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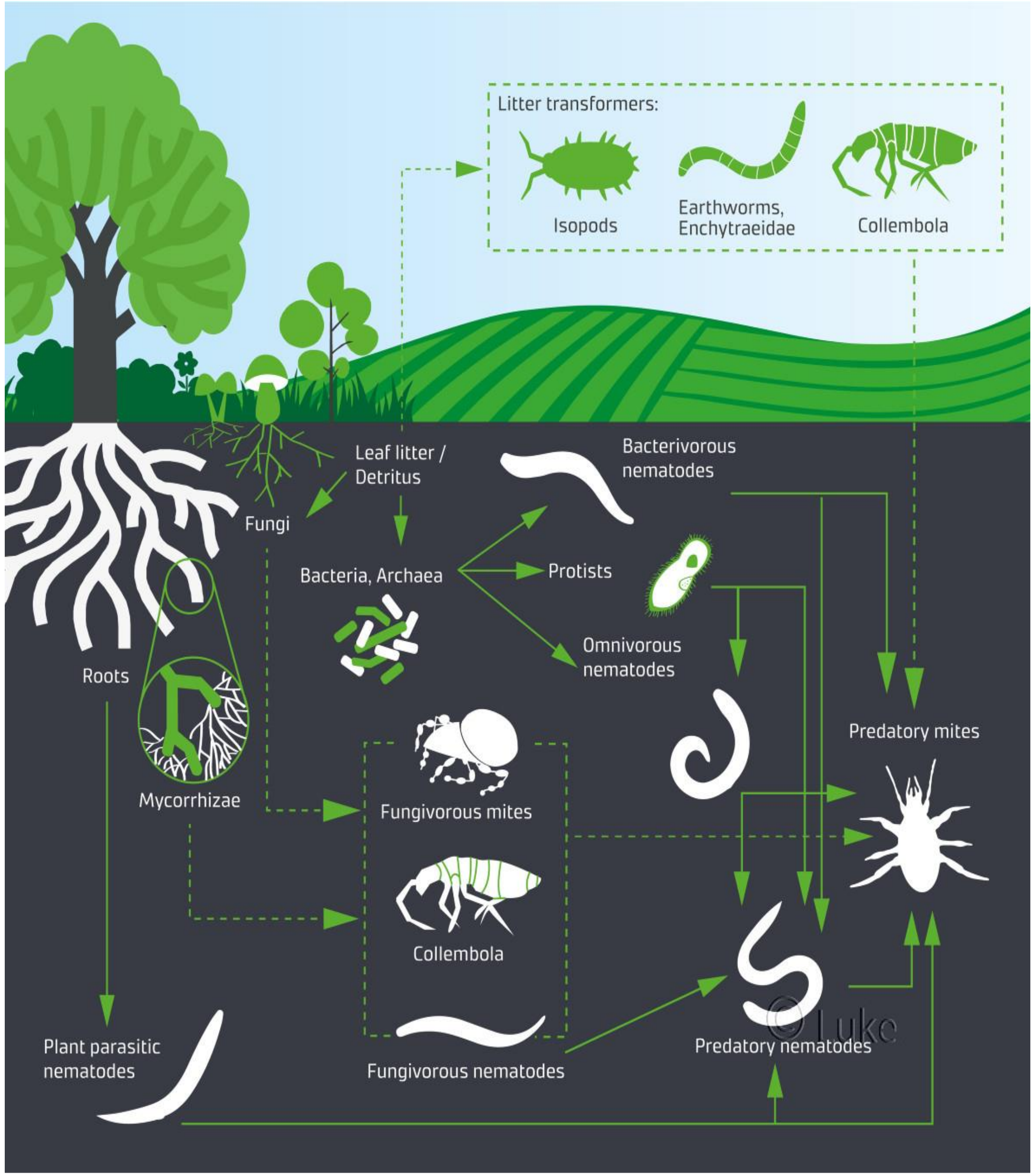
About the effects of farming system on soil microbial diversity and community

Krista Peltoniemi
Senior scientist

Background

- Organic systems have been reported to have 32% to 84% greater microbial biomass, carbon and nitrogen content, total phospholipid fatty acids and enzyme activities than conventional systems
- Higher microbial diversity in organically farmed fields is expected to have **positive output** to
    - C sequestration
    - GHG mitigation
    - nutrient and water uptake
    - pathogen control etc.



Functional soil community is vital to conduct organic farming succesfully. What are the impacts in different crop rotations (cereal vs forage producing dairy farms)?

Long-term experiment in Toholampi started 2001 to investigate the impacts of management system (organic/conventional in cereal/dairy farm) on nutrient (N and P) leaching into surrounding water system

Farm type	Producition system	Fertilization	Cropping cycle year 1	2	3	4
Cereal farm	organic (**OCer**)	manure	barley/ley	timothy-clover –ley	rye	oats
	conventional (**CCer**)	mineral	barley	barley	rye	oats
Milk farm	organic (**OMilk**)	manure	barley/ley	timothy-clover -ley	timothy-clover –ley	oats/clover
	conventional (**CMilk**)	manure/mineral	barley/ley	meadow fescue ley	meadow fescue-ley	barley

Sampling and analyses

Two samplings from the first 20 cm of bulk soil in 2018 (second year of cropping cycle)

I) spring in May before sowing

II) autumn in August after the harvest

Microbial biomass C and N: fumigation extraction

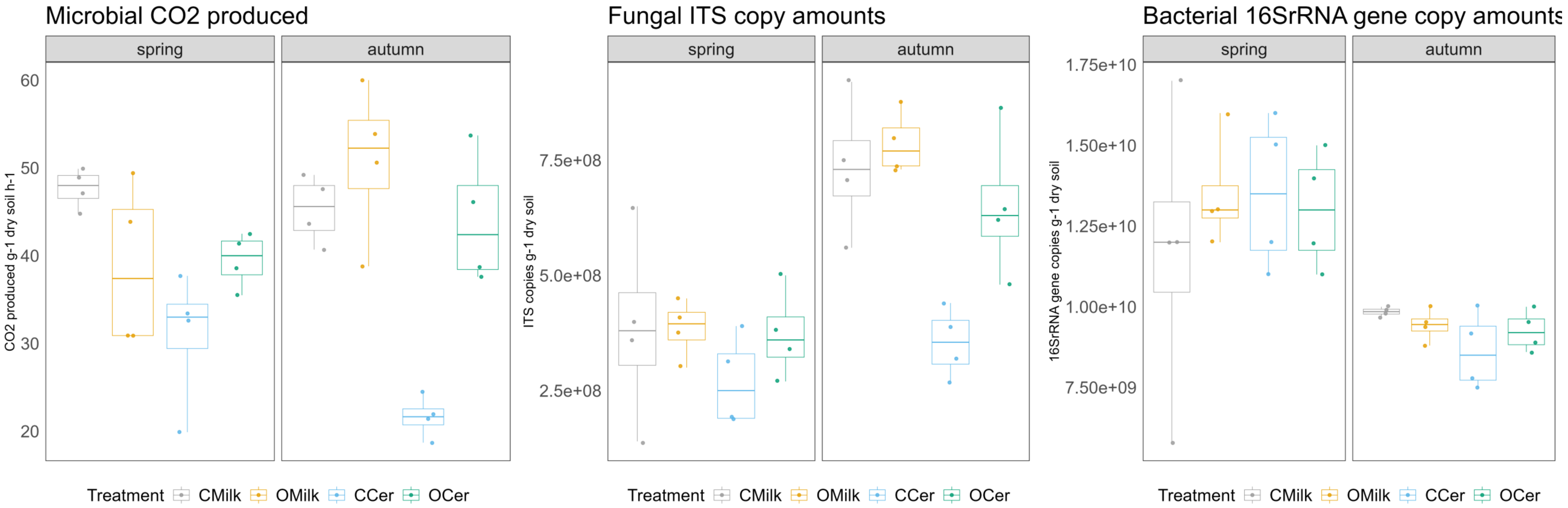
Microbial activity: CO_2 produced by GC

Microbial amounts: 16SrRNA gene and ITS copies by qPCR

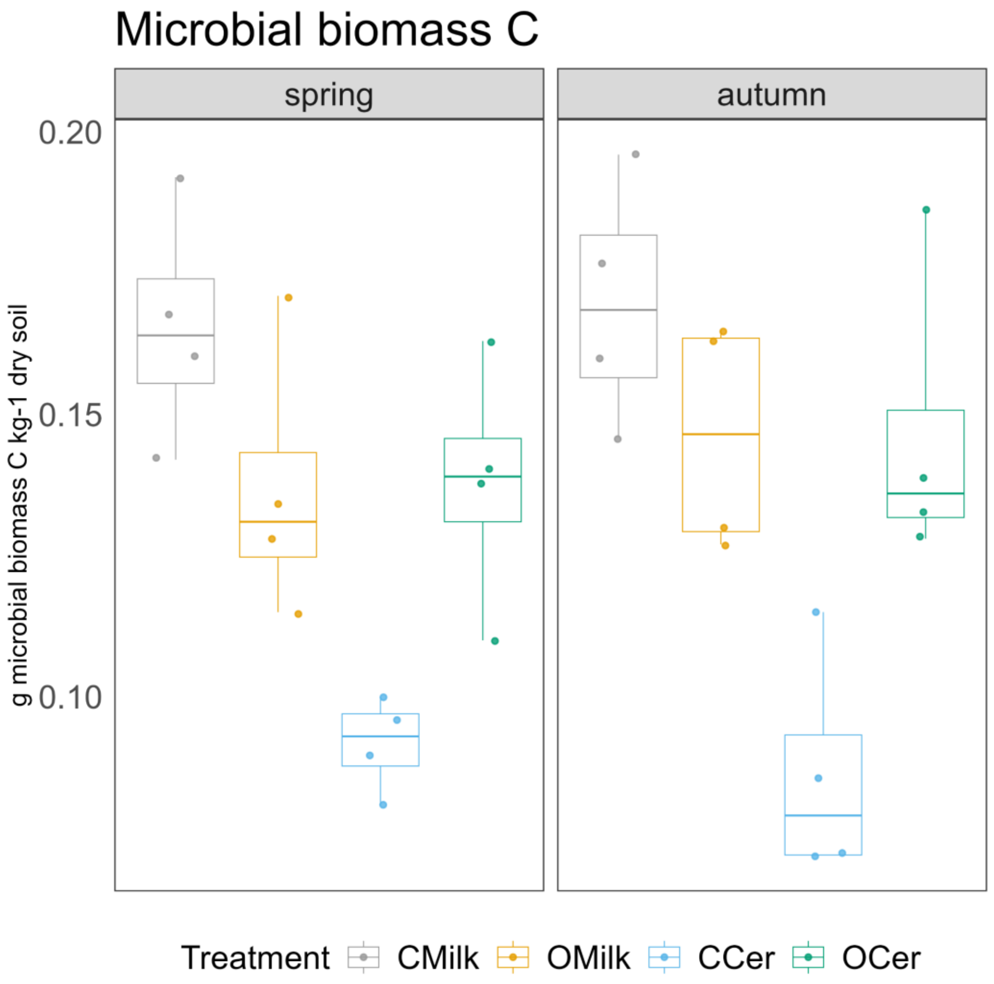
Microbial communities: Illumina amplicon sequencing

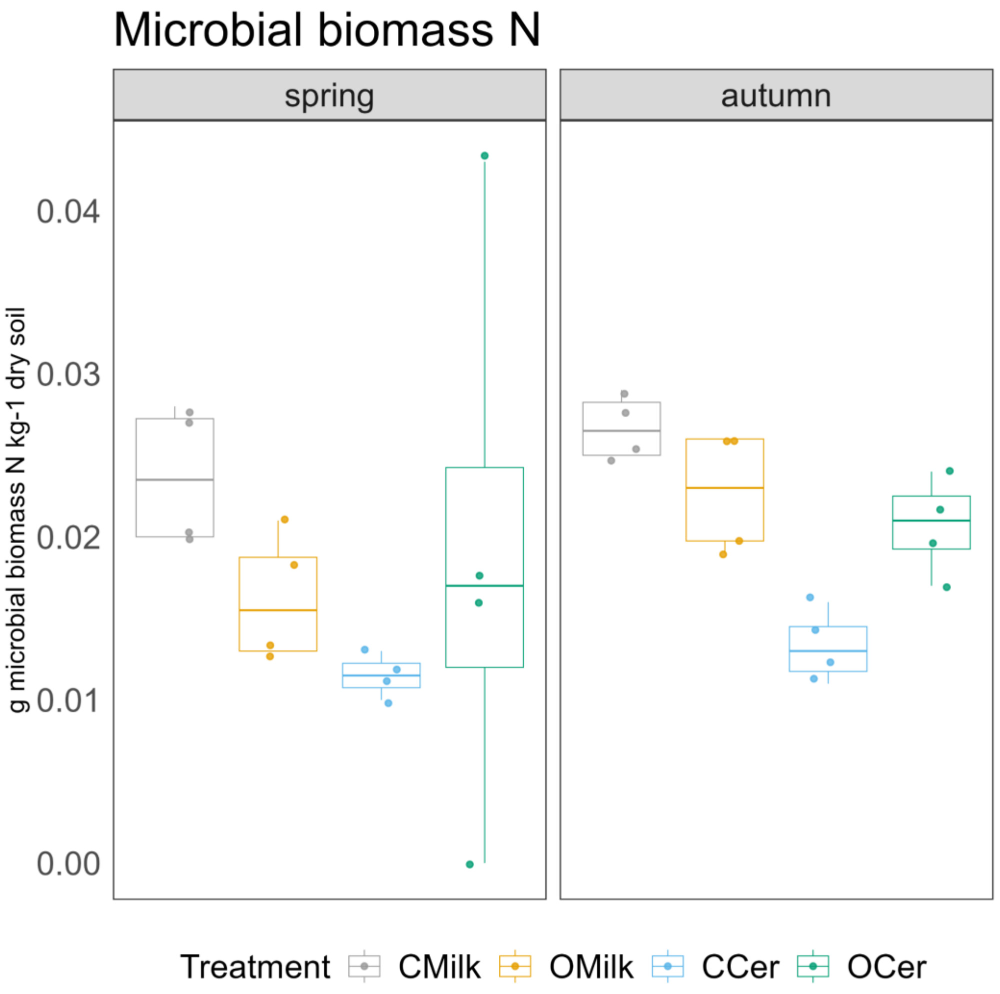
- NMDS with PERMANOVA

Microbial activity and amounts

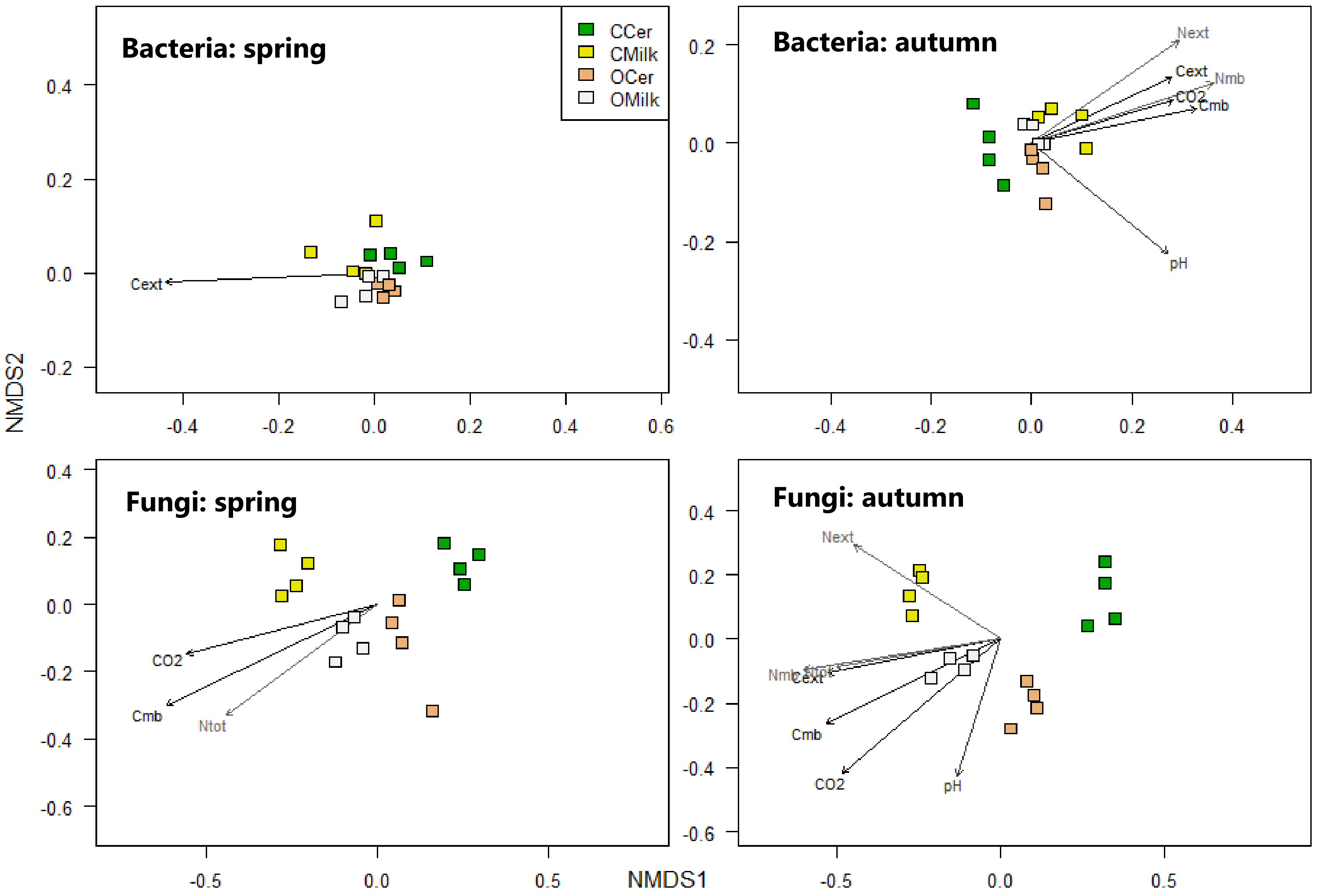


Microbial biomass C and N





Microbial community composition



	Season	System	Farm
Bacteria	Spring	R2=0.10, *p*=0.02	R2=0.08, *p*=0.14
	Autumn	R2=0.14, *p*=0.003	R2=0.10, *p*=0.03
Fungi	Spring	R2=0.11, *p*=0.05	R2=0.14, *p*=0.02
	Autumn	R2=0.21 *p*=0.001	R2=0.36, *p*=0.001

Status of soil biodiversity under organic and conventional wheat fields in Europe

188 sampled fields from 9 European pedoclimatic zones under organic and conventional farming

Boreal (Finland)

North-Atlantic (Denmark)

Continental (Germany)

Lusitanian (Northwestern-Spain)

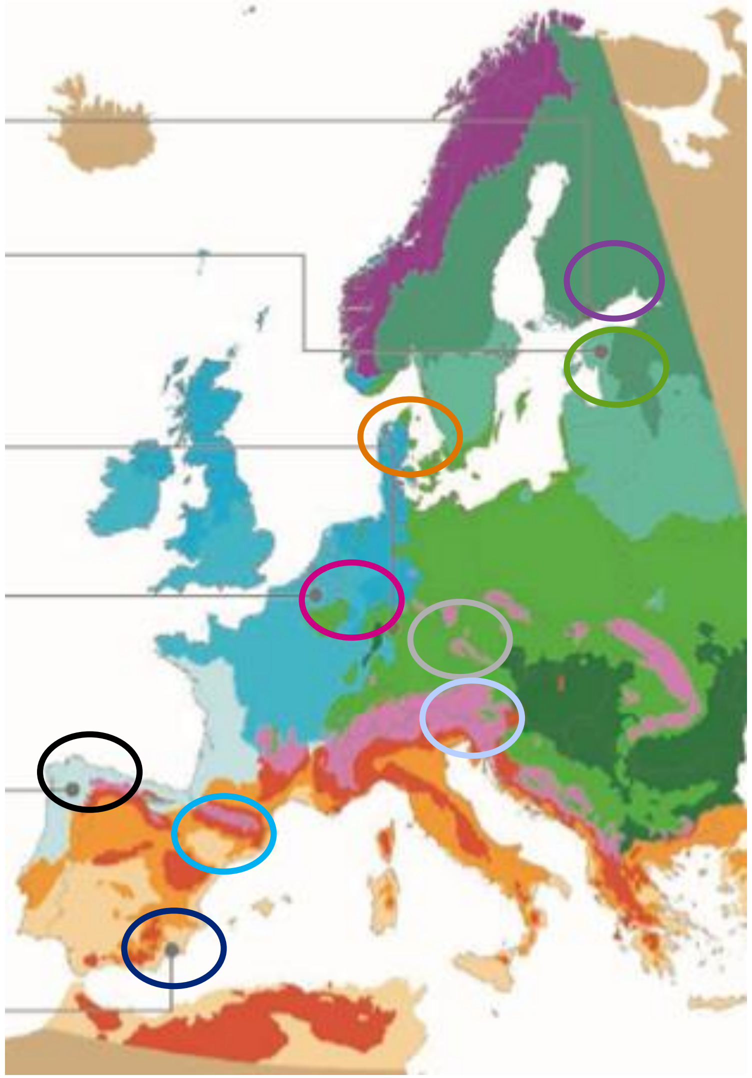
North-Mediterranean (Eastern-Spain, "high altitude areas")

South-Mediterranean (Southern-Spain, "low altitude areas")

Nemoral (Estonia)

Central-Atlantic (Belgium)

Pannonian (Hungary/Serbia)



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Sampling and analyses

Samples from the first 25 cm of bulk soil

After the harvest in autumn 2019

Chemical and physical soil analyses

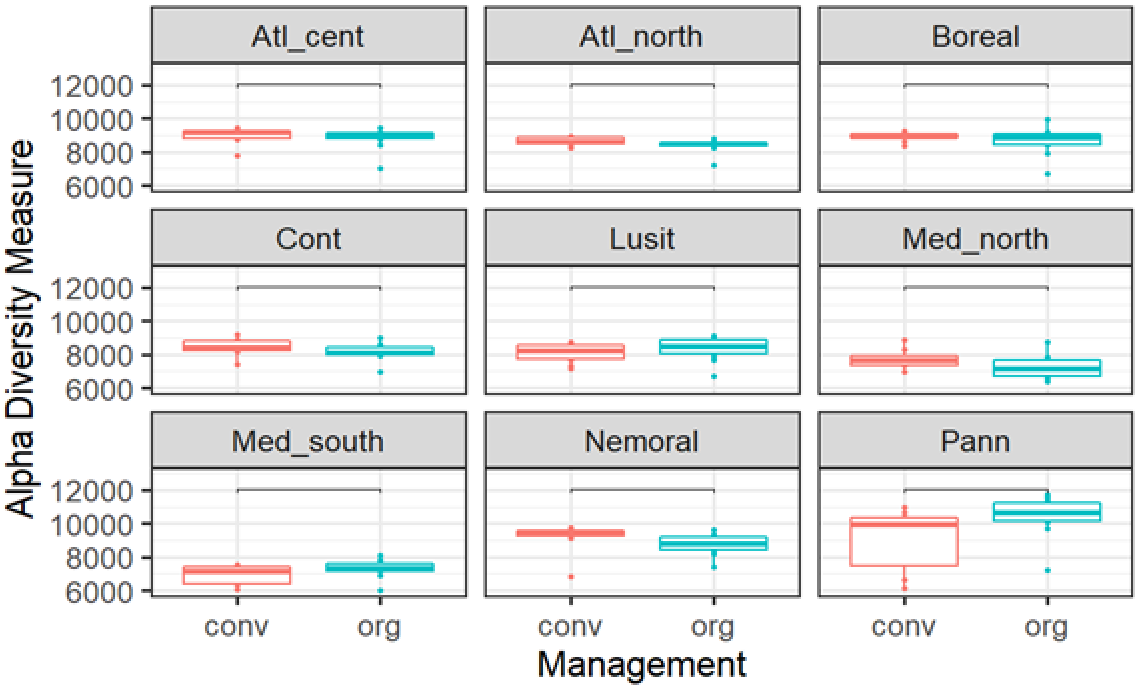
Bulk density, soil pH, nutrients, aggregate sizes etc

Microbial communities Illumina amplicon sequencing of bacterial 16SrRNA gene and fungal ITS1

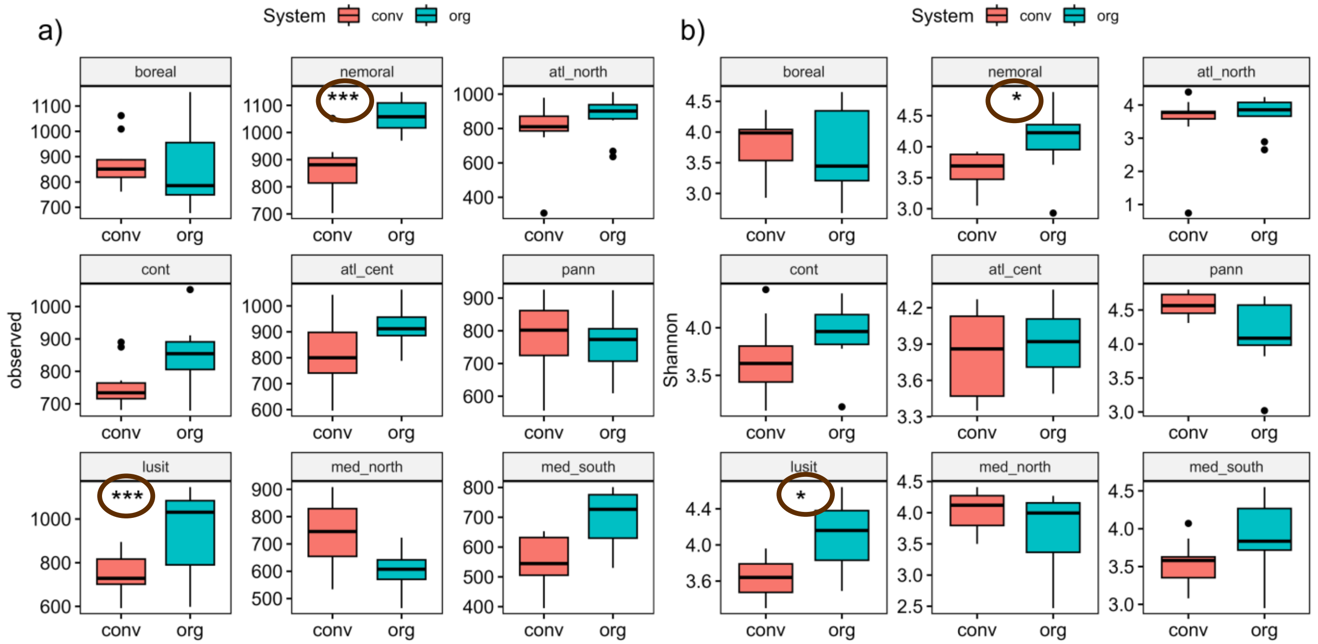
- NMDS with PERMANOVA
- Linear models

Alpha diversity

Bacterial richness



Fungal richness and diversity

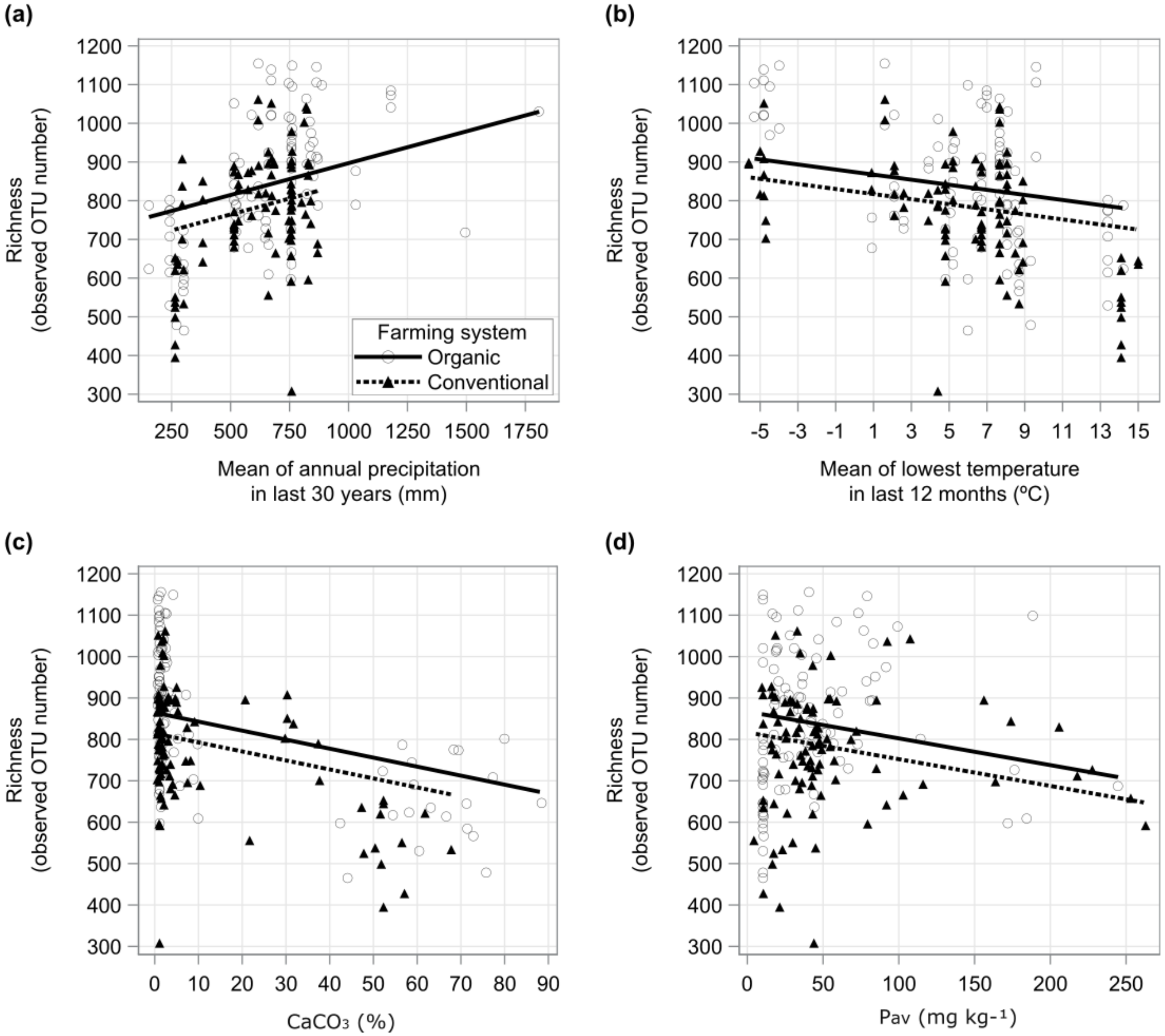


Factors affecting fungal richness

Fungal richness was bigger

in conditions with

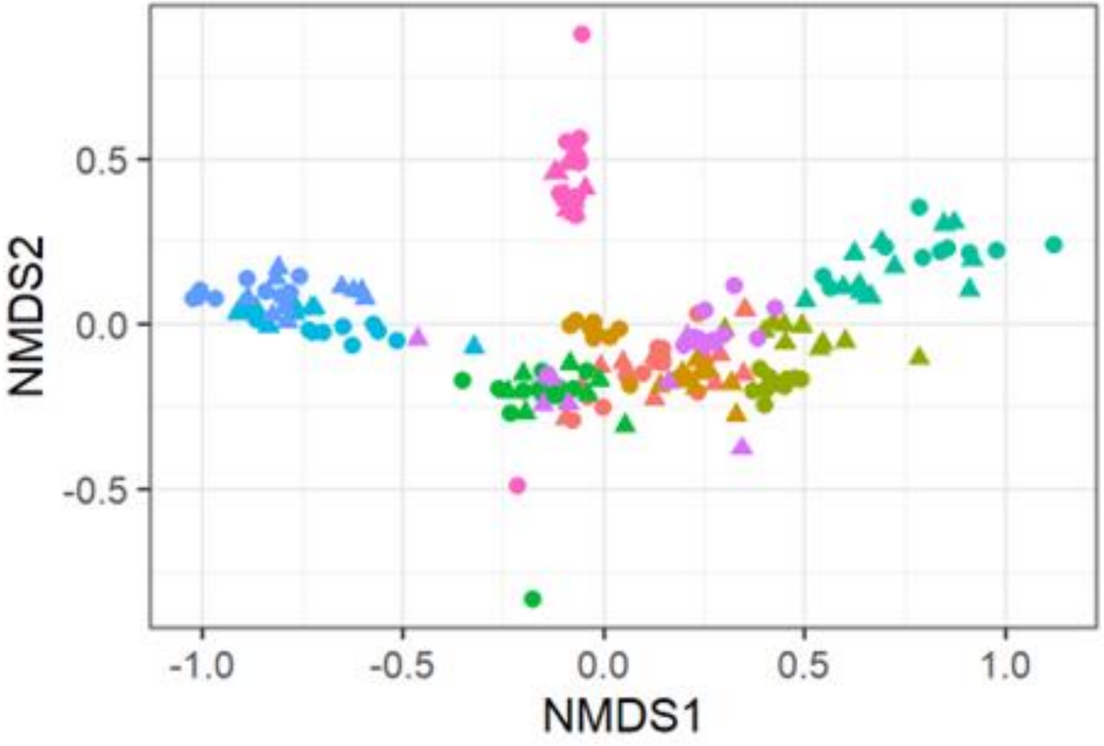
- higher long-term precipitation
- lower temperature within last 12 months before sampling
- lower $CaCO_3$
- lower available phosphorus



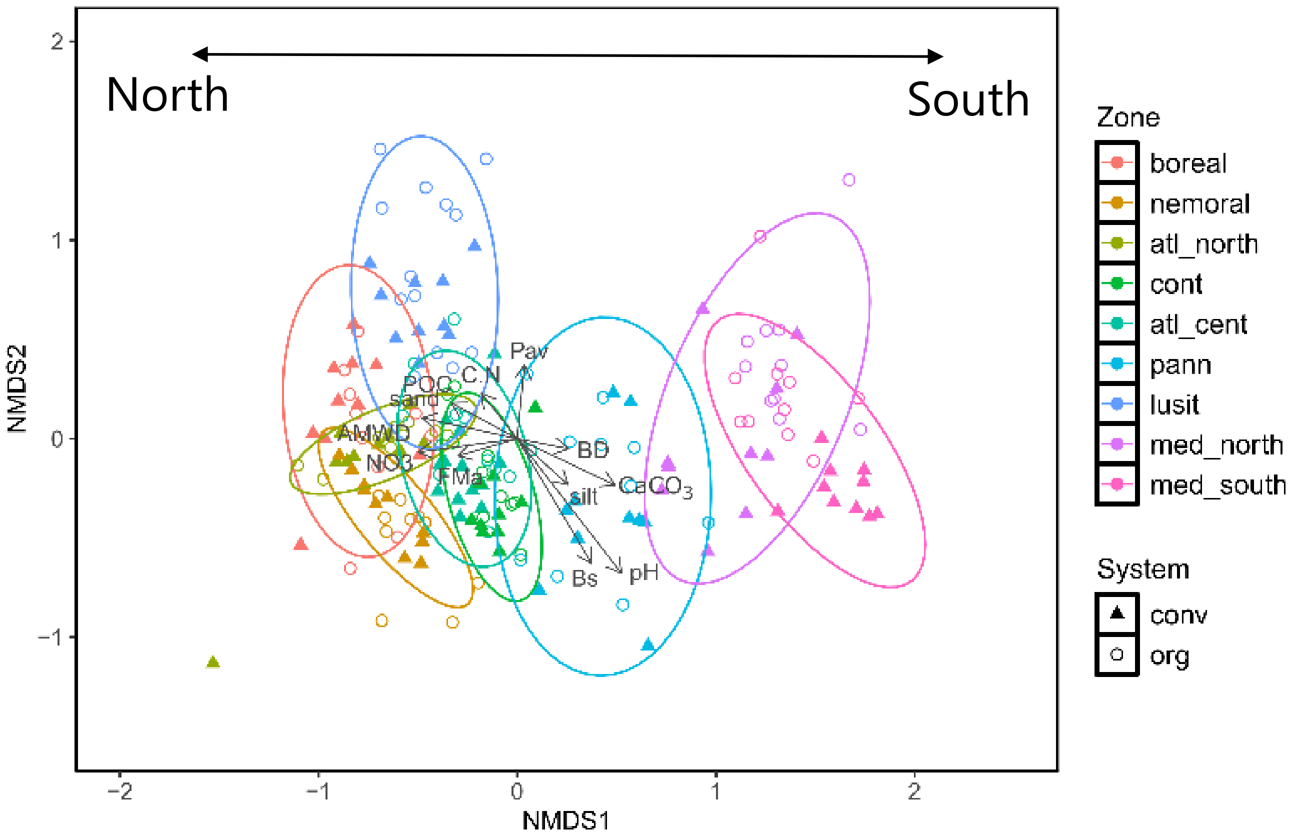
Community composition

	Zone	System	Zone&System
Bacteria	R2=0.747, p=0.001	R2=0.003, p=0.038	R2=0.386 p=0.001
Fungi	R2=0.404, p=0.001	R2=0.015, p=0.001	R2=0.061, p=0.001

Bacteria

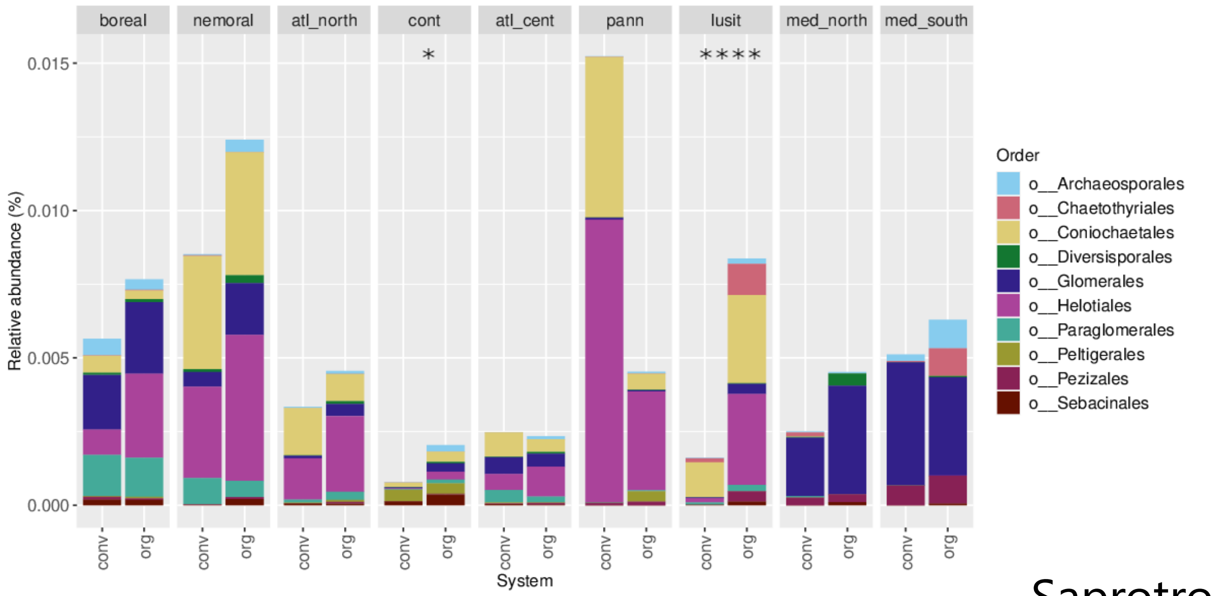


Fungi

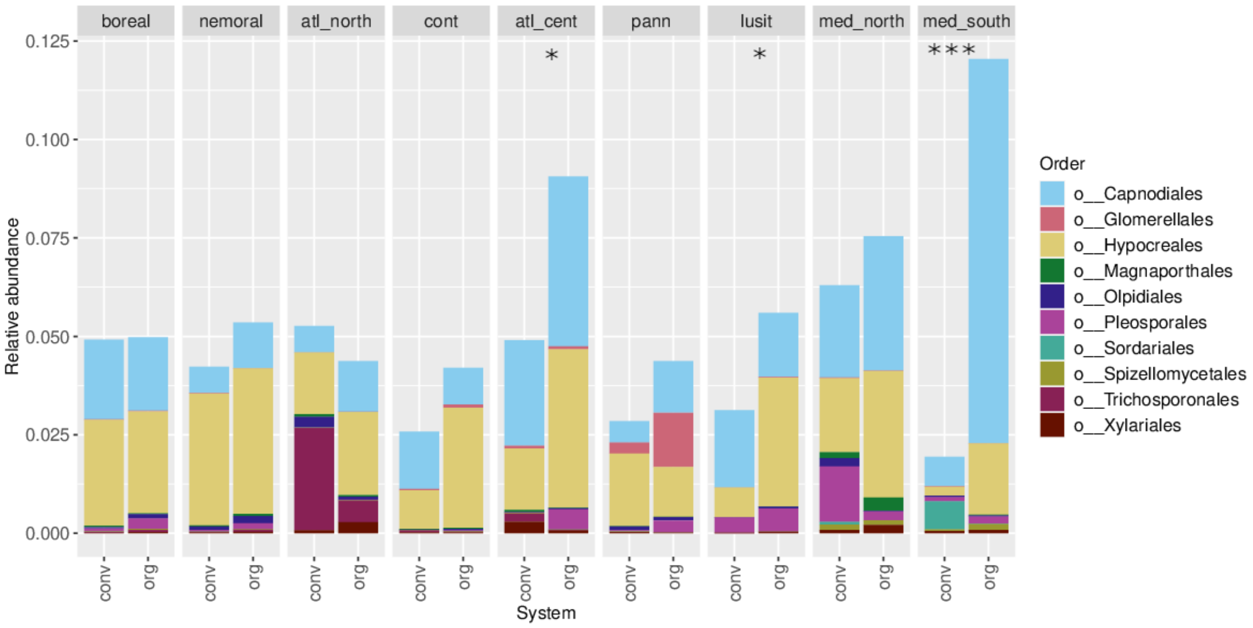


Fungal groups

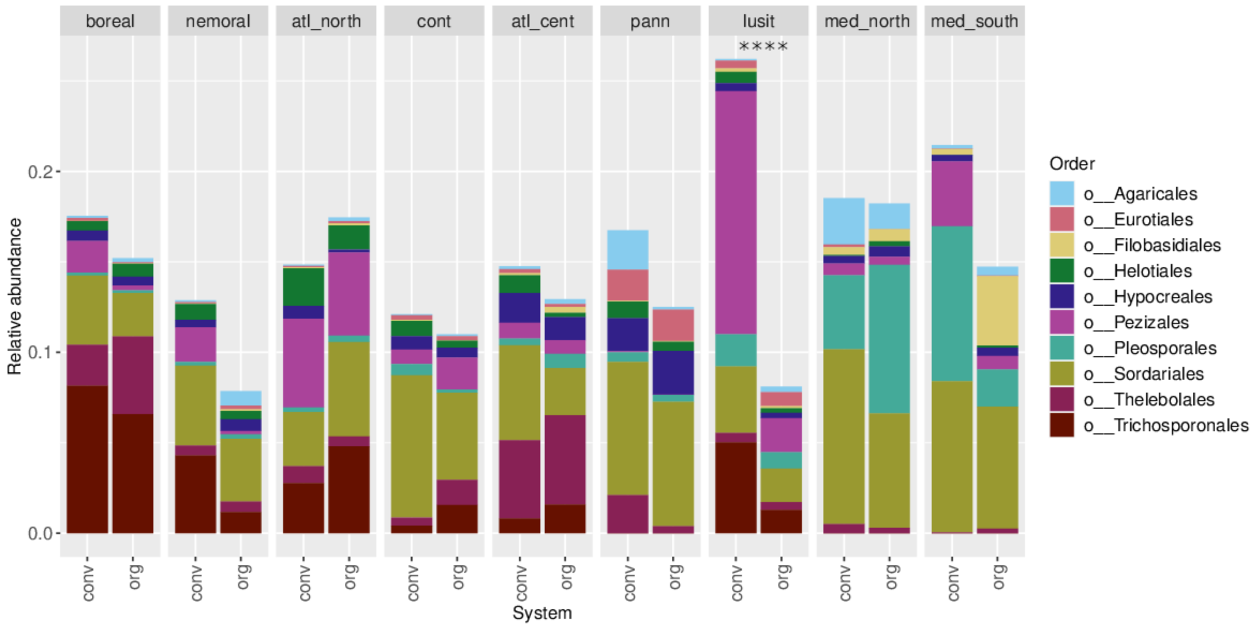
Symbiotrophs



Pathotrophs



Saprotrophs



Conclusions

- Boreal scale:
    - farming system in the long-term affects microbial biomass, fungal amounts, both bacterial and fungal community composition, but the impact of crop plant is also obvious especially for the fungi
    - absence of manure fertilization and more frequent tillage likely explains the divergent results for conventional cereal crop field
- European scale:
    - organic farming generally increases fungi, but diversity increased only in some region
    - the fungal diversity is affected by local weather and soil conditions
        - ➢ the cooler and moister OR less P and acidity> more fungi
    - more symbiotrophs and ”beneficial” fungi, but also pathotrophs in the north-western Spain (lack of fungicides?)

More results in our publications

European Journal of Soil Biology 104 (2021) 103314

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Long-term impacts of organic and conventional farming on the soil microbiome in boreal arable soil

Krista Peltoniemi[a,*], Sannakajsa Velmala[a], Hannu Fritze[a], Riitta Lemola[b], Taina Pennanen[a]

Agriculture, Ecosystems and Environment 370 (2024) 109035

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Soil and climatic characteristics and farming system shape fungal communities in European wheat fields

Krista Peltoniemi[a,*], Sannakajsa Velmala[a], Eva Lloret[b], Irene Ollio[b], Juha Hyvönen[c], Eero Liski[d], Kristian K. Brandt[e], Claudia Campillo-Cora[f], Hannu Fritze[a], Sari Iivonen[g], Simon B. Lassen[e], Kaire Loit[h], Silvia Martínez-Martínez[b], Taina Pennanen[a], Marian Põldmets[h], Stefan Schrader[i], Merrit Shanskiy[h], Raúl Zornoza[b], Lieven Waeyenberge[j], David Fernández Calviño[f]

Thanks!

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