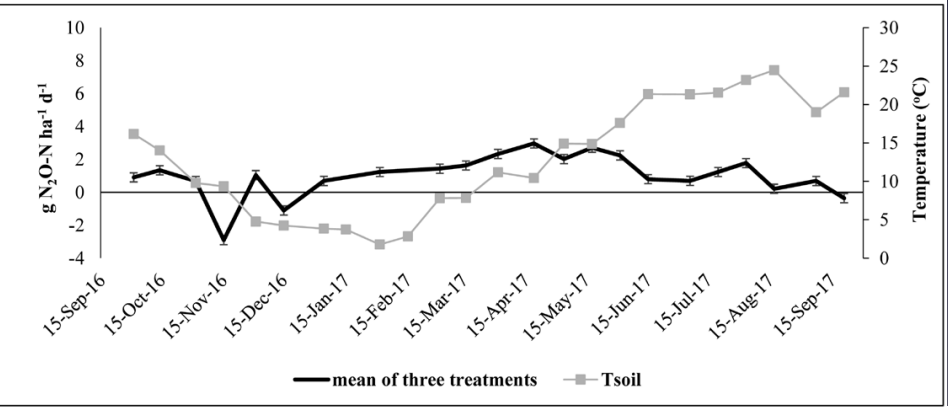

Between 5 and 20% of the C fixed by mycorrhizal plants is allocated to the fungal mycelium.
(Pearson and Jakobsen, 1993; Bonfante and Genre, 2010; Fellbaum et al., 2012).

Significant portion (up to 7%) of the C transferred to the AM fungus is released to the atmosphere shortly after fixation (Johnson et al., 2002).

Due to the increase in microbial activity after the rapid transfer of C to the soil microbial community.

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AMF have an indirect effect upon the annual Gas emissions.

The efficacy is probably temperature depended.

As the increased mycorrhizal activity suggests at the low depth.

Thank you