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Facoltà di Scienze agrarie, ambientali e alimentari
Faculty of Agricultural, Environmental and Food Sciences

EMERGE
From Farm to Glass

Microbiome Research: From Theory to Practice

Prof. Youry Pii
Facoltà di Scienze Agrarie, Ambientali e Alimentari
Libera Università di Bolzano

Workshop EMERGE – From Farm To Glass
Bologna, 15 Febbraio 2024

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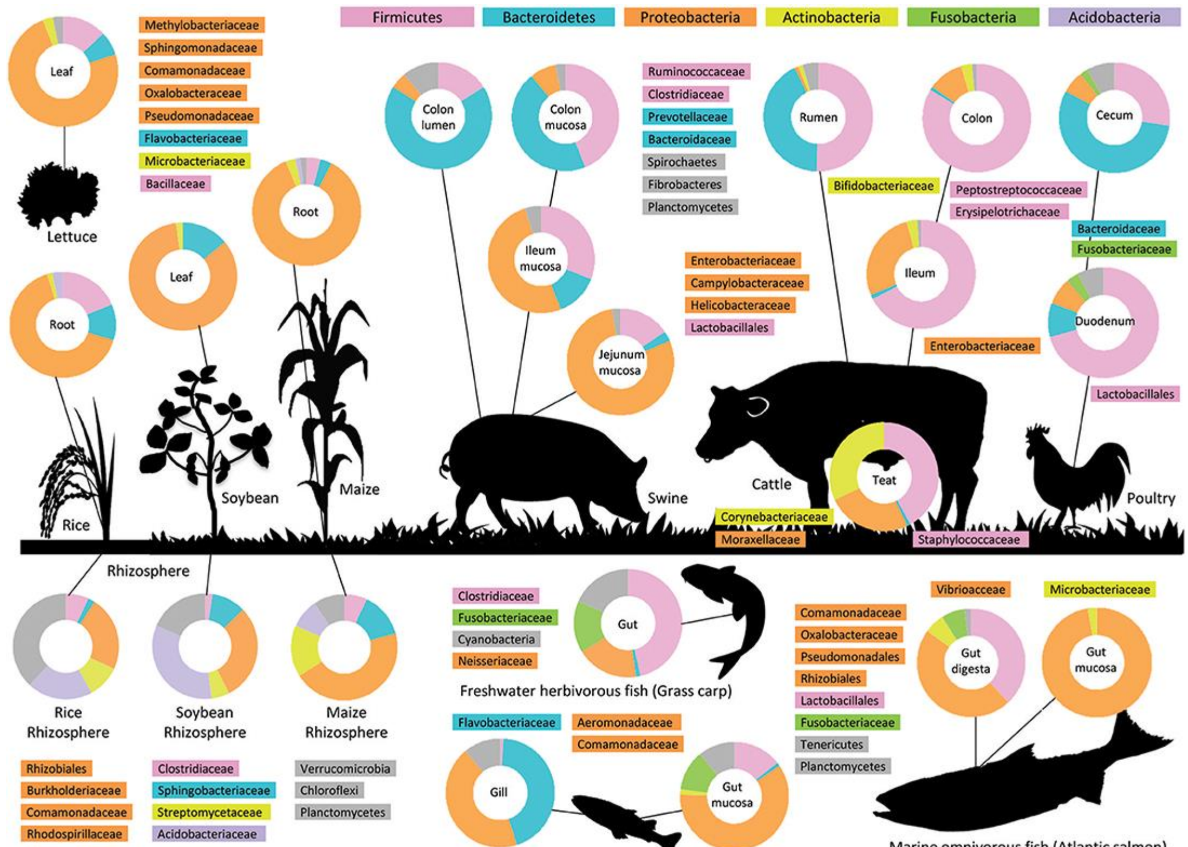
The Microbiome: a definition

The **microbiome** is defined as a diverse community of microorganisms associated with a higher organism (human, animal, plants etc.). All higher organisms examined to date harbor microbiomes.



Ikeda-Ohtsubo et al., 2018

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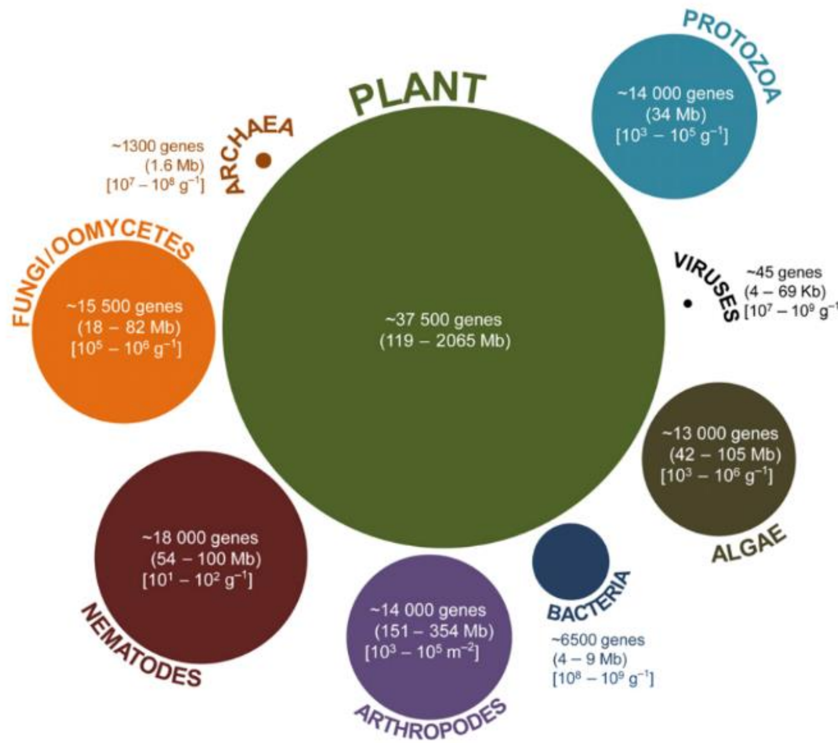
The Plant Holobiont

Plants are not separate entities, but rather they live in association with a large variety of microbes.

They play important roles such as **increased nutrient availability**, **uptake** by plants and **increased plant stress tolerance**.

Plant fitness (growth and survival) is the result of physical and physiological functions of the plant *per se* as well as the associated microbiome, which together are known as a **plant holobiont**.



Bulgarelli et al., 2013

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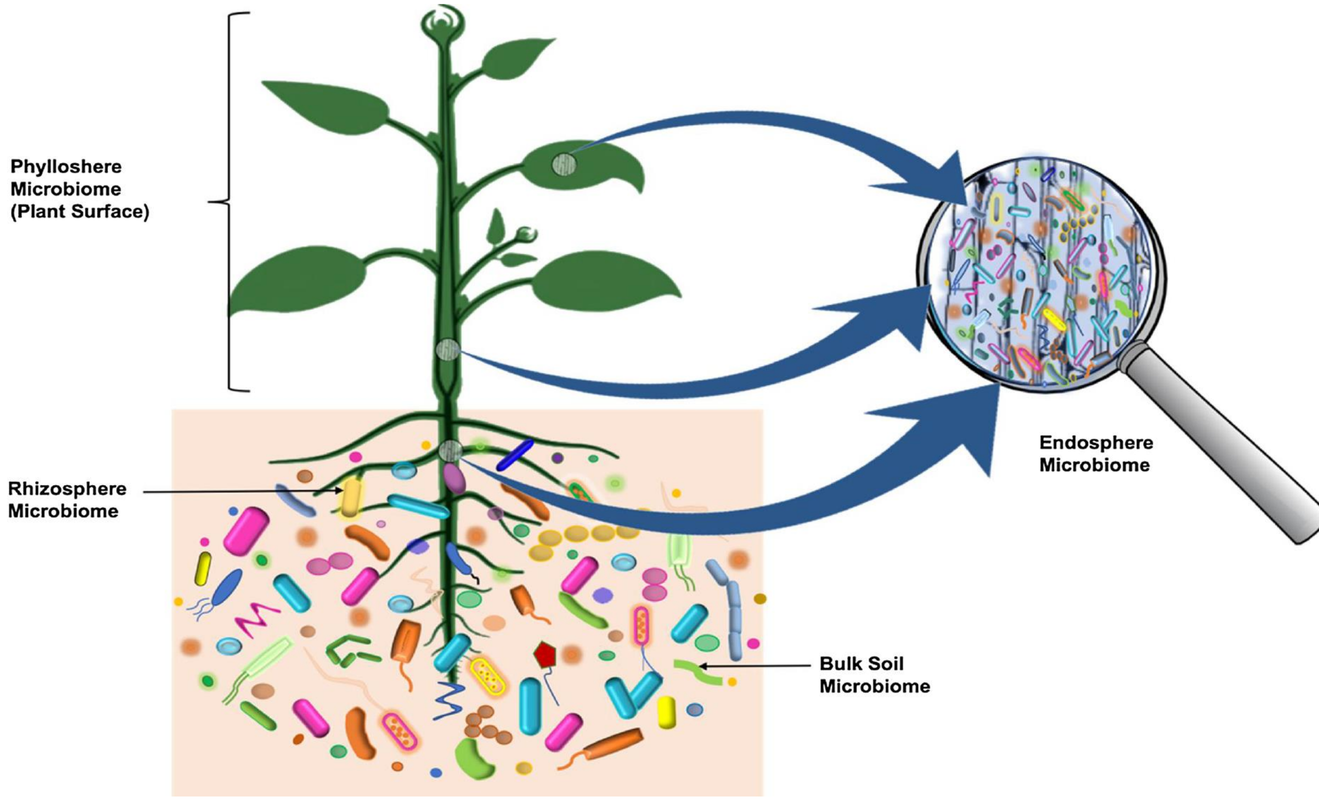
The Plant Holobiont

These microbes live either inside (endosphere) or outside (episphere) of plant tissues.

Among these microorganisms, bacteria and fungi are predominant.

About a few thousand bacterial and fungal taxa have been reported from plant tissues



Dastogeer et al., 2020

Microbiome research

Symbiosis between plants and AMF

Symbiosis between legumes and Rhizobia

Both of them greatly influence the mineral nutrition of plants by making not available elements (P and atmospheric N) available for plants

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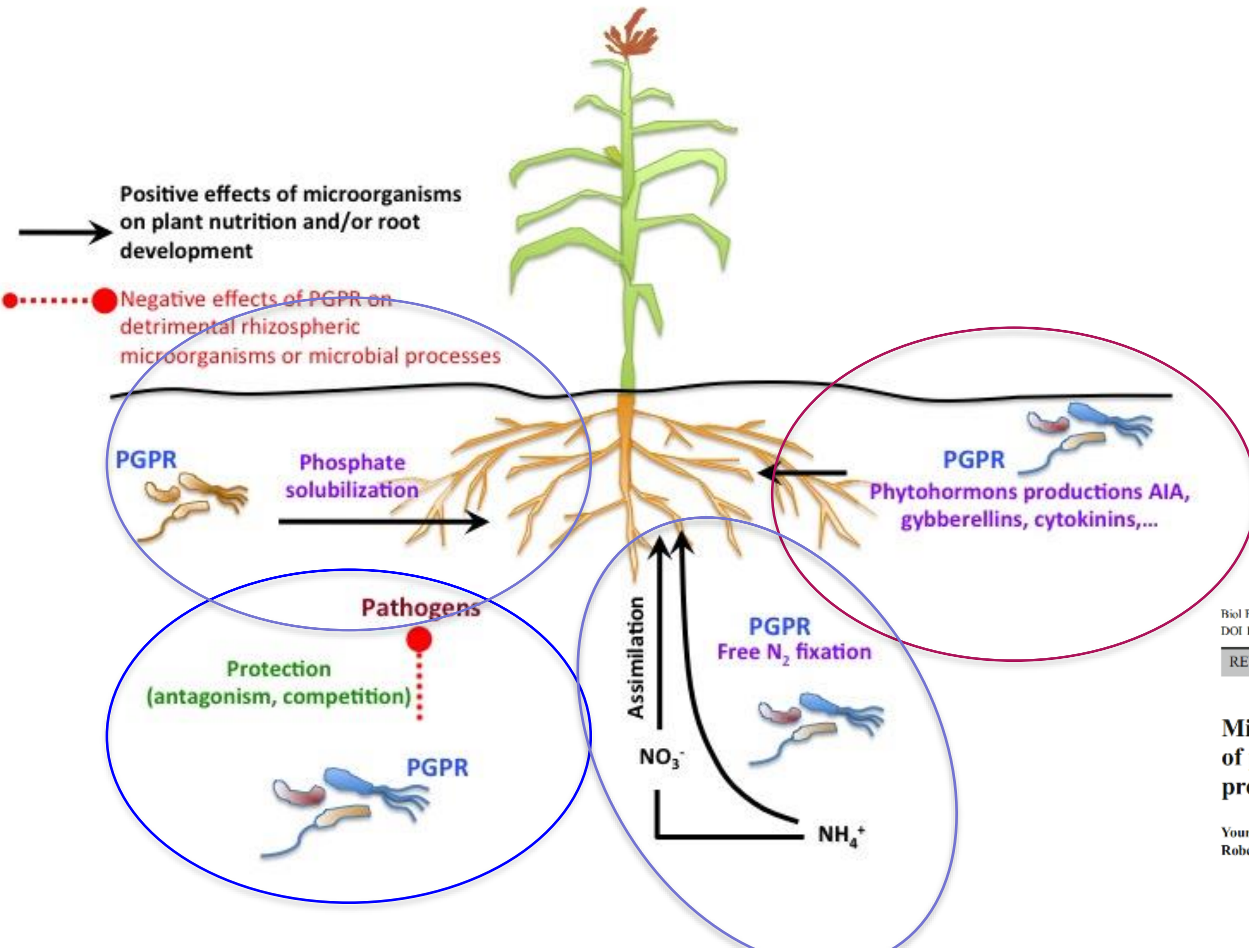
Microbiome research

Positive Interactions
→ Biocontrol
→ Root Growth Promotion
→ Biofertilization

Plant Growth-Promoting Rhizobacteria (**PGPR**)



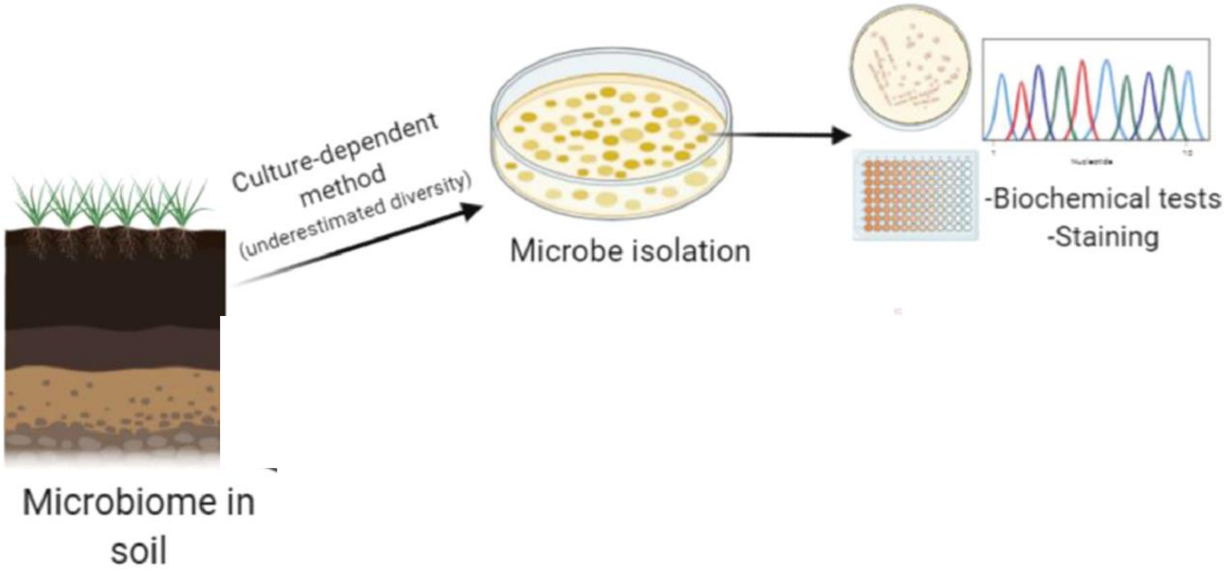
Biol Fertil Soils (2015) 51:403–415
DOI 10.1007/s00374-015-0996-1

REVIEW

Microbial interactions in the rhizosphere: beneficial influences of plant growth-promoting rhizobacteria on nutrient acquisition process. A review

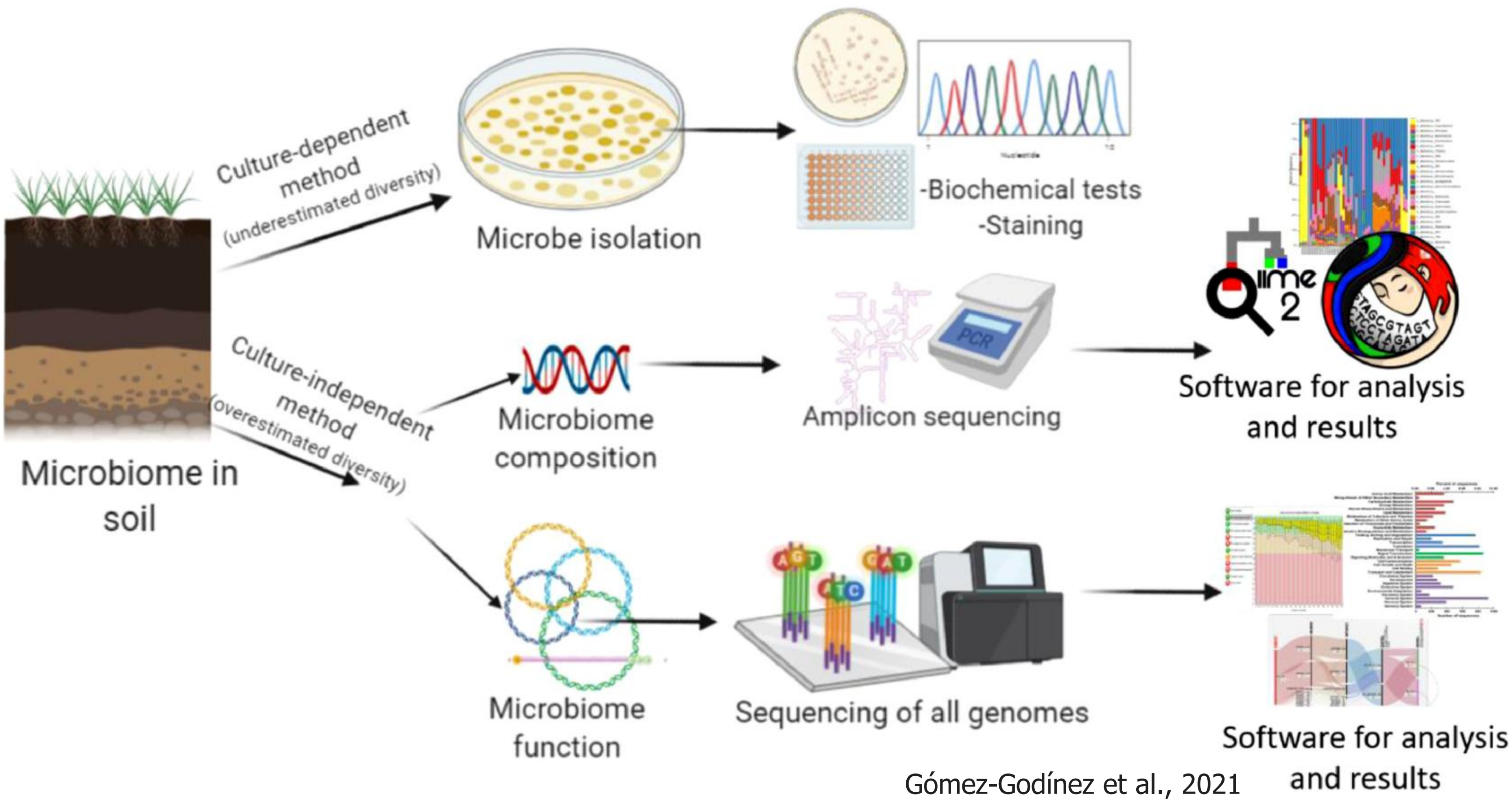
Youry Pii · Tanja Mimmo · Nicola Tomasi · Roberto Terzano · Stefano Cesco · Carmine Crecchio

Microbiome research



Gómez-Godínez et al., 2021

Microbiome research



Gómez-Godínez et al., 2021

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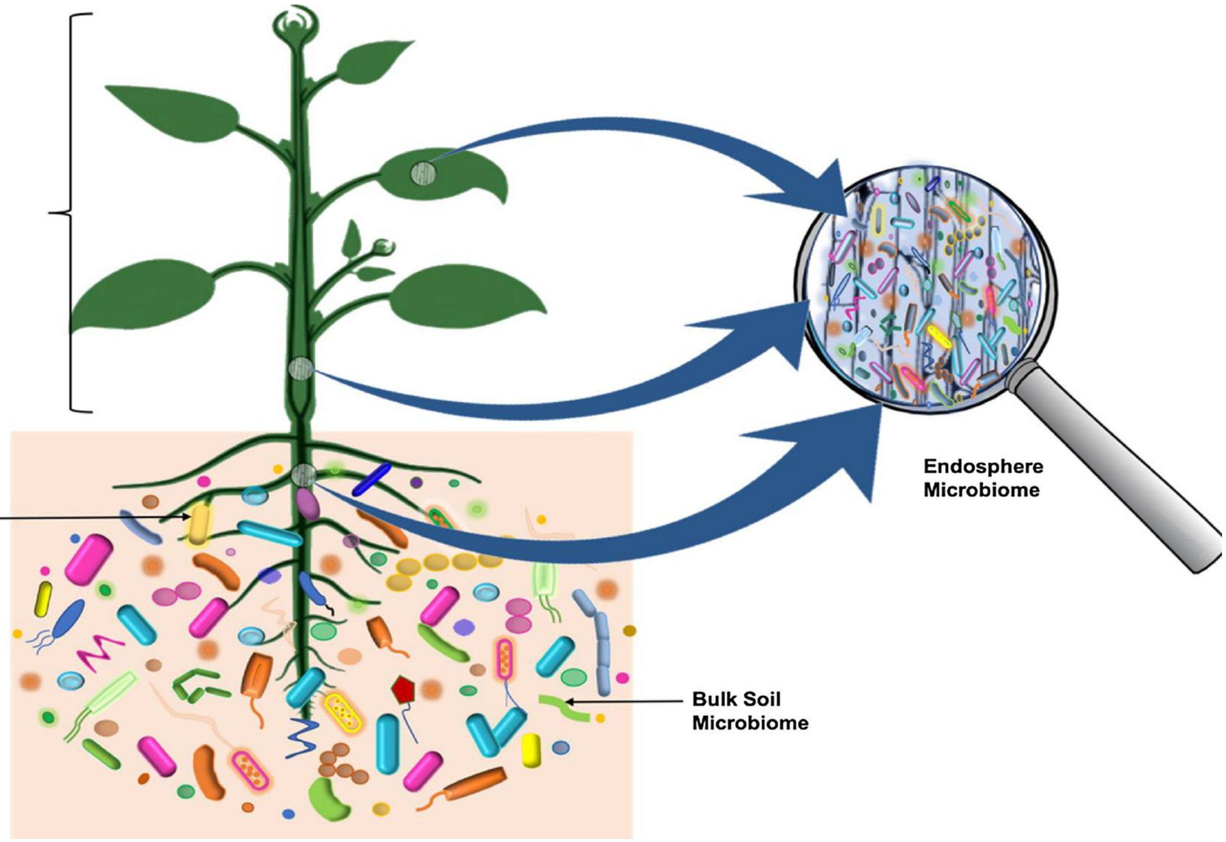
Different Microbiomes



Dastogeer et al., 2020

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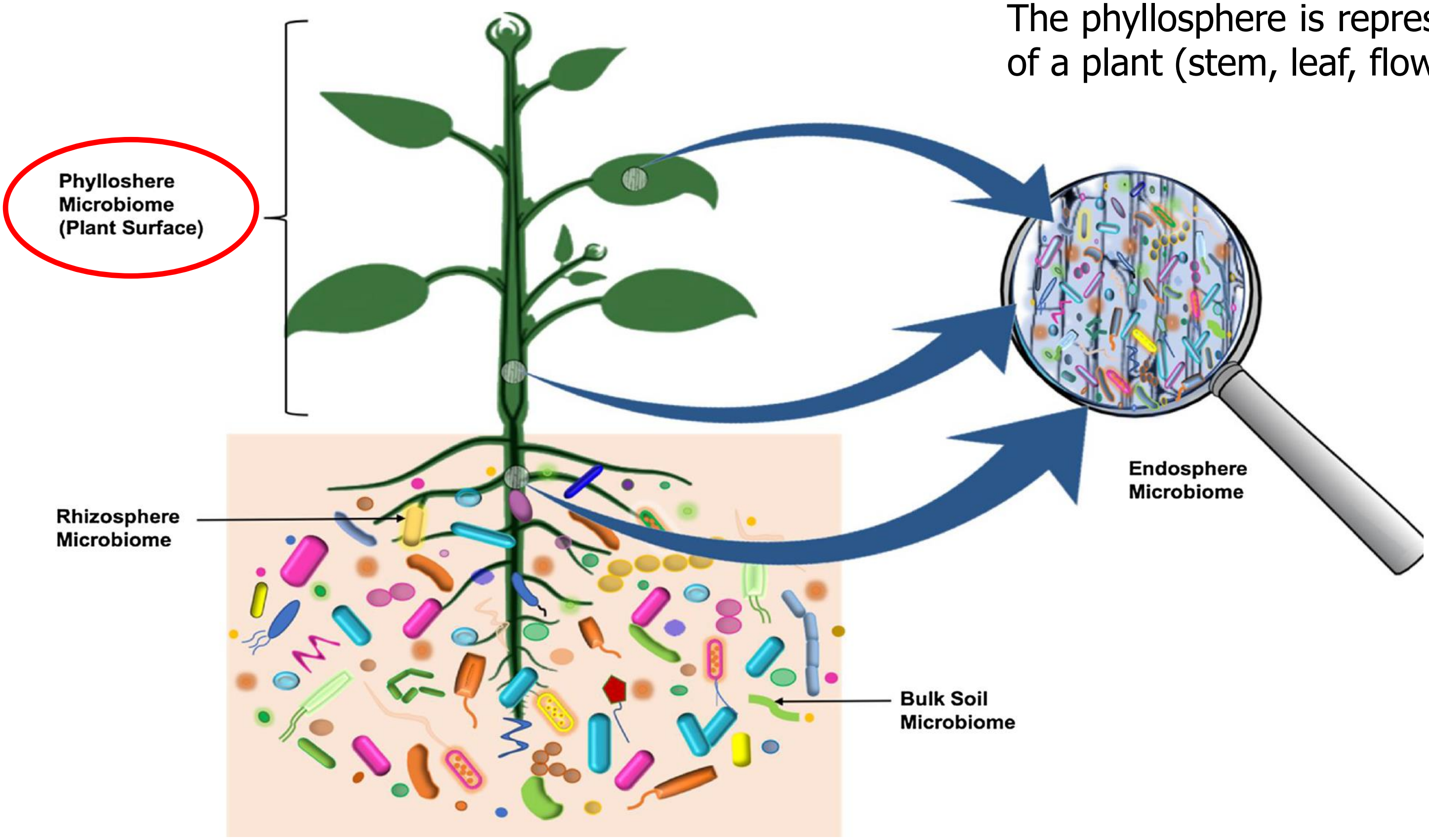
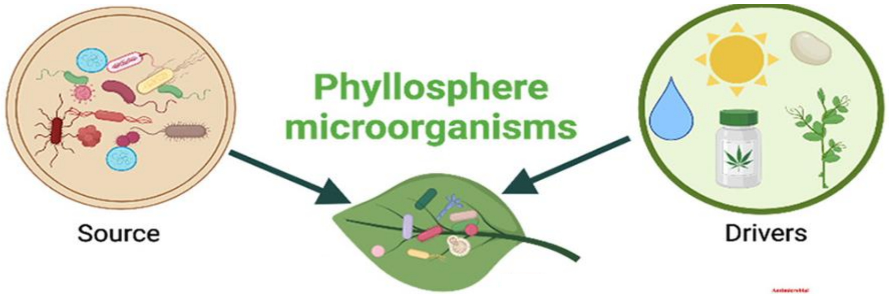
Different Microbiomes: Phyllosphere



The phyllosphere is represented by the aerial surface of a plant (stem, leaf, flower, fruit).

Dastogeer et al., 2020

Different Microbiomes: Phyllosphere



Compared to other compartments, phyllosphere is considered nutrient poor.

Phyllosphere is very dynamic → Microbes are subjected to diurnal and seasonal fluctuations of heat, moisture, and radiation.

Environmental elements affect plant physiology (such as photosynthesis, respiration, water uptake etc.) and indirectly influence microbiome composition.

Dastogeer et al., 2020

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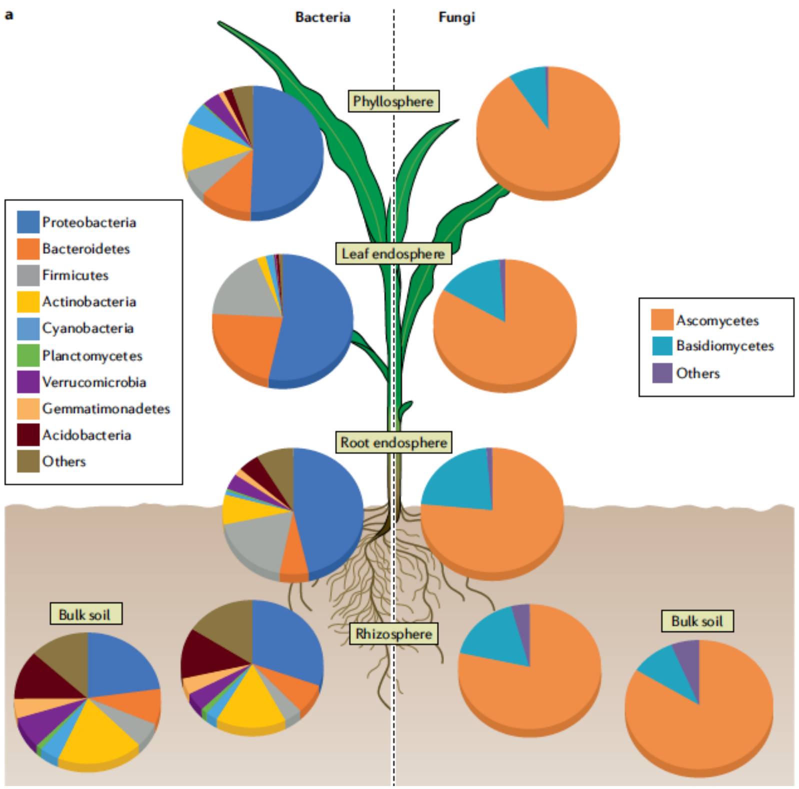
Different Microbiomes: Phyllosphere

Phyllosphere microbes from different plants appear to be somewhat similar at high levels of taxa, but at the lower levels taxa there remain significant differences.

Phylum>Class>Order>Family>Genus>Species

Microorganisms may need finely tuned metabolic adjustment to survive in phyllosphere environment??



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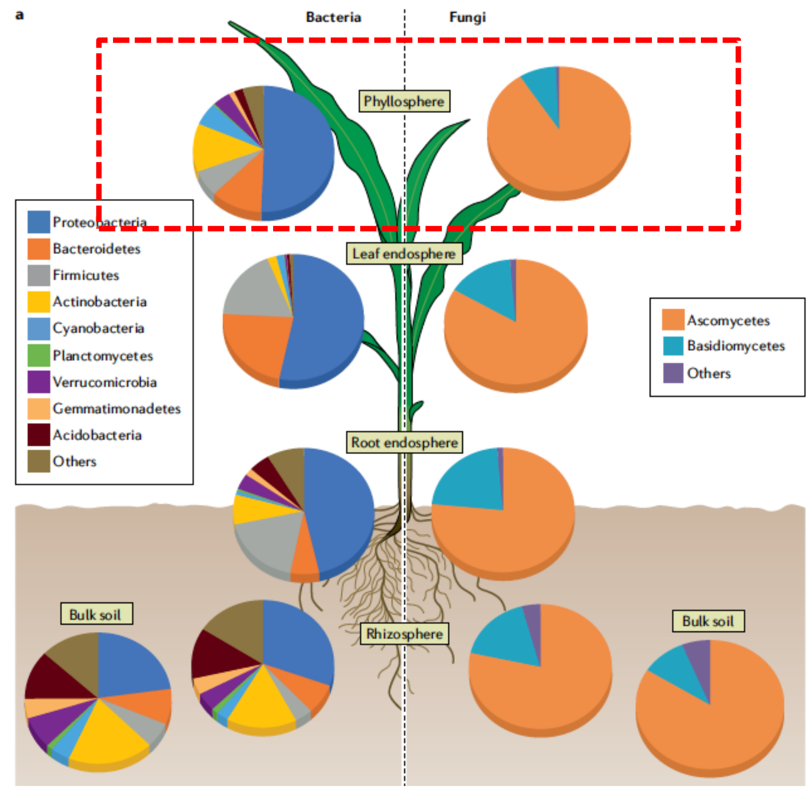

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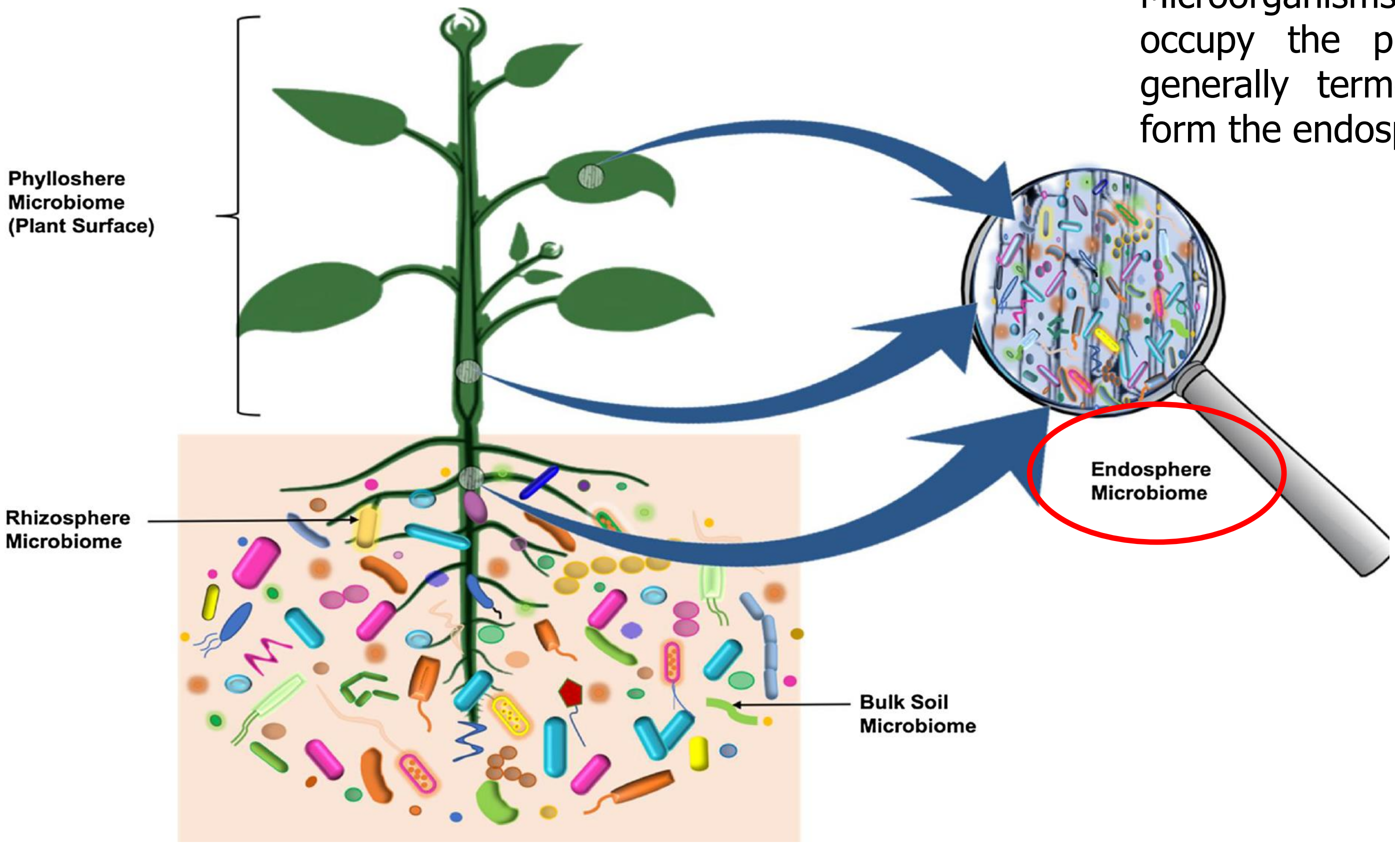
Different Microbiomes: Endosphere



Microorganisms that penetrate and occupy the plant internal tissues are generally termed endophytes and they form the endospheric microbiome

Dastogeer et al., 2020

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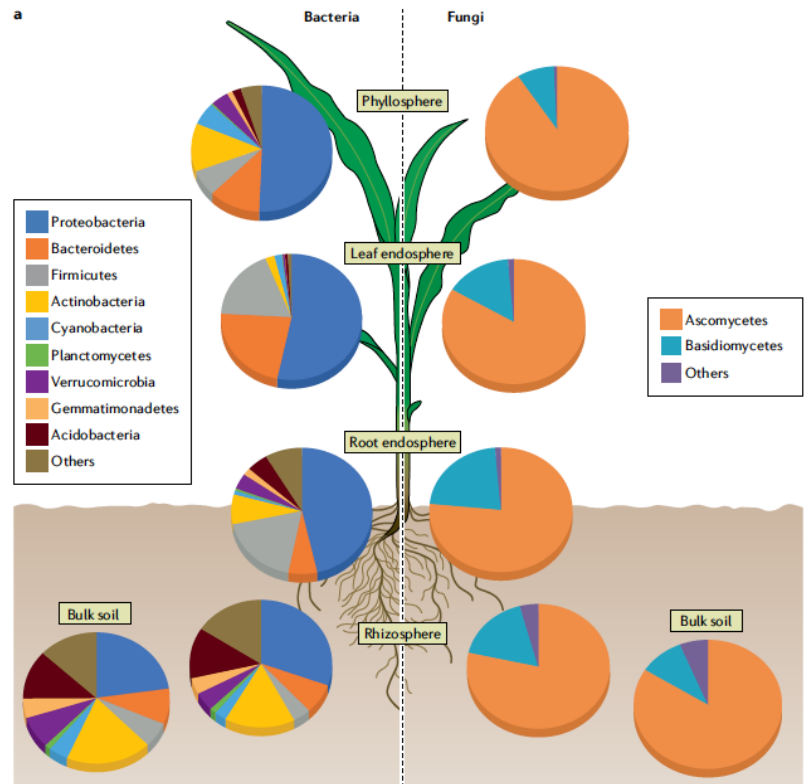
Different Microbiomes: Endosphere

Endophytic microbes interact with their host and provide obvious benefits to plants

The endospheres harbor highly specific microbial communities. The root endophytic community can be very distinct from that of the adjacent soil community.

The identity and diversity of the endophytic microbiome of above-and below-ground tissues may also differ within the plant.



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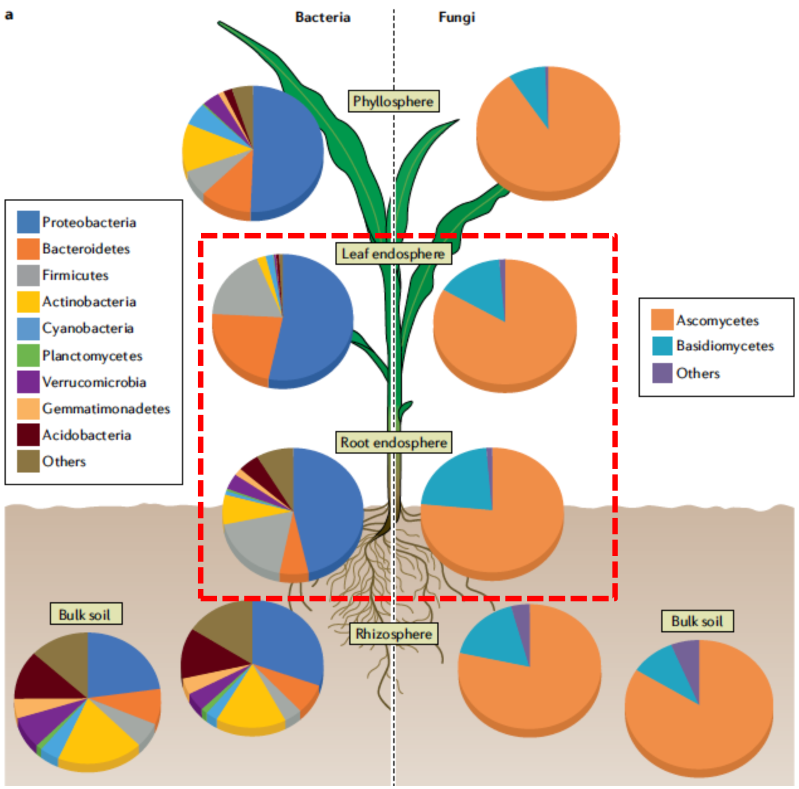

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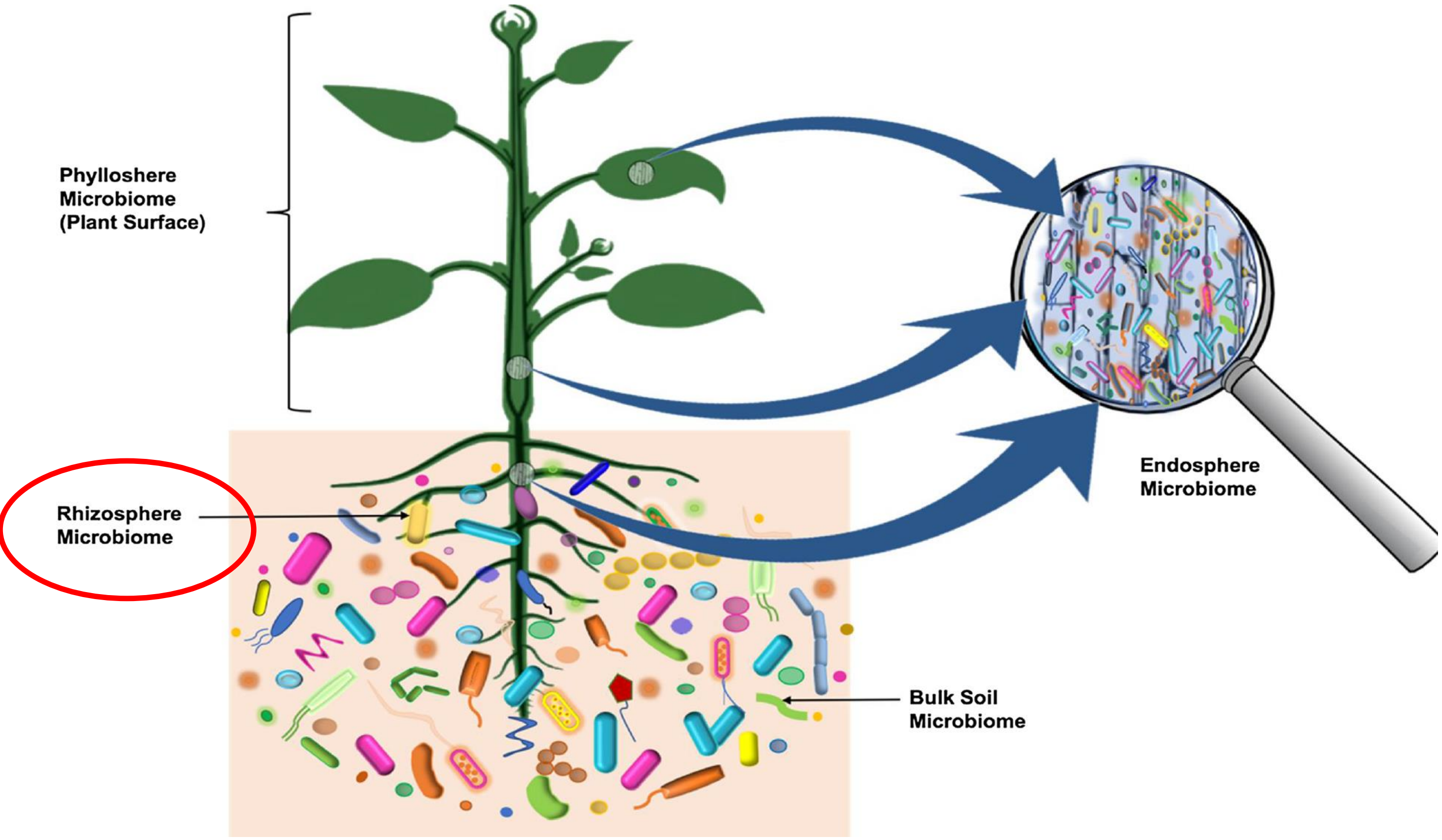
Different Microbiomes: Rhizosphere



Dastogeer et al., 2020

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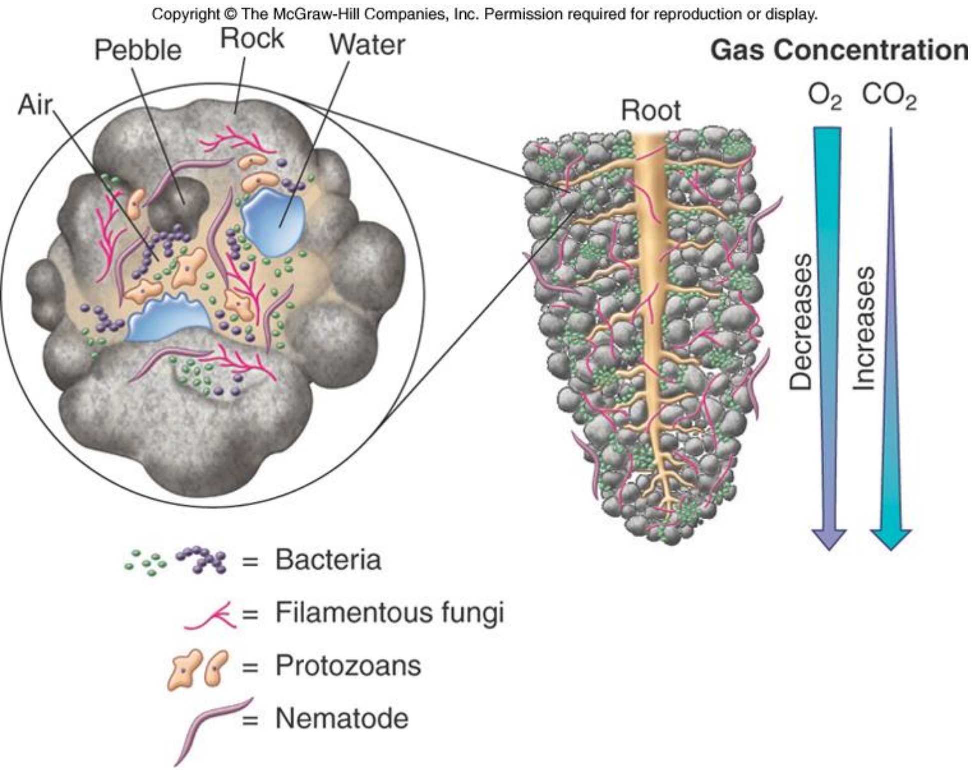
Different Microbiomes: Rhizosphere



Rhizosphere: soil surrounding the root where highly complex relationships are established between soil, plants and soil biota (Hiltner, 1904).

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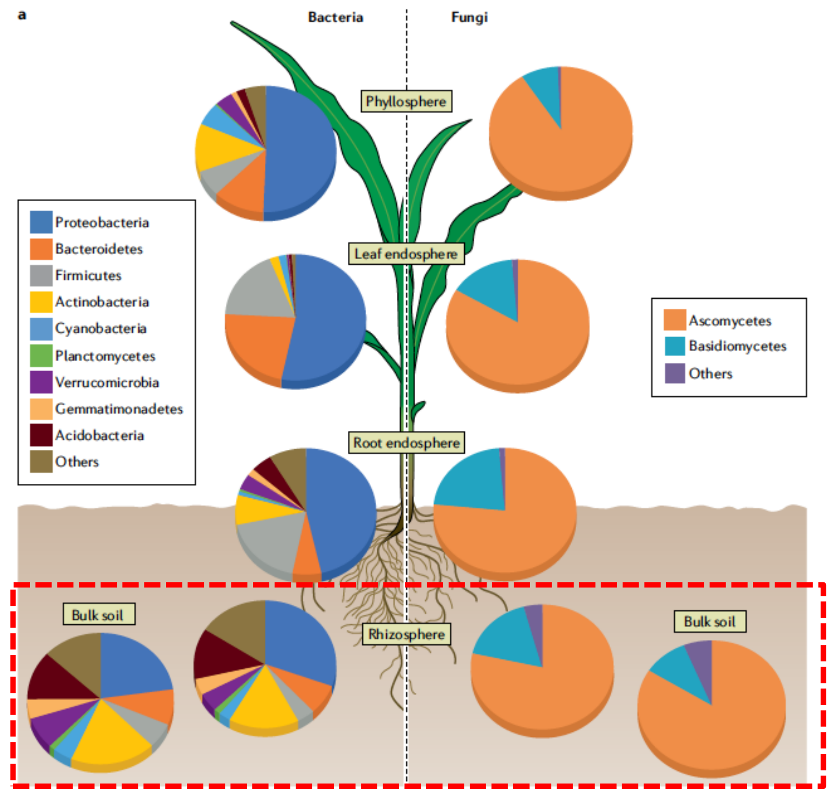
Different Microbiomes: Rhizosphere

A diverse array of organisms specialize in living in the rhizosphere, including bacteria, fungi, oomycetes, nematodes, algae, protozoa, viruses, and archaea.

The most frequently studied beneficial rhizosphere organisms are mycorrhizae, rhizobium bacteria, plant growth promoting rhizobacteria (PGPR), and biocontrol microbes.



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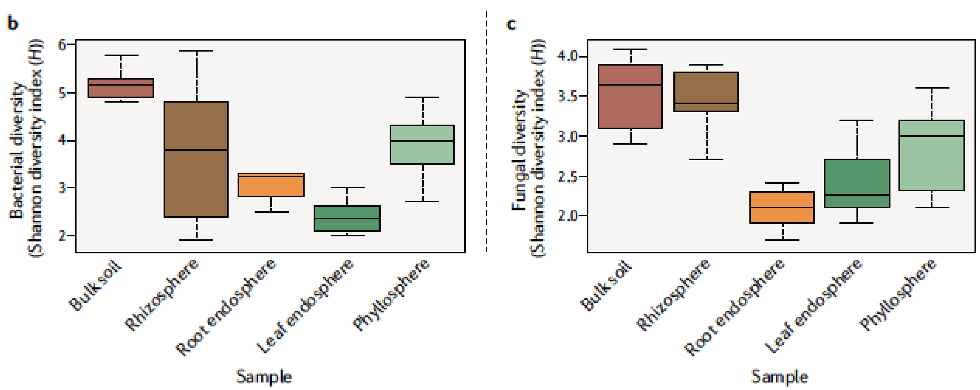

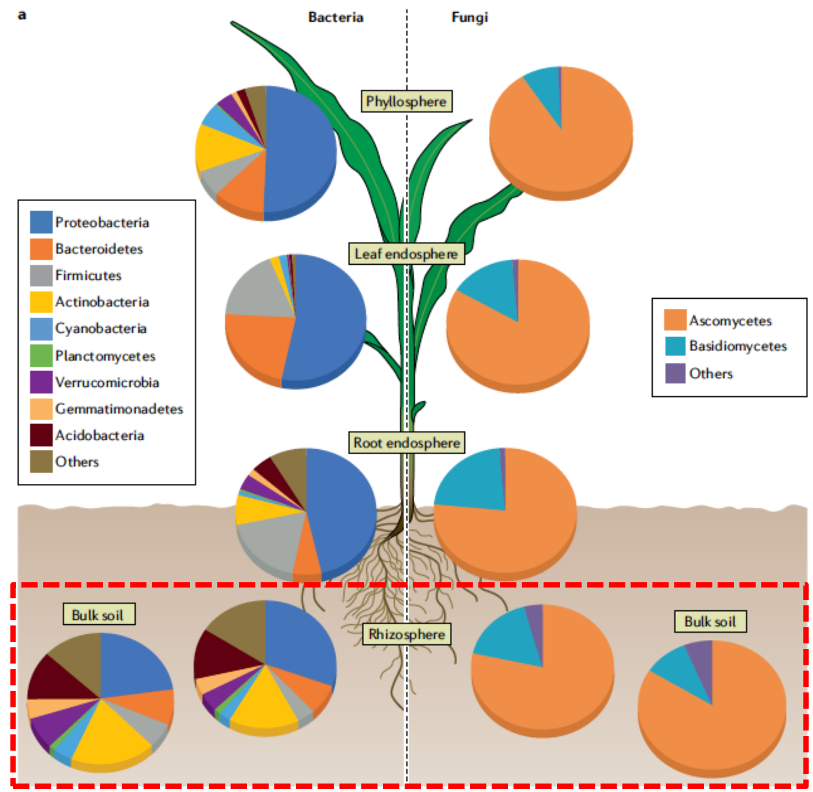

Dastogeer et al., 2020

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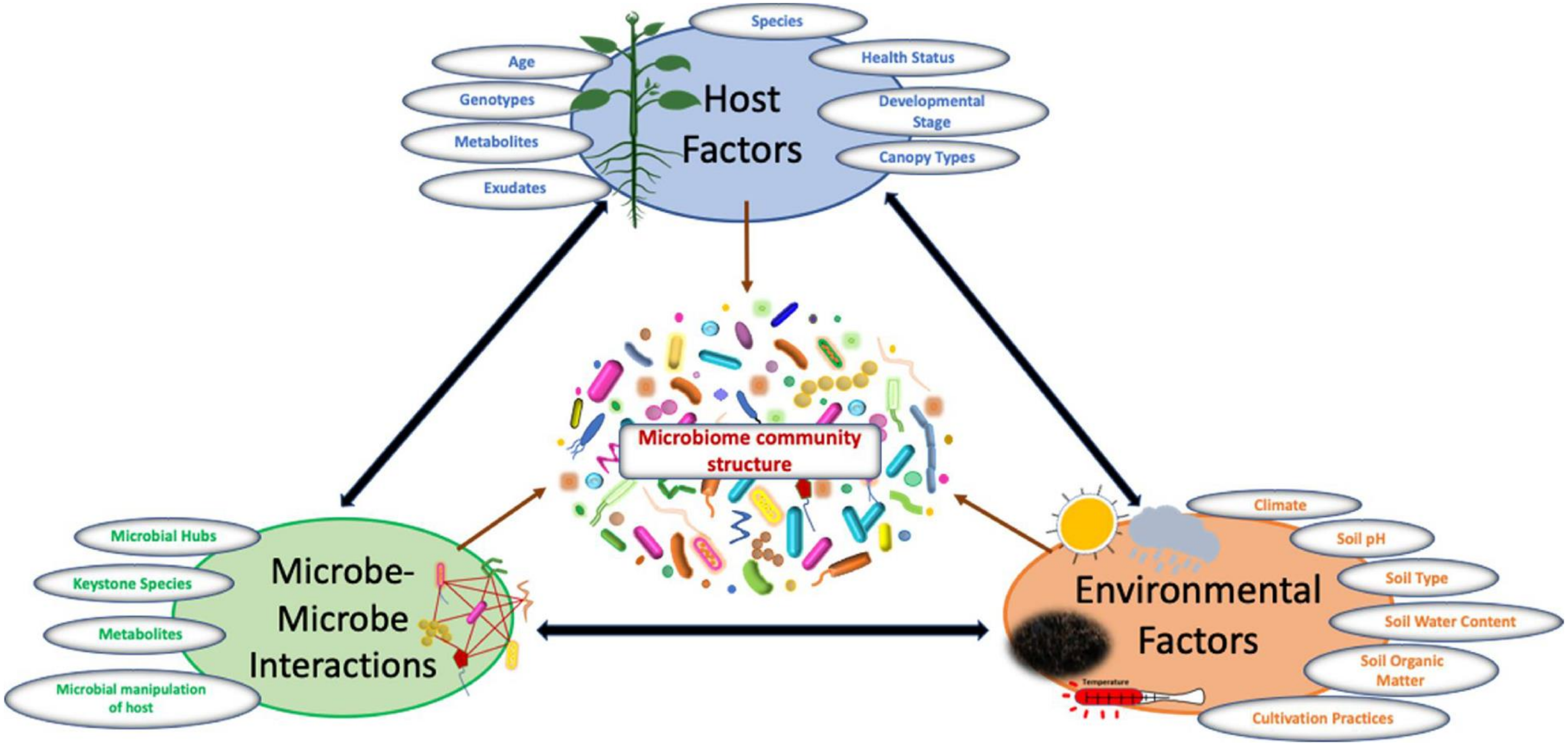
Rhizosphere microbiome: recruitment and selection



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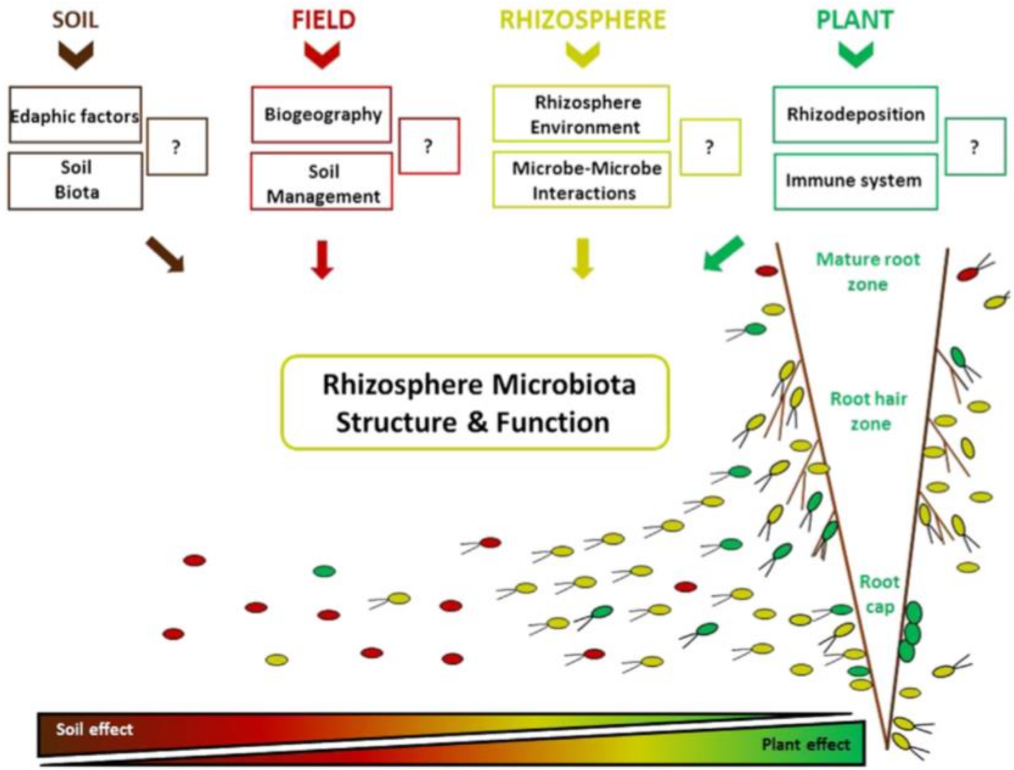

Alegria-Terrazzas et al., 2016

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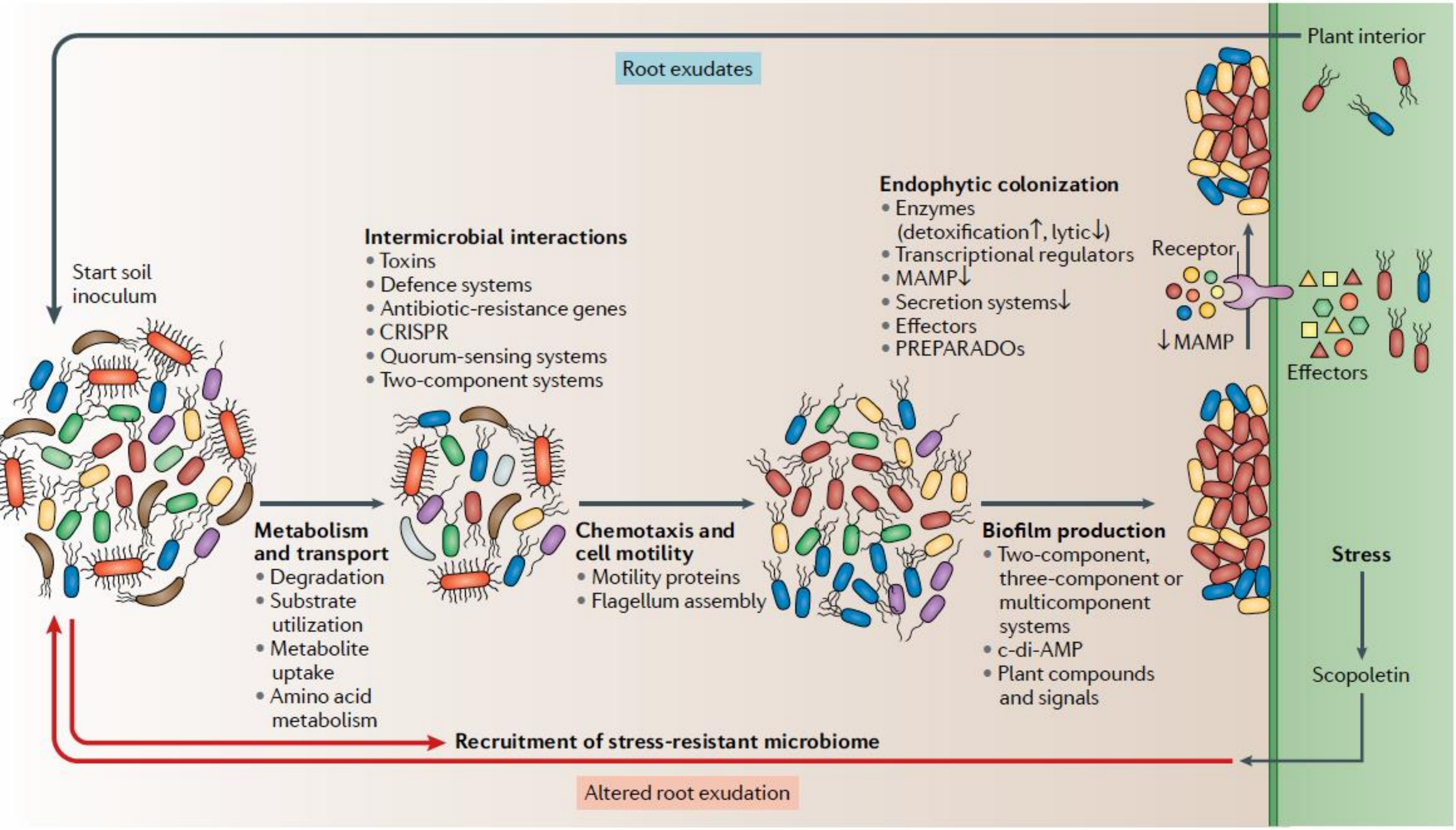
Rhizosphere microbiome: recruitment and selection



Trivedi et al., 2020

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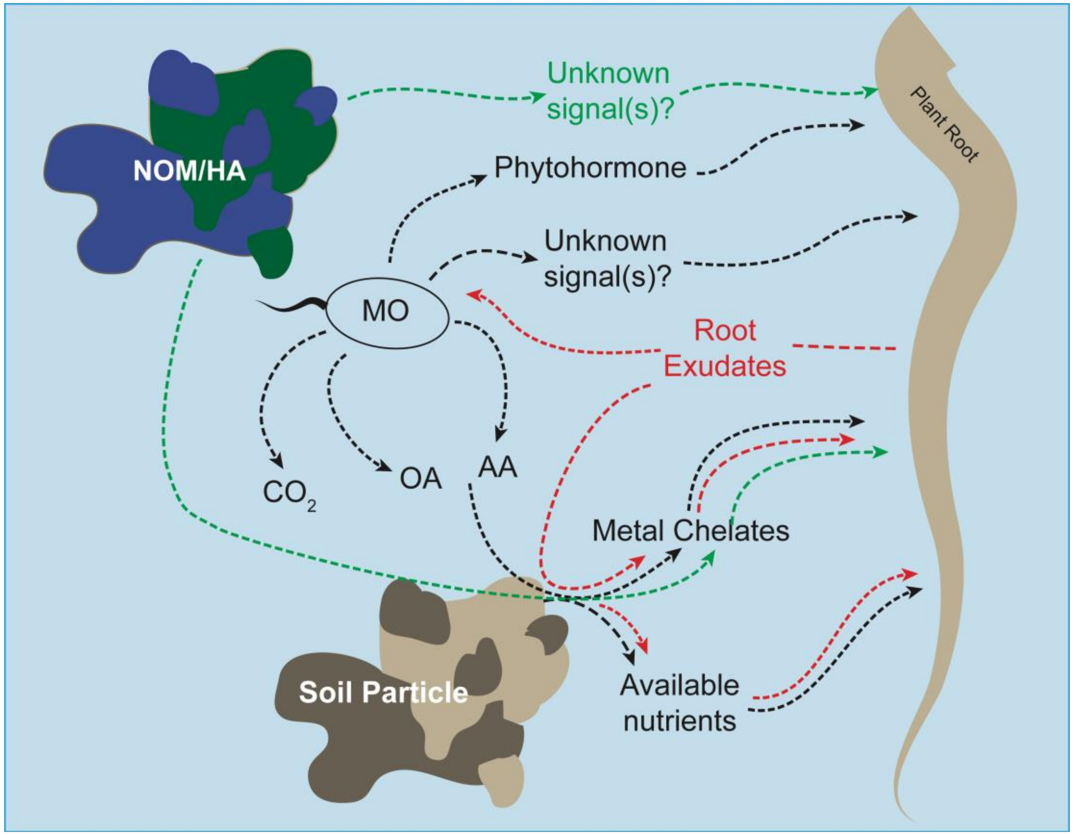

Mimmo et al., 2018

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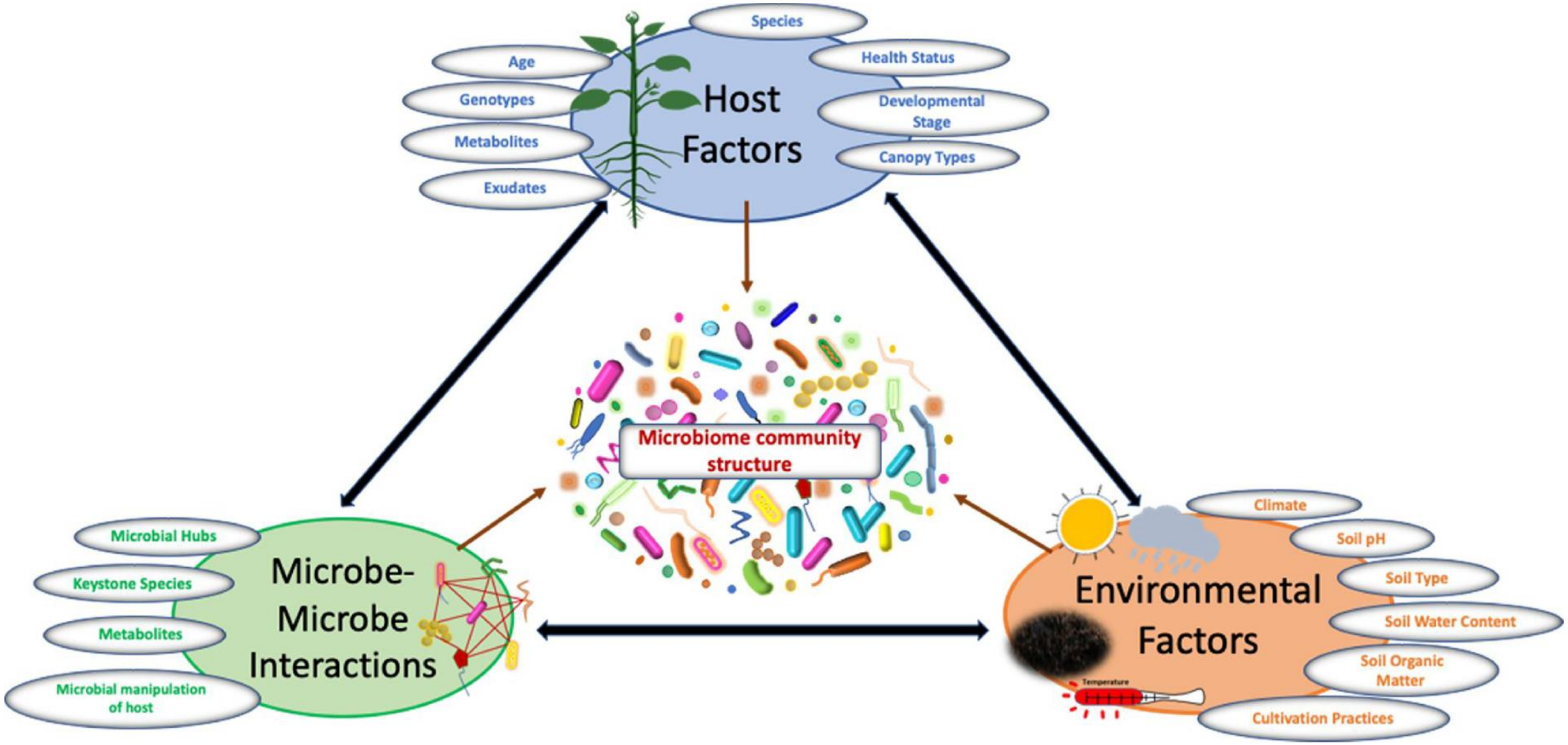

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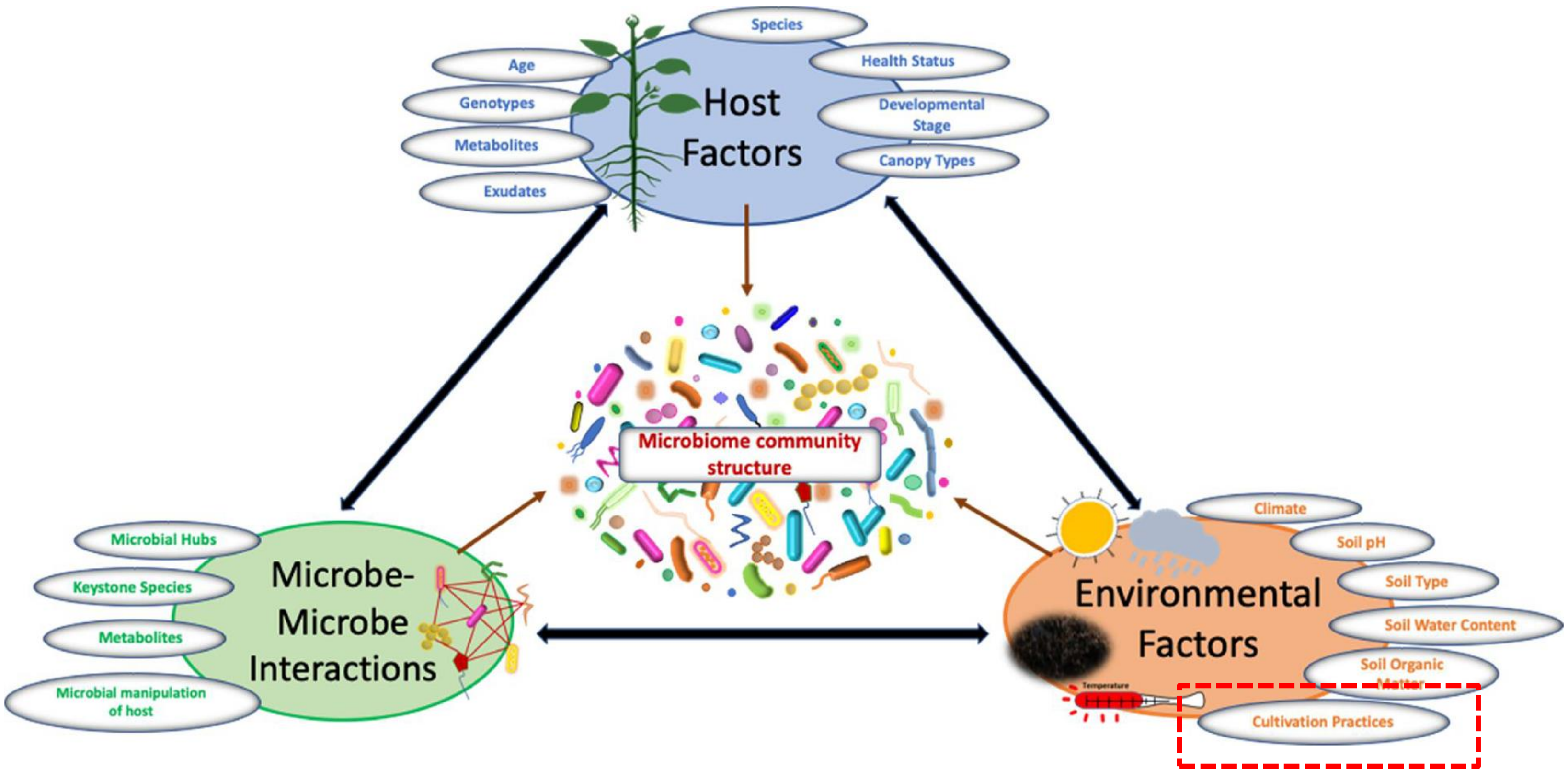

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Rhizosphere microbiome & Agricultural practice (1)

Applied Soil Ecology 166 (2021) 104088

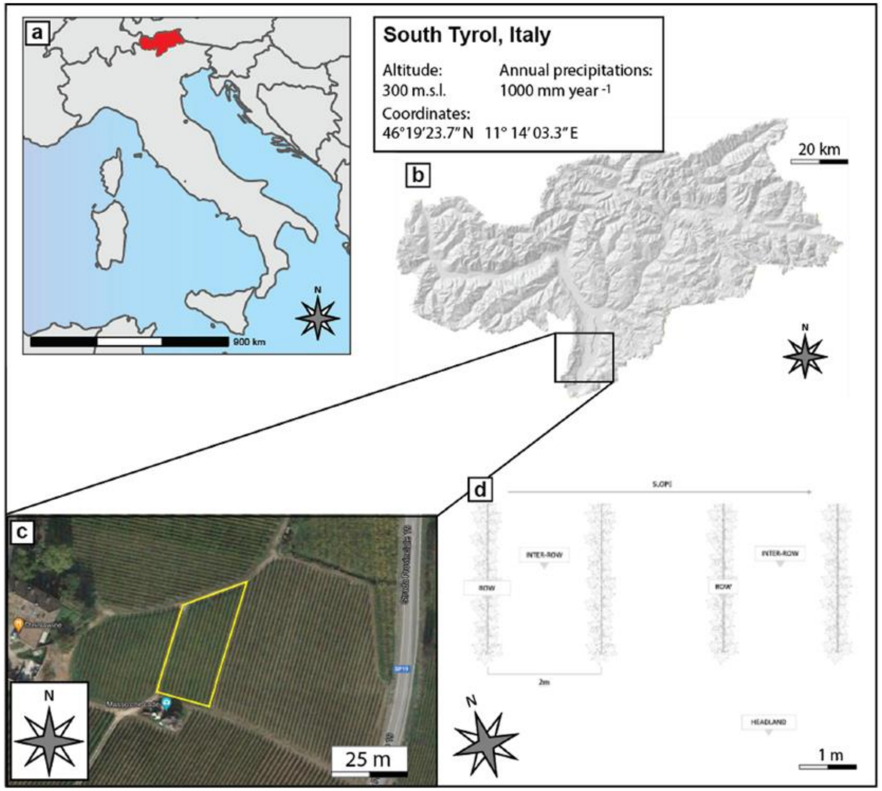
Contents lists available at ScienceDirect

Applied Soil Ecology

journal homepage: www.elsevier.com/locate/apsoil

Soil heterogeneity within a vineyard impacts the beta but not the alpha microbial agro-diversity

Marco Signorini[a,*], L. Borruso[a], K.C. Randall[b], A.J. Dumbrell[b], Y. Pii[a], T. Mimmo[a,c], Stefano Cesco[a]



Rhizosphere microbiome & Agricultural practice (1)

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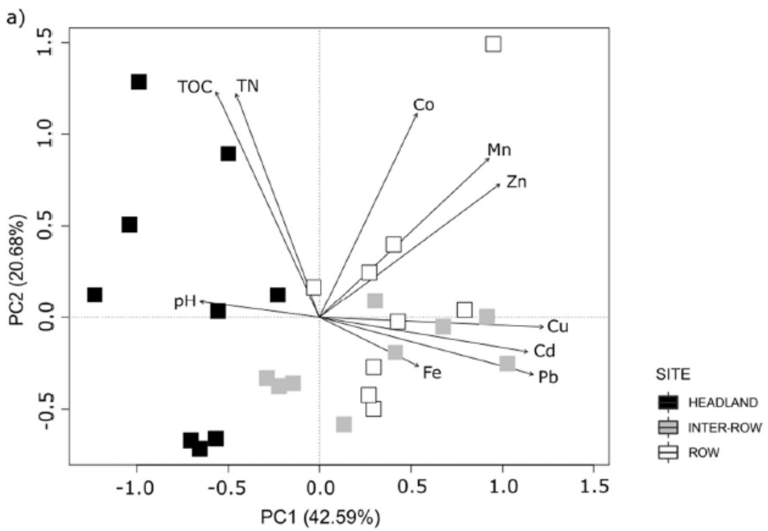

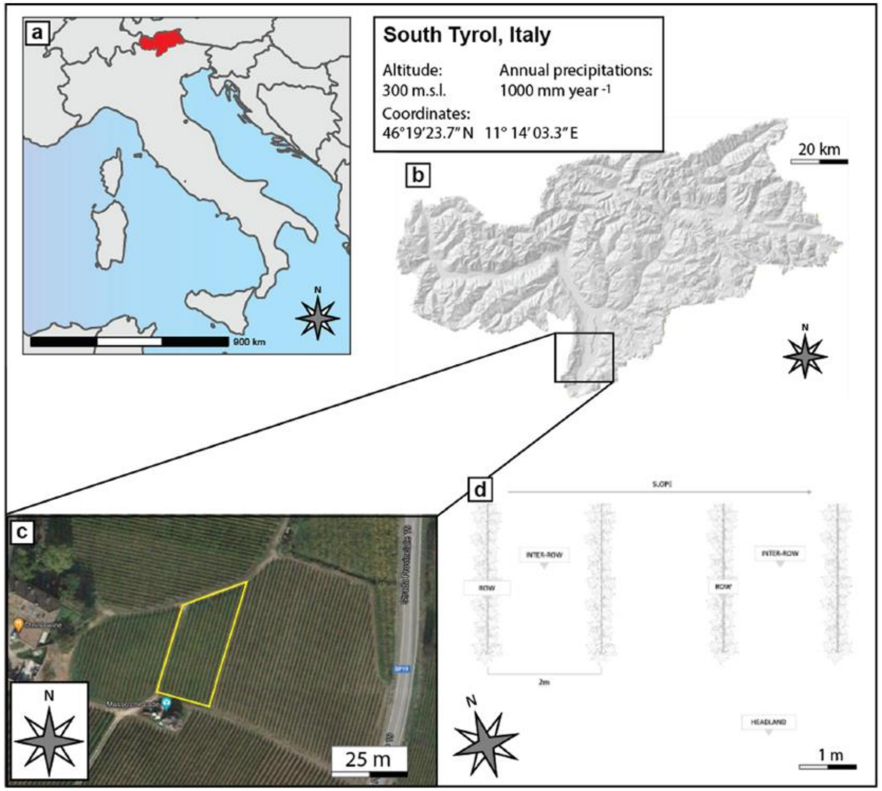

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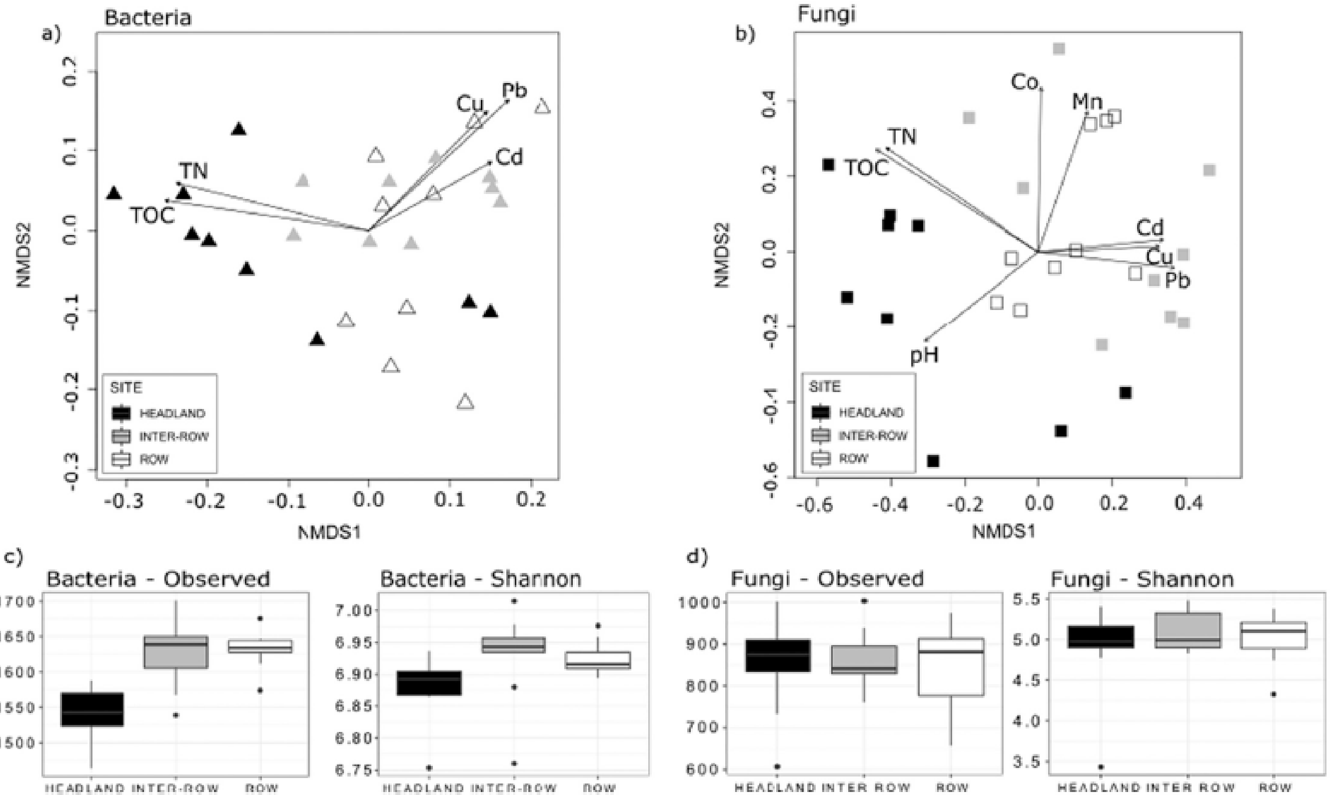
Rhizosphere microbiome & Agricultural practice (1)



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Rhizosphere microbiome & Agricultural practice (1)

Conclusions

The soil chemical composition and microbial beta-diversity within a vineyard can reflect the soil heterogeneity due to the site-specific agronomic management practice.

Small changes in soil heavy metal availability among different microsites have significantly contributed to the **soil microbial community beta-diversity**. Increased levels of bioavailable HMs (i.e. Cu, Cd, Pb, Mn, Zn) in the row and inter-row soils samples due to the application of HMs-containing agrochemicals resulted in driving the bacterial and fungal beta-diversity but not the alpha-diversity.

The discordancy between alpha- and beta-diversity results to a probable adaptation of soil microbes to **long-period agronomic management** (e.g. slow release of heavy metals into agroecosystem).

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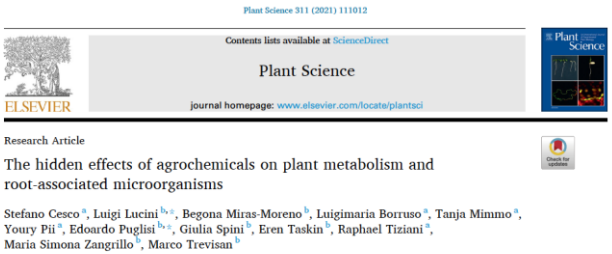
Rhizosphere microbiome & Agricultural practice (2)


Plant Science 311 (2021) 111012

Contents lists available at ScienceDirect

Plant Science

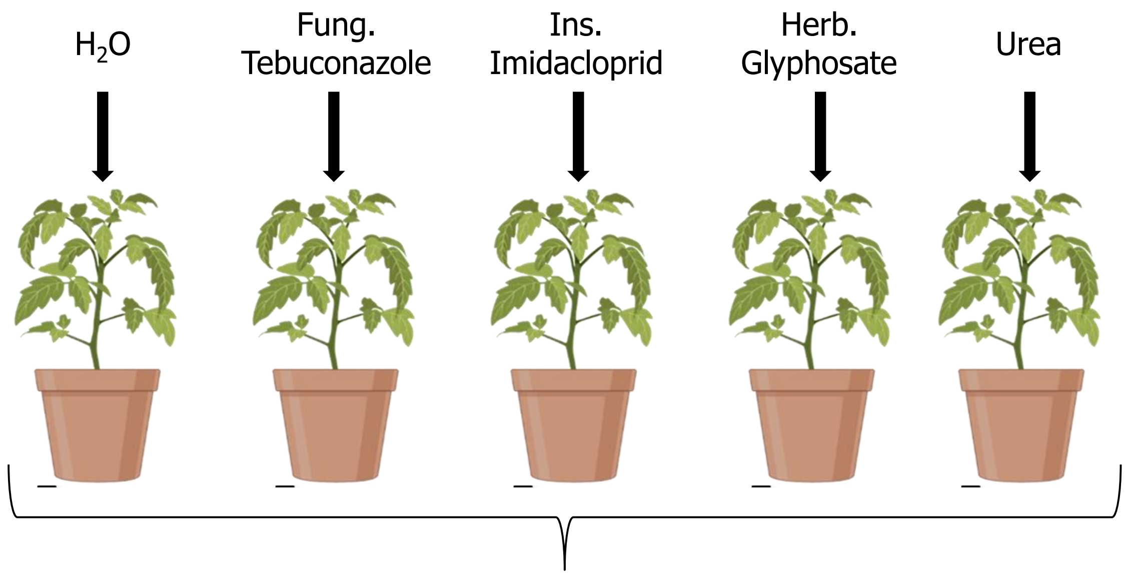
journal homepage: www.elsevier.com/locate/plantsci

Research Article

The hidden effects of agrochemicals on plant metabolism and root-associated microorganisms

Stefano Cesco[a], Luigi Lucini[b,*], Begona Miras-Moreno[b], Luigimaria Borruso[a], Tanja Mimmo[a], Youry Pii[a], Edoardo Puglisi[b,*], Giulia Spini[b], Eren Taskin[b], Raphael Tiziani[a], Maria Simona Zangrillo[b], Marco Trevisan[b]

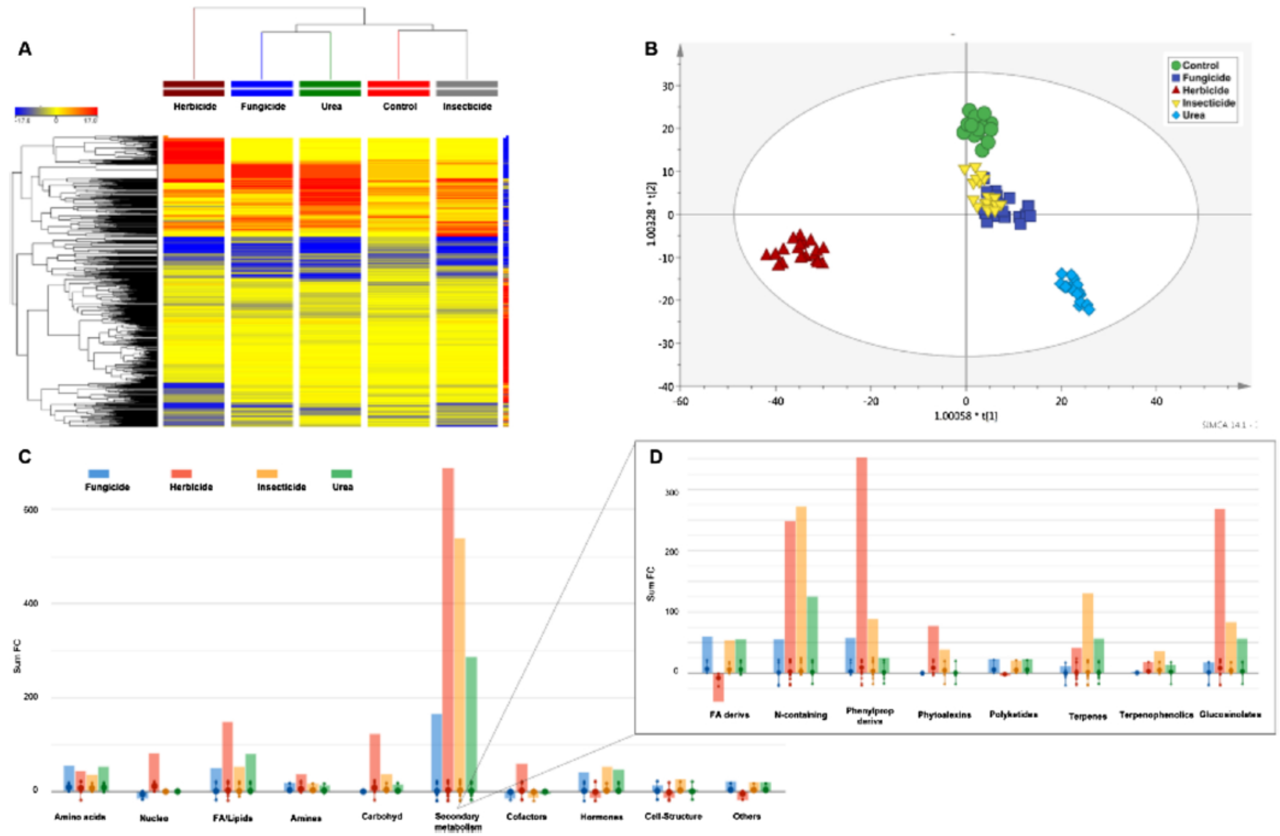
→ elucidating the plant biochemical perturbations underlying the use of pesticides, together with the resulting changes at the root microbiota level.



→ Metabolomic analyses of roots and shoots
→ Rhizosphere microbial community analysis

Rhizosphere microbiome & Agricultural practice (2)

Distinctive metabolomic responses following the application of the tested chemicals, suggesting that such a broad reprogramming might not be limited to the detoxification pathways already known for xenobiotics.



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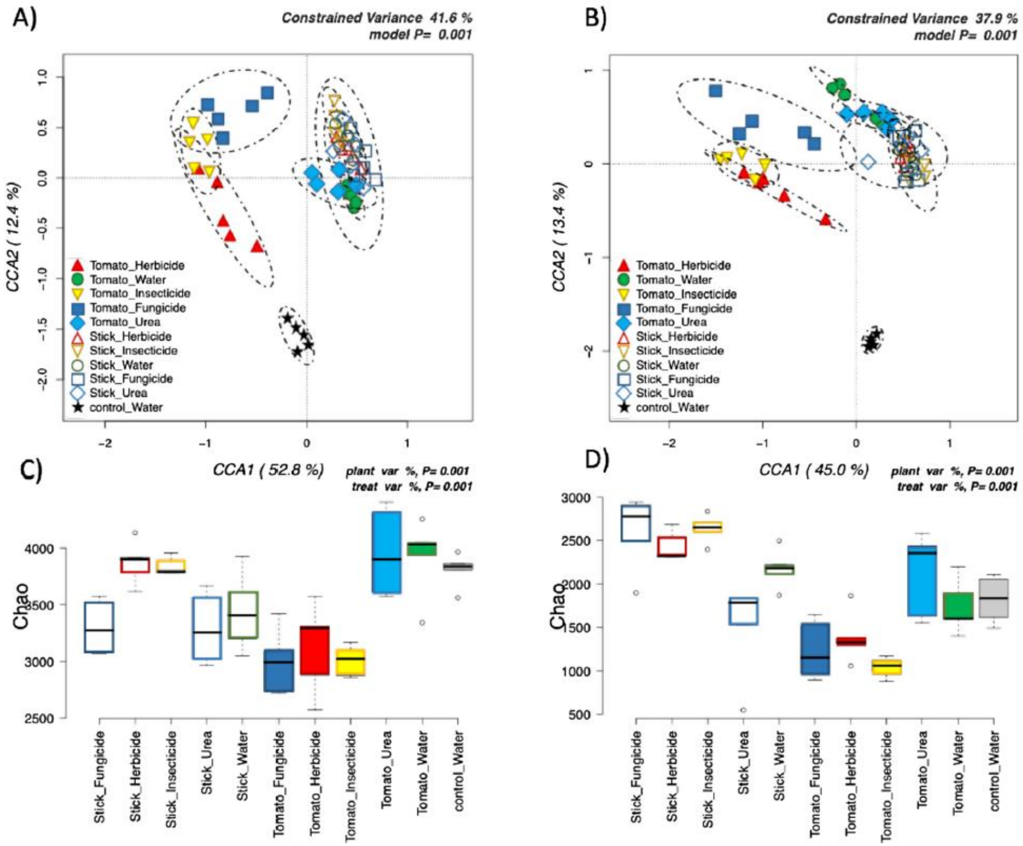
Rhizosphere microbiome & Agricultural practice (2)



Treatments with agrochemicals significantly impacted the biodiversity of rhizosphere.

Increase in the relative abindance of bacterial and fungal species with PGP traits and with the ability of degrading xenobiotics.

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Rhizosphere microbiome & Agricultural practice (2)

Conclusions
The results on microbial communities of the rhizosphere reveal **two complementary effects** as a consequence of the plant treatments considered.

In fact, while a **reduction in biodiversity** has been recorded, on the other hand there is a clear modulation of the **bacterial and fungal species featuring important functional roles**.

Indeed, these results highlight a remodulation of the rhizosphere microbial diversity where microbial groups that can help the plant under chemical stress (**PGPR, xenobiotic degraders**), are enriched through **exudates-mediated communication systems.**

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Rhizosphere microbiome & Agricultural practice (3)

frontiers | Frontiers in Plant Science

TYPE Original Research
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†These authors have contributed equally to this work and share first authorship

Compost application boosts soil restoration in highly disturbed hillslope vineyard

Marco Lucchetta[1,2*†], Alessandro Romano[1†], Monica Yorlady Alzate Zuluaga[2], Flavio Fornasier[3], Sonia Monterisi[2], Youry Pii[2], Patrick Marcuzzo[1], Lorenzo Lovat[1] and Federica Gaiotti[1]

[1]Council for Agricultural Research and Economics-Research Centre for Viticulture and Enology (CREA-VE), Conegliano, TV, Italy, [2]Faculty of Agricultural, Environmental and Food Sciences, Free University of Bozen/Bolzano, Bolzano, Italy, [3]Council for Agricultural Research and Economics-Research Centre for Viticulture and Enology (CREA-VE), Gorizia, Italy

Effects of compost produced from **manure, pruning residues and pomace** on a Cabernet sauvignon vineyard located in a hilly area in the North-East of Italy.

We addressed the specific goals of:

i) explore how the compost addition could shift soil bacterial and fungal structure and enzyme activity.

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Rhizosphere microbiome & Agricultural practice (3)

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†These authors have contributed equally to this work and share first authorship

Compost application boosts soil restoration in highly disturbed hillslope vineyard

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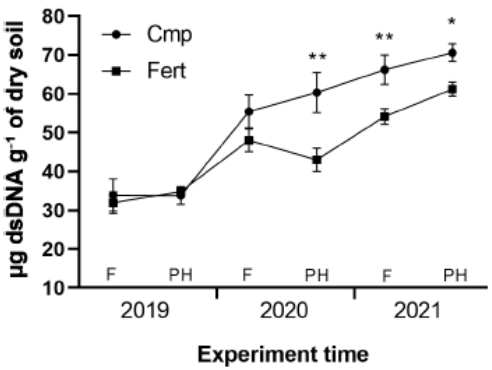

Effects of compost produced from **manure, pruning residues and pomace** on a Cabernet sauvignon vineyard located in a hilly area in the North-East of Italy.

We addressed the specific goals of:

i) explore how the compost addition could shift soil bacterial and fungal structure and enzyme activity.

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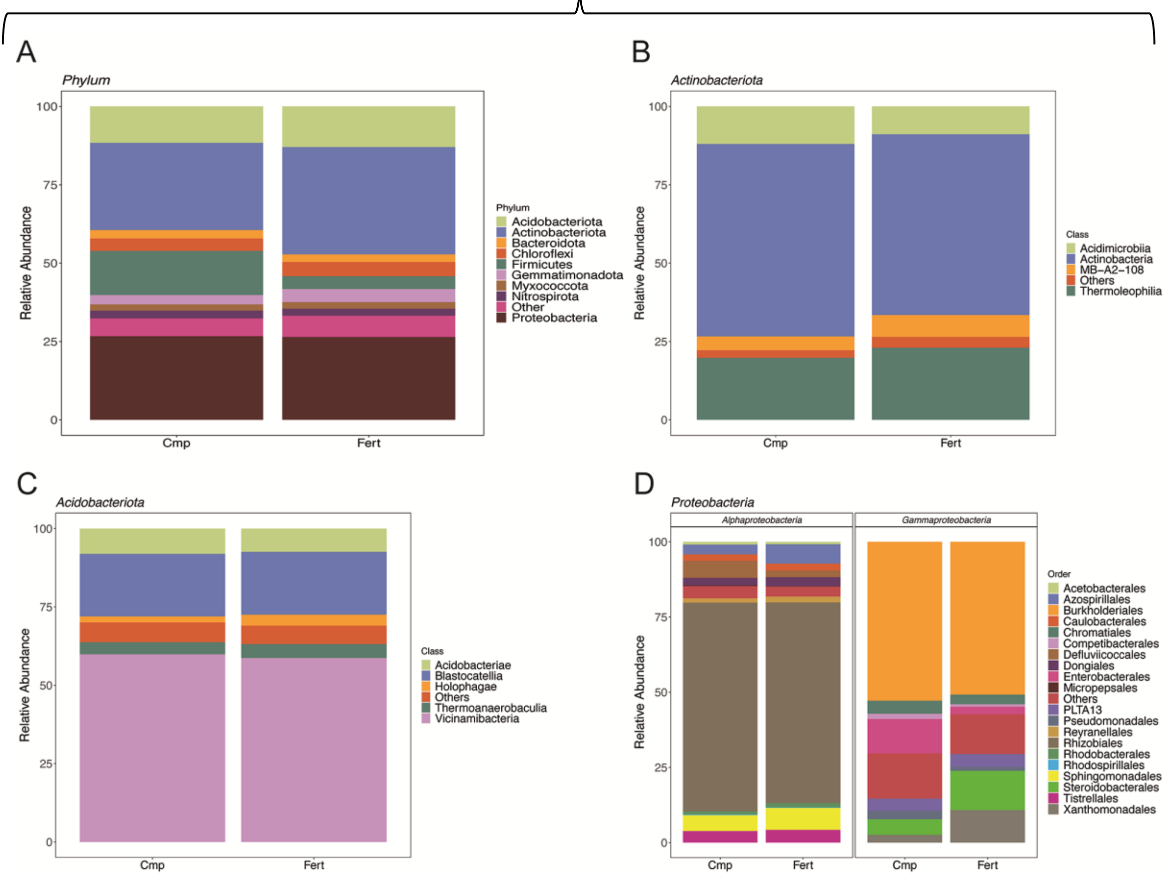
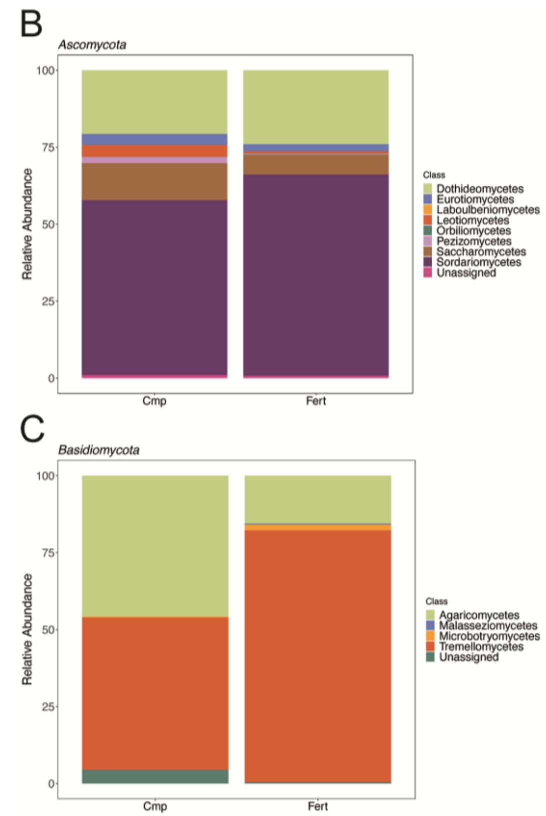
Rhizosphere microbiome & Agricultural practice (3)

Bacteria



Fungi



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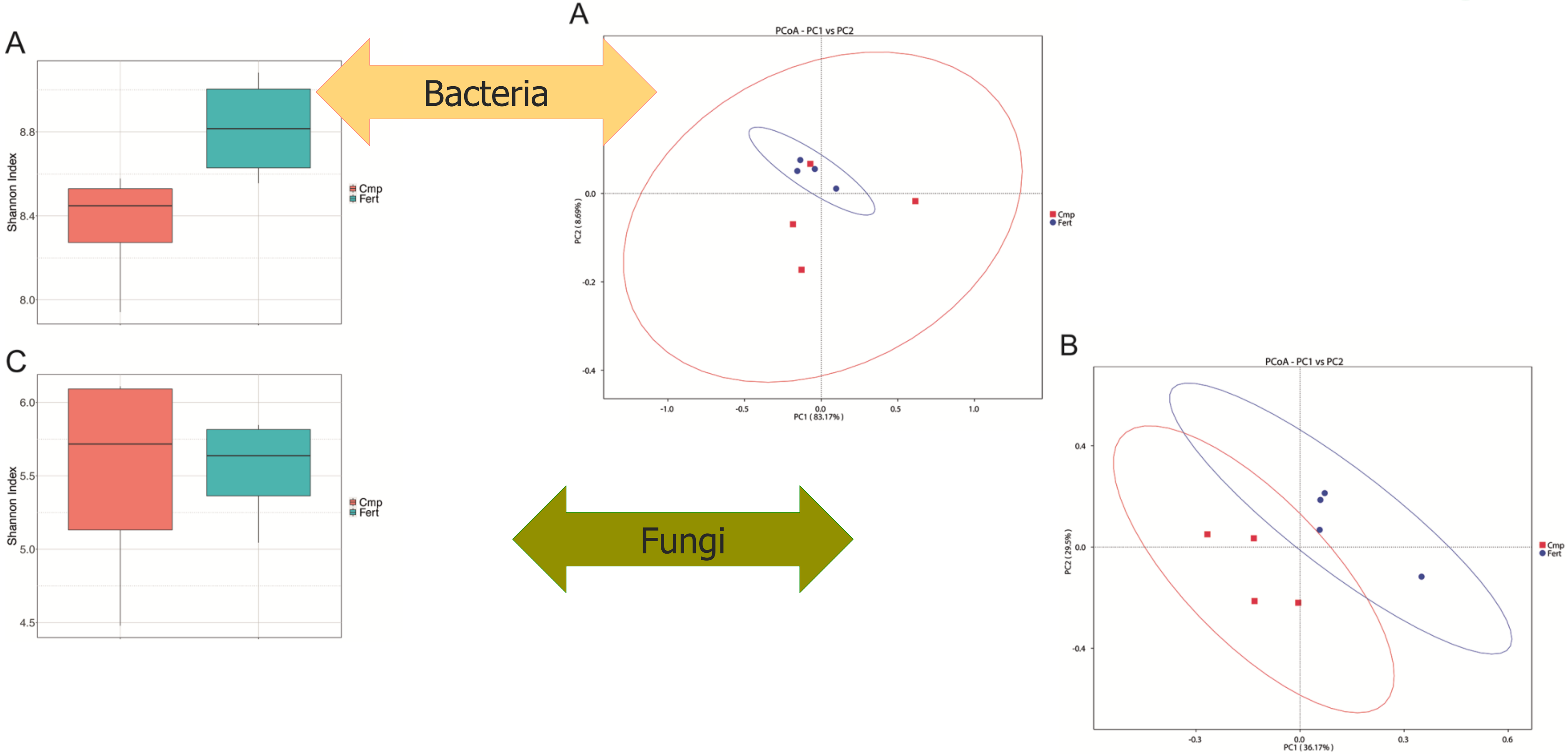

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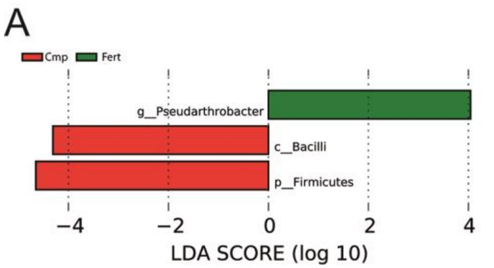

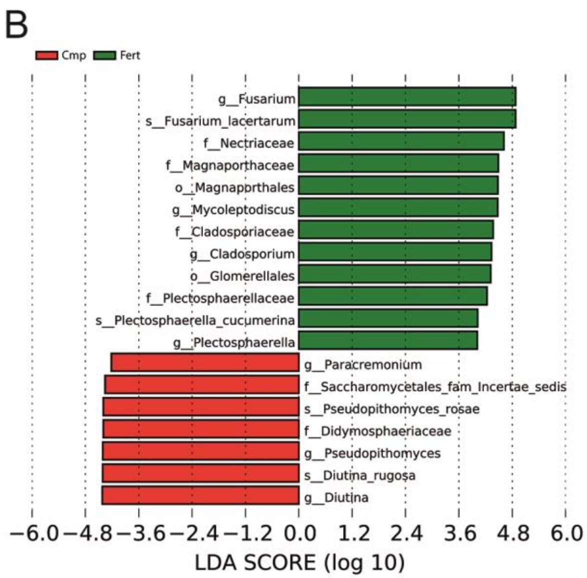

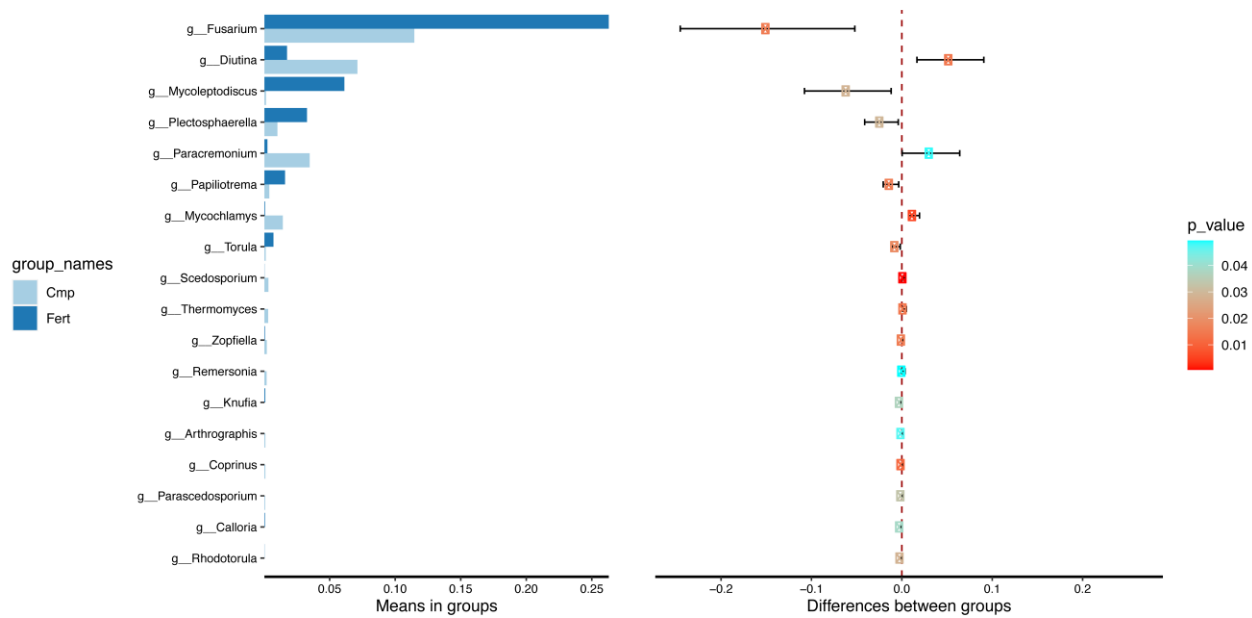

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Rhizosphere microbiome & Agricultural practice (3)

Conclusions

Organic fertilization induced **changes in the soil microbial community structure**, promoting the presence of **copiotrophic bacteria**, indicators of soil quality, and **P solubilizing bacteria**.

A **reduction of fungal pathogenic** strains was also observed, suggesting a positive effect of compost application on soil health.

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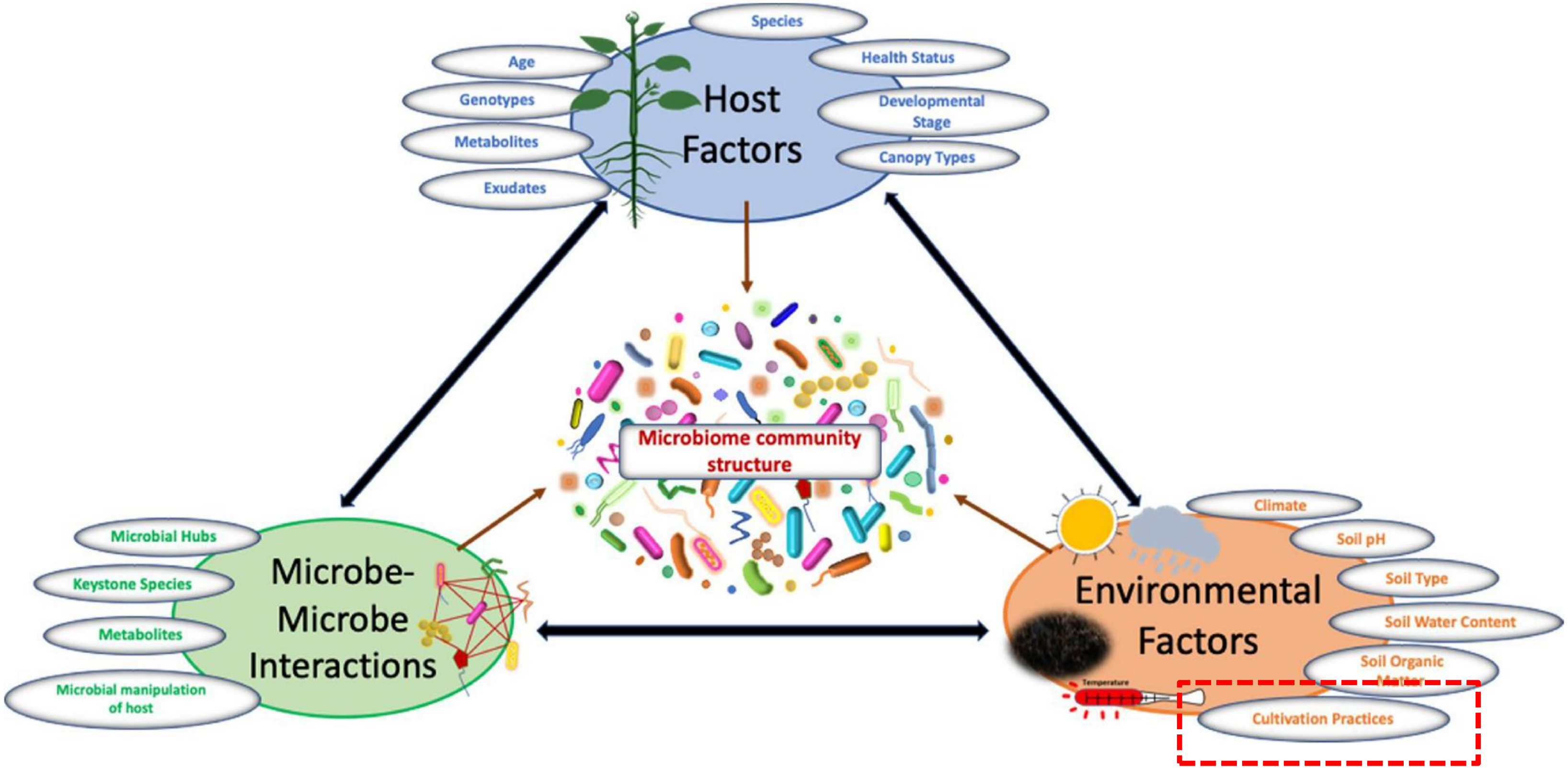
Rhizosphere microbiome: future perspectives



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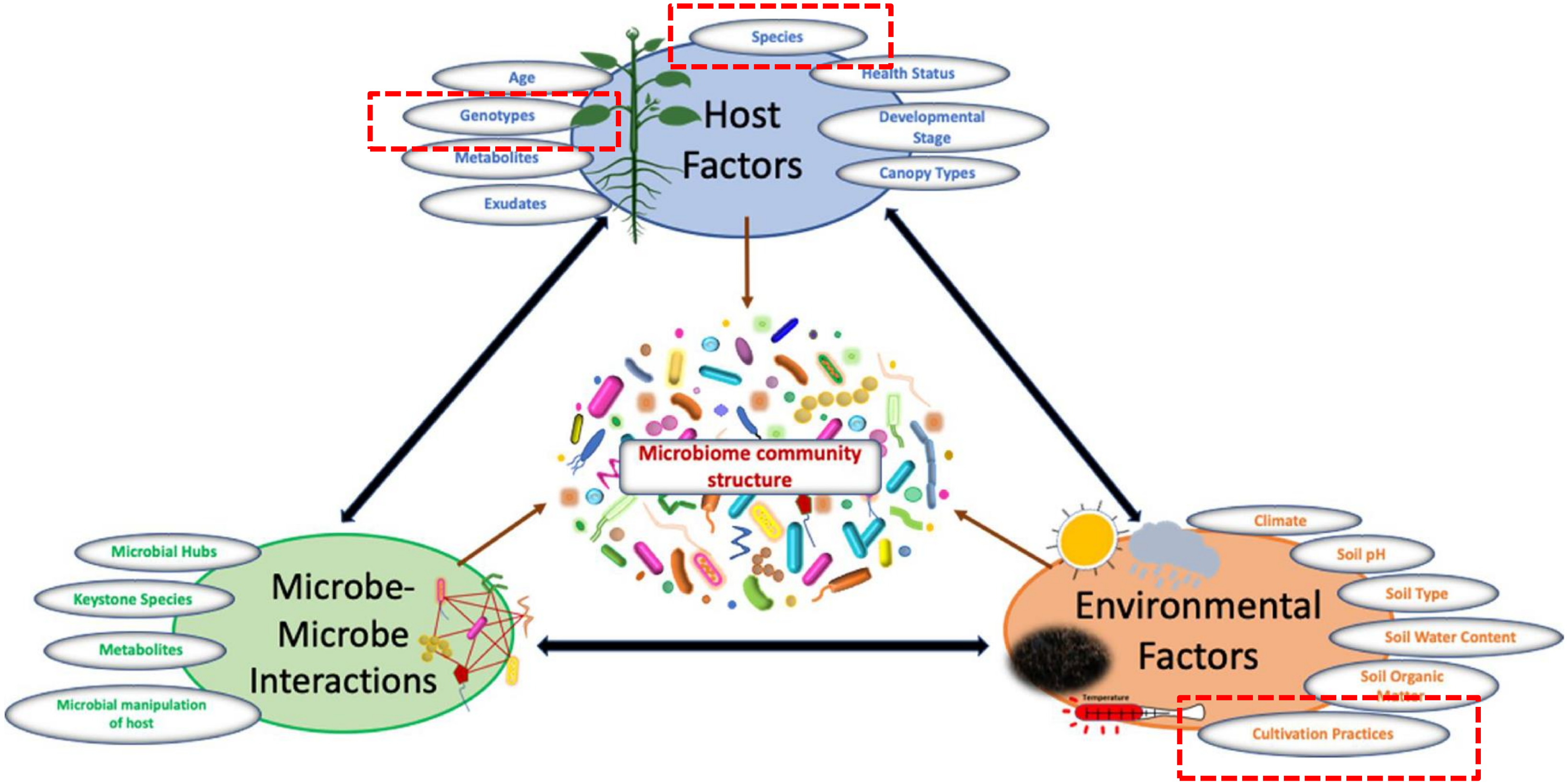
Rhizosphere microbiome: future perspectives



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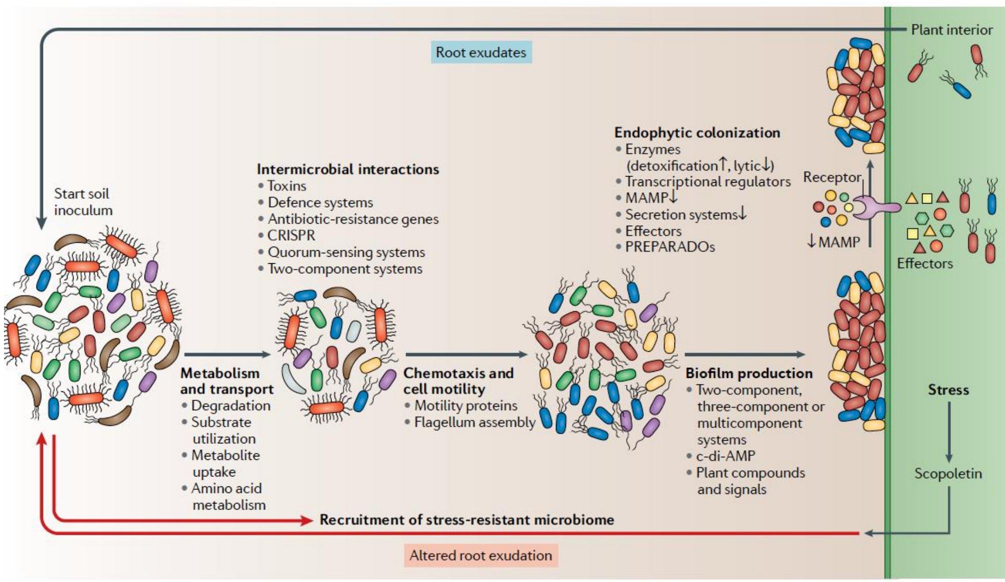
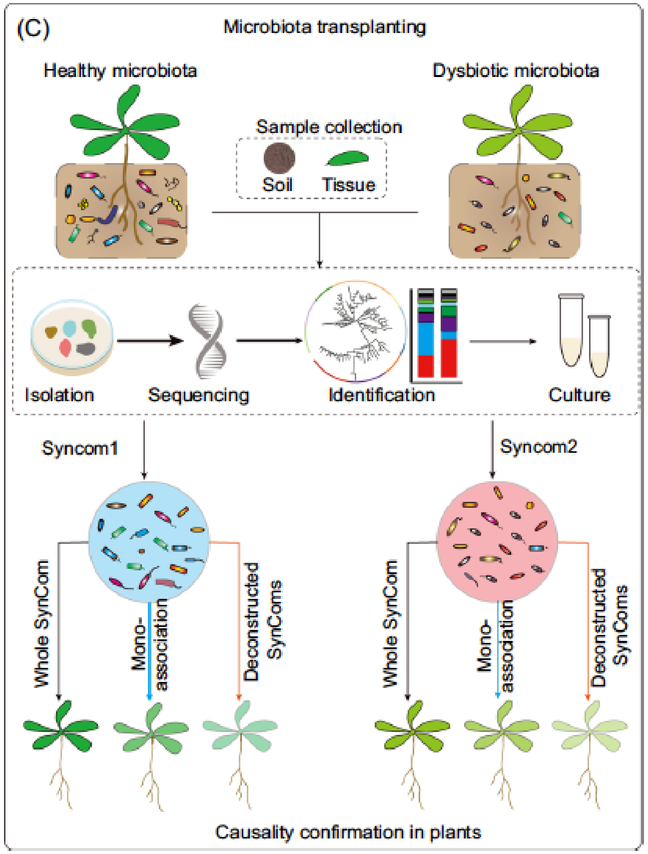
Rhizosphere microbiome: future perspectives

Several plant traits are co-regulated by the plant-associated microbiome. There is an emerging paradigm in which **interactions** between plants and their associated microbiome should be **considered as means to generate new phenotypes with increased fitness under distinct environmental conditions.**



Rhizosphere microbiome: future perspectives

The rational design and application of **synthetic communities (SynComs)** of microorganisms with **broad, persistent and durable plant growth-promoting traits** have the potential to translate basic scientific findings into applications in either greenhouse or field settings.



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