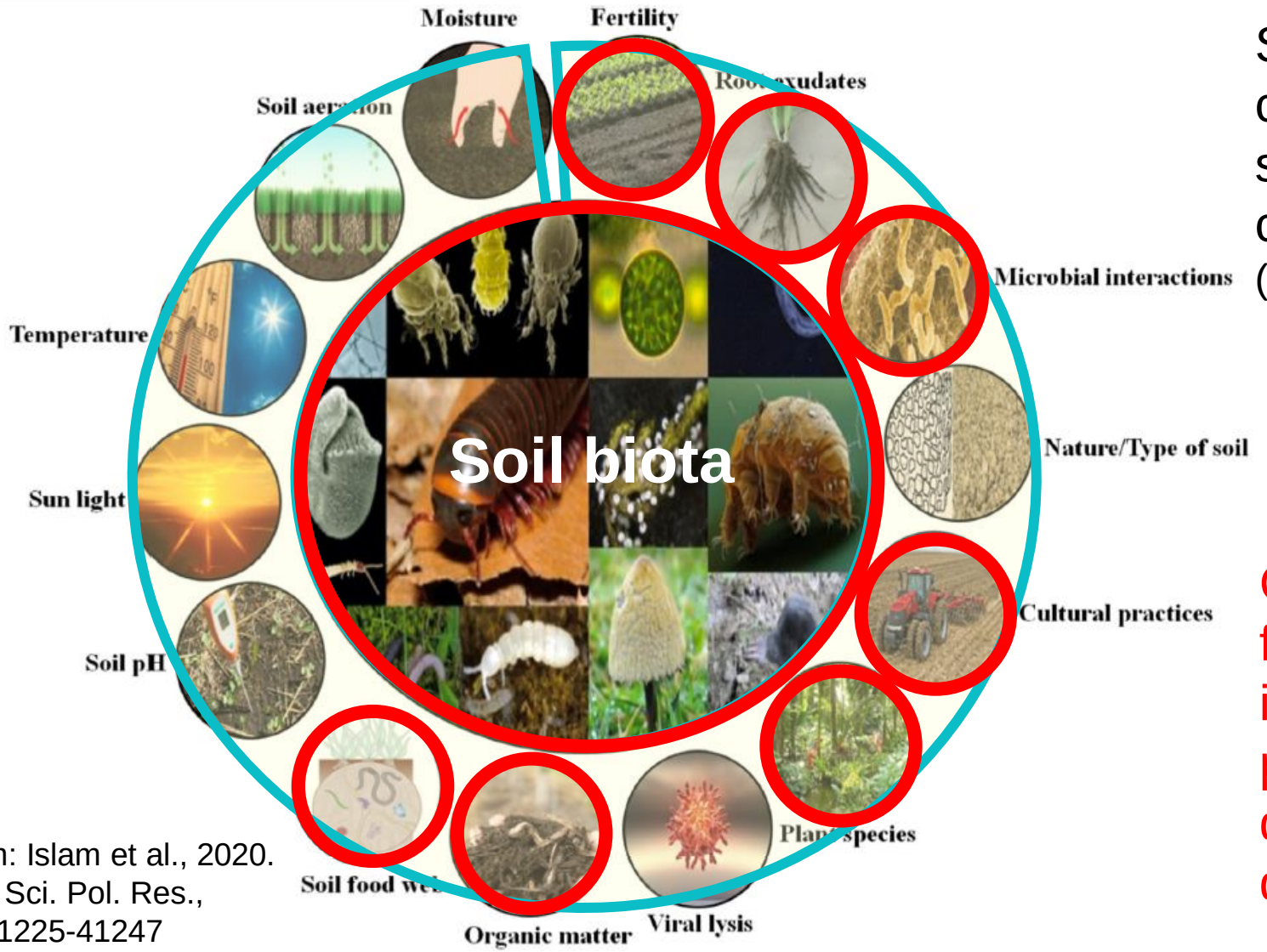
Sculpting the soil microbiota: the role of soil management and plant diversity-based farming practices

Alessandra Trinchera

Elena Testani, Dylan Warren Raffa, Corrado Ciaccia

Council for Agricultural Research and Economics
Research Centre for Agriculture and Environment
(Rome, Italy)

Abiotic and biotic factors affect soil microbiota



From: Islam et al., 2020. Env. Sci. Pol. Res., 27:41225-41247

Soil microbiome provides critical contributions to nutrient cycling, soil fertility maintenance, and carbon sequestration (Jacoby et al., 2017)

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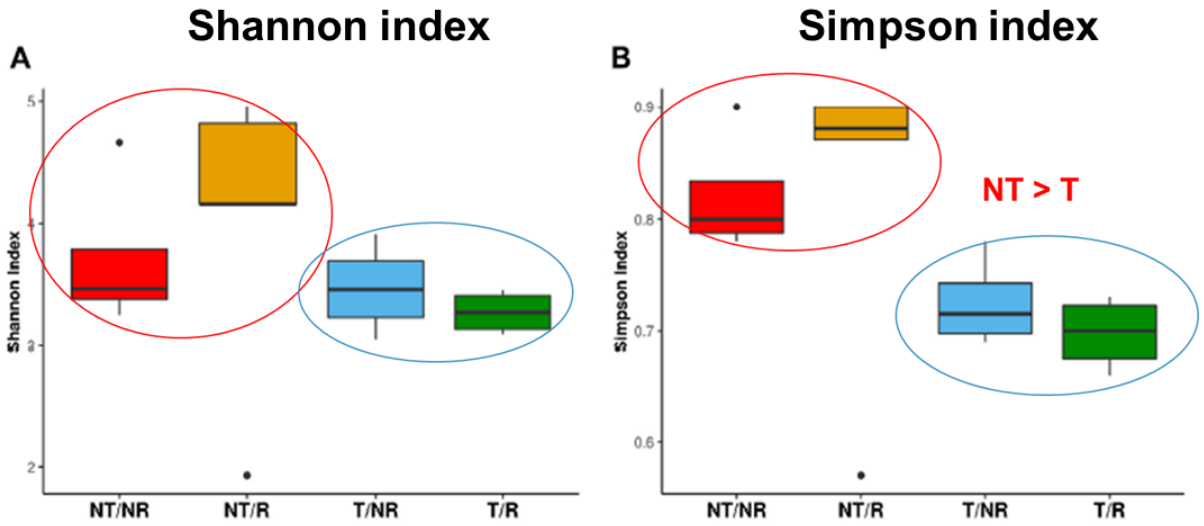
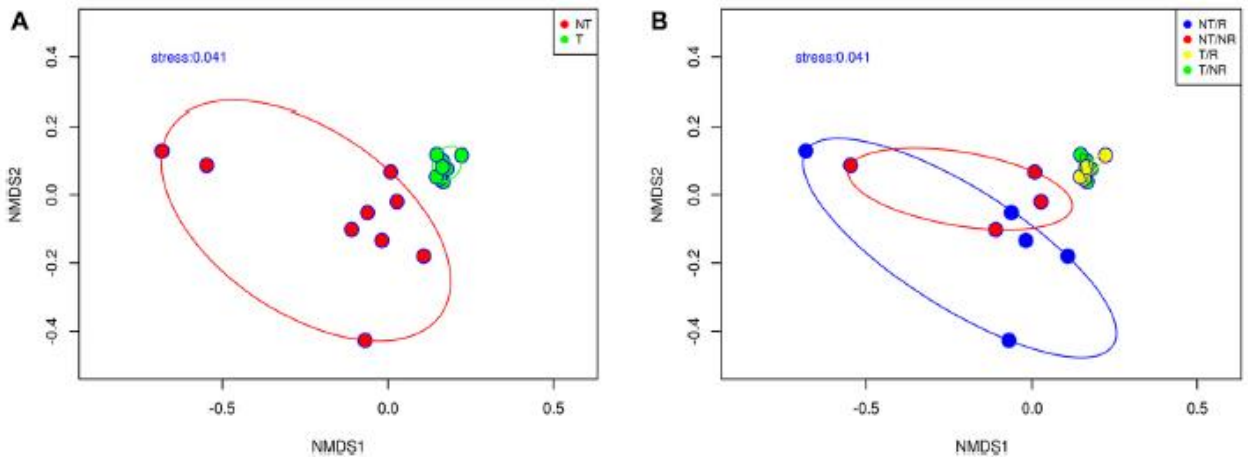
Can we shape diversity and functioning of soil microbiota by introducing agroecological practices based on reduced soil disturbance and increased plant diversity?

No-tillage and crop rotation: effect on fungi community diversity



A: Shannon index of diversity: number of species (richness) and equitability (eveness)
B: Simpson index of diversity: probabilty that 2 individuals belong to different species



Factors:

- Tillage at 30 cm vs. no tillage (**T** and **NT**)
- Durum wheat monocrop vs 2-years durum wheat – field bean rotation (**NR** and **R**)

Non-metric multidimensional scaling based on Bray Curtis dissimilarities

A: effect of tillage
B: effect of rotation

on the fungal community composition.

Just after 2-years, no tillage and crop rotation gave the highest fungal α-diversity

→ Tillage (T) affects fungi community composition, while rotation (R) does not

Orrù L., Canfora L., Trinchera A., Migliore M., Pennelli B., Marcucci A., Pinzari F. (**2021**). How tillage and crop rotation change the distribution pattern of fungi. **Frontiers in Microbiology** 12, 1469.

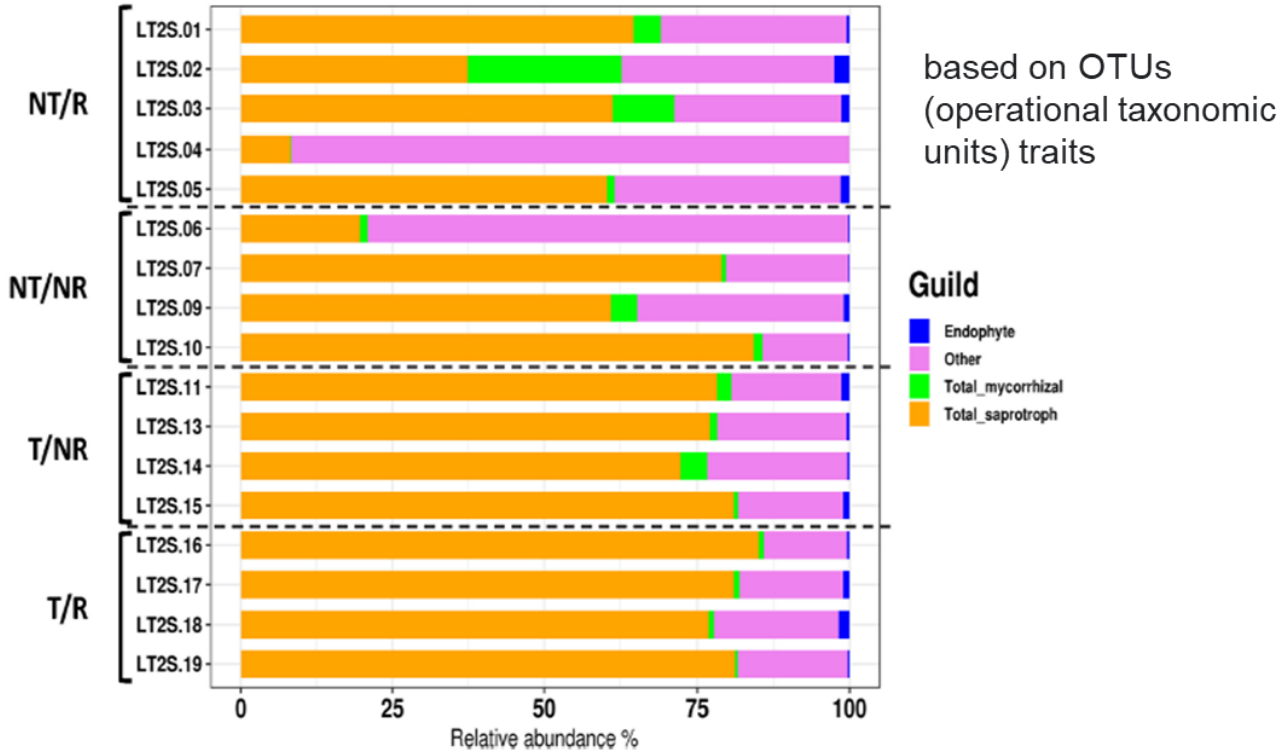
Effect on fungi community composition

Phylum	FDR
Ascomycota	**0.005**
Basidiomycota	0.37
Chytridiomycota	0.23
Entomophthoromycota	0.15
Glomeromycota	0.74
Mortierellomycota	**8.2 e^{-05}**
Mucoromycota	**0.01**
Olpidiomycota	**0.02**
Rozellomycota	0.06
unidentified	**8.2 e^{-05}**

In the table are reported the FDR corrected P-value. Statistically significant values are shown in bold.

Wilcoxson signed-rank test: comparison of fungi phylum relative aboundance in NT and T management systems

(Orrù et al., 2019)



based on OTUs (operational taxonomic units) traits

→ ***Ascomycota* overrepresented in NT** soils, active in lignin and carbohydrates degradation.

→ ***Mortierellomycota* (*Mortierella* genus as phosphate-solubilizing species) associated to T soils**, and negatively correlated to soil available P

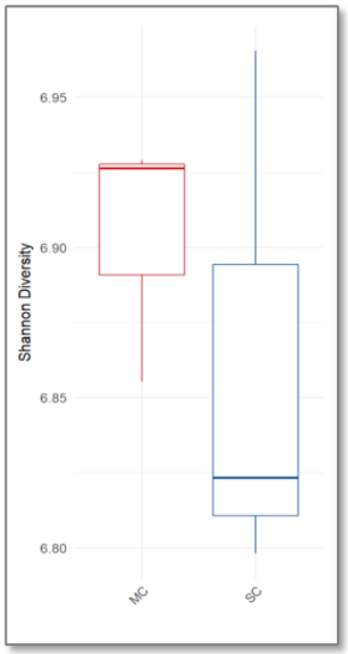
FUNGuild – **Total saprotroph was the most abundant functional group → higher diversity in T soils**

→ **Highest total mycorrhizal fungi abundance In NT soils under rotation**

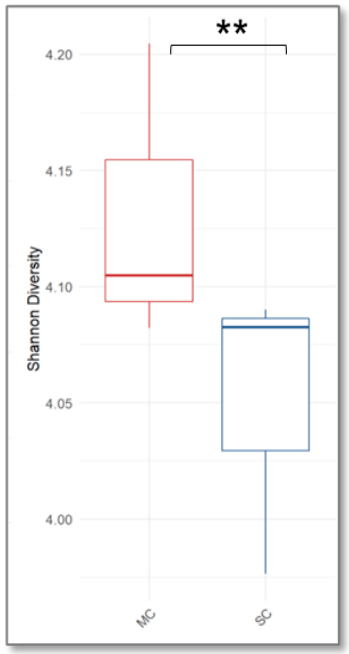
Effect of strip-cropping on microbial community

Monocropped tomato (**MC**)
Strip cropped tomato (**TC**)

Bacteria *

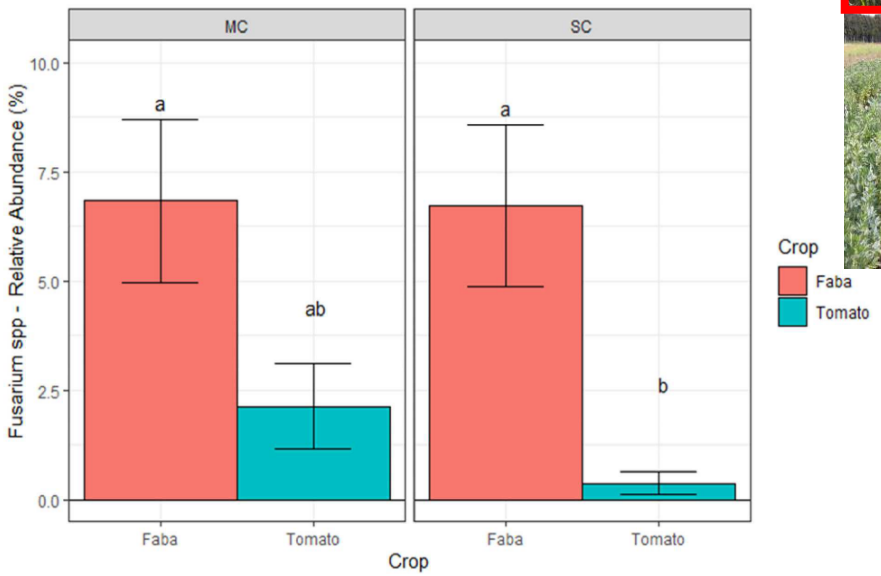


Fungi *

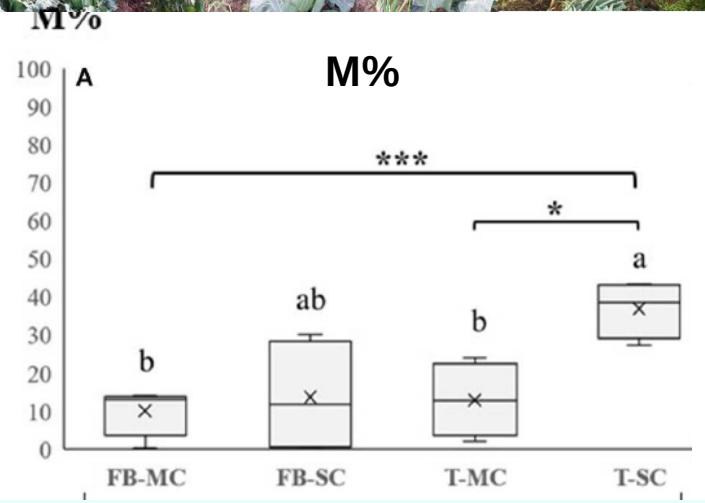


No significant effect on **bacteria diversity** in tomato

Fungi diversity higher in tomato **SC** when compared to tomato **MC**

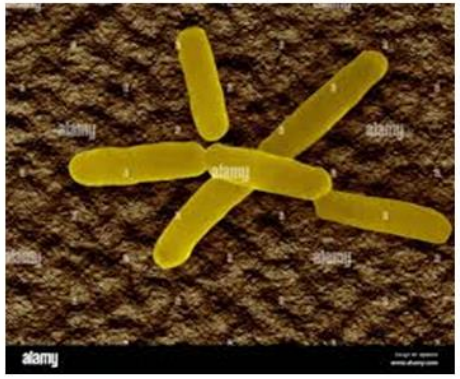


Under tomato **SC**, the relative abundance of ***Fusarium* spp**. **decreased** in rhizosphere soil, compared to **MC**



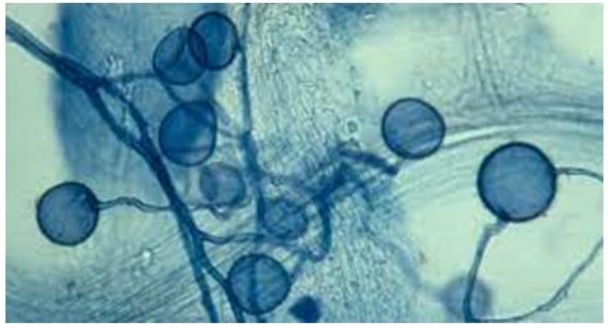
Higher mycorrhizal colonization in tomato **SC**

Effect of SC on bacteria & fungi community composition



Proteobacteria ↑

Bacteroidetes ↑



Glomeromycota ↑

Mortierellomycota ↓

- Bacterioidetes → testifying the introduction of low-impact agricultural practices
- Mortierellomycota → undirect indicator of the reduced pressure made by pathogens

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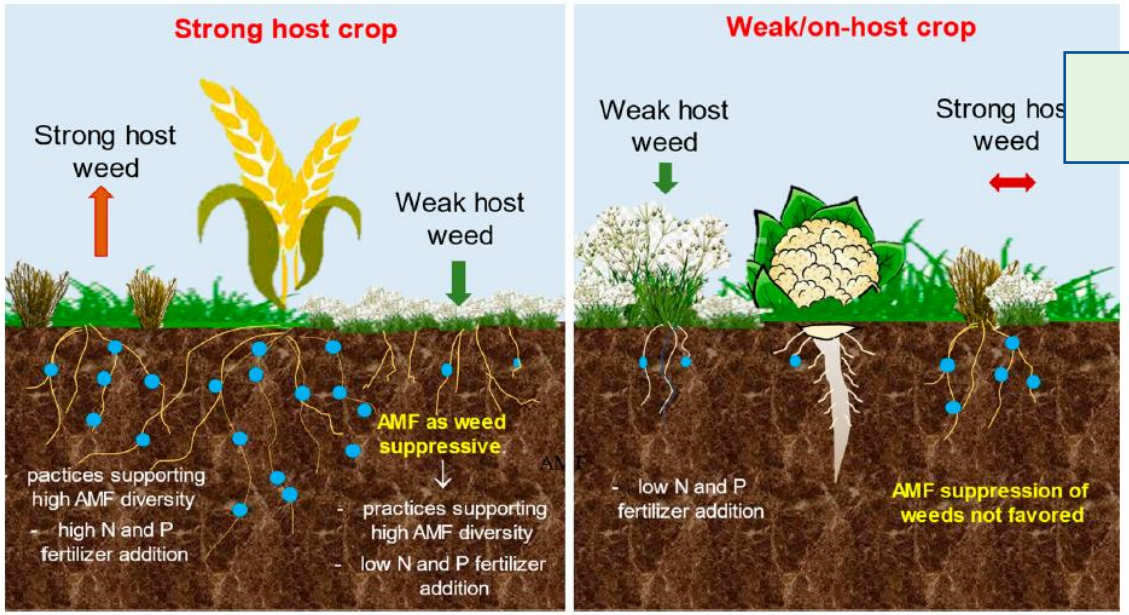
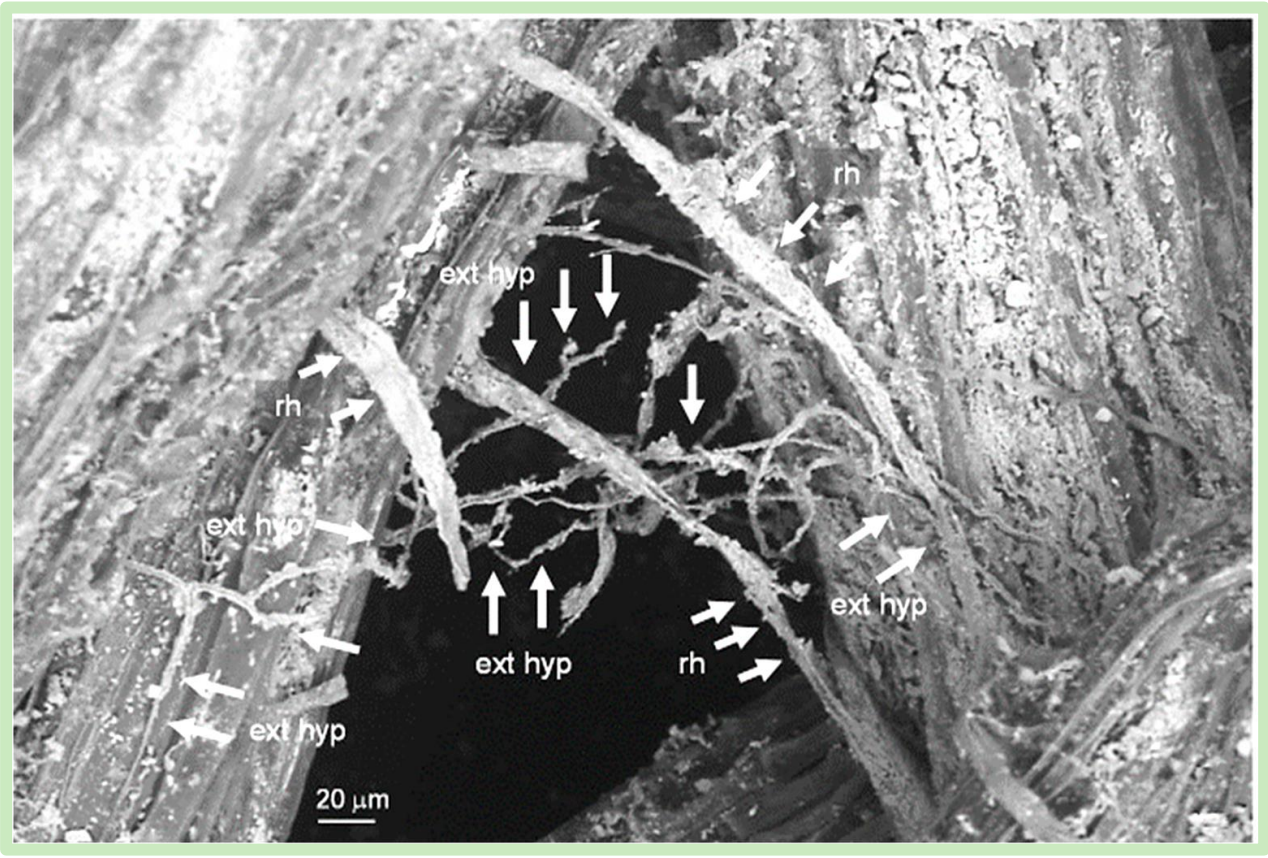
Shaping soil fungi community: plant diversity may support AMF colonization



Service crops and/or **weeds** with Supporting Arbuscular Mycorrhizal (SAM) trait boost mycorrhization of the main crop by developing a common mycorrhizal hyphal mycelium among coexisting plants

AMF as weed species selection

(From: Trinchera, A.; Warren Raffa, D. Weeds: An Insidious Enemy or a Tool to Boost Mycorrhization in Cropping Systems? Microorganisms 2023, 11, 334)



Mycorrhizal hyphal mycelium of *Cucumis melo* L., grown on flattened spelt. ext-hyp: AMF extra-radical hyphae; rh: root hairs. (SEM image at 10 VP; magnification = 1.0 KX.

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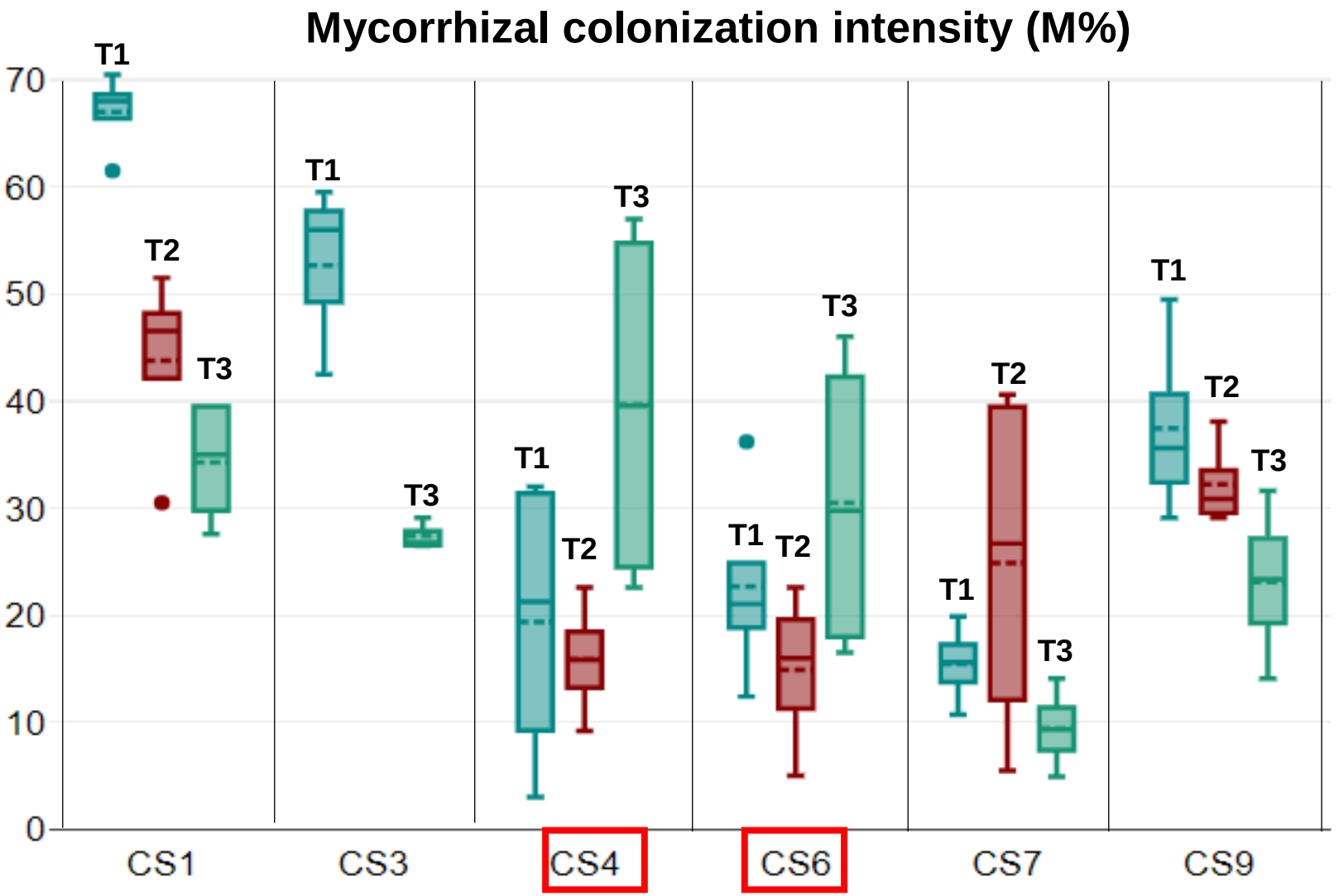
AGROECOseqC hypothesis: high plant diversity increases agrosystem mycorrhization



T1 = Agroecological intensification 1
T2 = Agroecological intensification 2
T3 = Control (BAU or conventional)

No tillage and **natural coverage** increase plant mycorrhization

Hypothesis rejected in:

- ✓ CS4 - T3>T2: which species in CS4 mixture?
- ✓ CS6 - T3>T2: in T2 plant mix, the radish was added → B*rassicacea,* non-host specie!

Take-home messages

- ✓ Soil management practices may be tool to address soil community composition towards beneficial microbes, while suppressing fungal pathogens
- ✓ No tillage increases fungi diversity and relative abundance of Glomeromycota and *Ascomycota* (→ crop residue degradation), while reducing *Mortierellomycota* phyla
- ✓ Preliminary AGROECOseqC results suggest that, in field, a reduced soil disturbance and an increased plant diversity promote the development of a common mycelium among roots of coexisting plants, whose functional traits are key in promoting or suppressing beneficial symbiotic interactions

Thank you!

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European Joint Programme

Annual Science Days 2023

University of Latvia campus in Riga

Breakout sessions C2: **Soil biodiversity and ecosystem services**

Alessandra Trinchera

CREA – Research Centre for Agriculture and Environment

alessandra.trinchera@crea.gov.it