Understanding & managing rhizosphere processes using innovative organic amendments

Agro-ecological requirements

Increasing soil carbon stocks

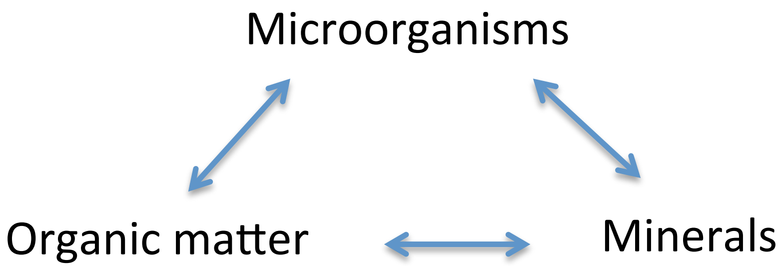
- ✓ C storage in soil to contribute to climate change mitigation
- ✓ Improve soil quality to increase sustainable agricultural production and food security

Reduce inputs and environmental externalities

- ✓ Improve soil fertility and nutrient availability
- ✓ Reduce nutrient loss and pollution of waterways
- ✓ Reduce greenhouse gas emissions from agriculture

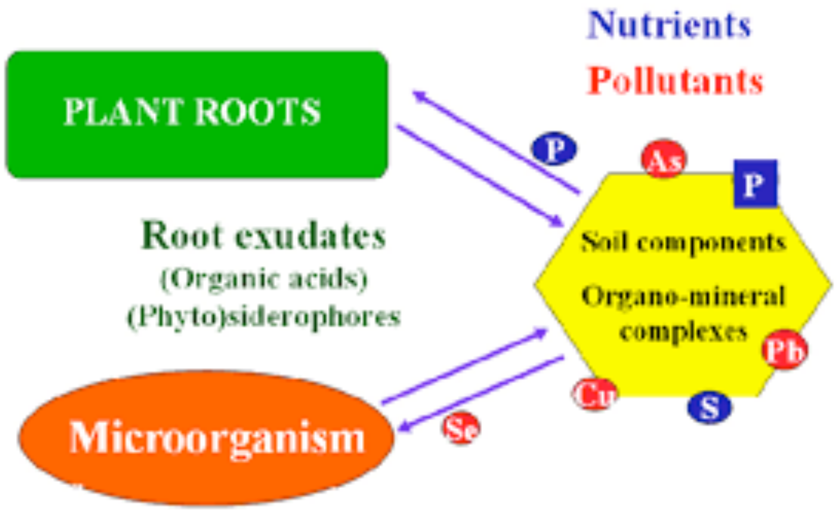
➡ Hypothesis: organic soil amendments generated through the transformation of organic waste materials can be used to manage soil plant interactions

Rhizosphere as a biogeochemical hotspot

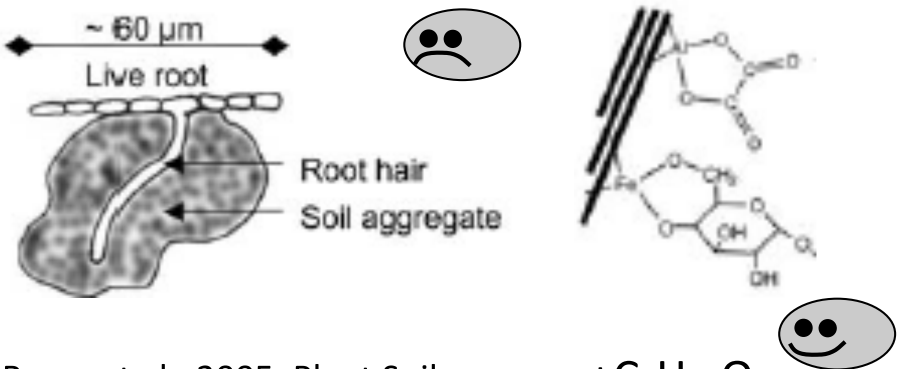


Bladogatskaya and Kuzyakov, 2015, SBB

Nutrient availability and storage



Carbon turnover



Rasse et al., 2005, Plant Soil

$+C_6H_{12}O_6$

Violante et al., 2015, JSSPN

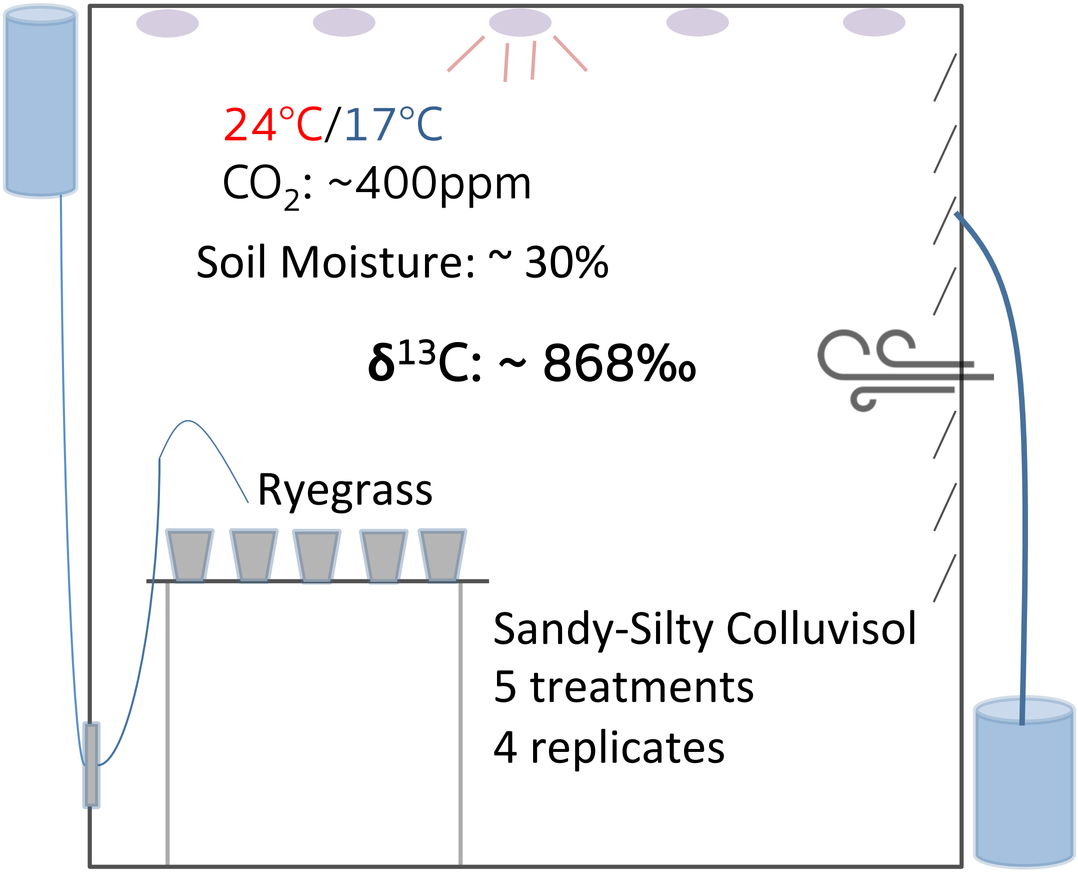
Objective




The aim of the study was to use compost and co-composts with minerals produced in the presence or absence of worms (*Eisenia andrei* and *foetida)* for soil amelioration and investigate their effect on plant growth and rhizosphere processes.

^{13}C labelling experiment

Master T. Lenhart
Coll. with A. Vidal (TUM)



Ryegrass (*Lolium perenne*)

Treatments (application of amendments eq 30T ha^{-1}):

- Control
- Compost (C)
- Co-Compost (30% Montmorillonite) (C+M)
- Vermicompost (V)
- Co-Vermicompost (30% Montmorillonite) (V+M)

After 41 days, sampling of:

- Shoot and root biomass
- Rhizospheric soil
- Non-rhizospheric soil

Analyses

Elemental content (Plant roots and shoots and soil)

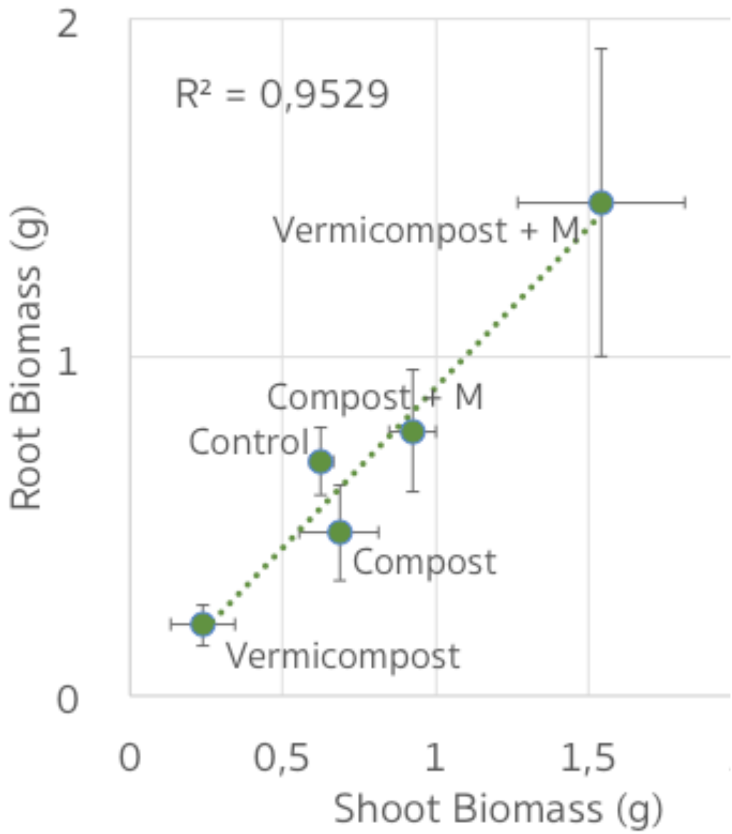
Stable isotope content (Root carbon contribution to soil)

Bulk samples
– C allocation to
rhizopheric and non-rhizospheric
soil

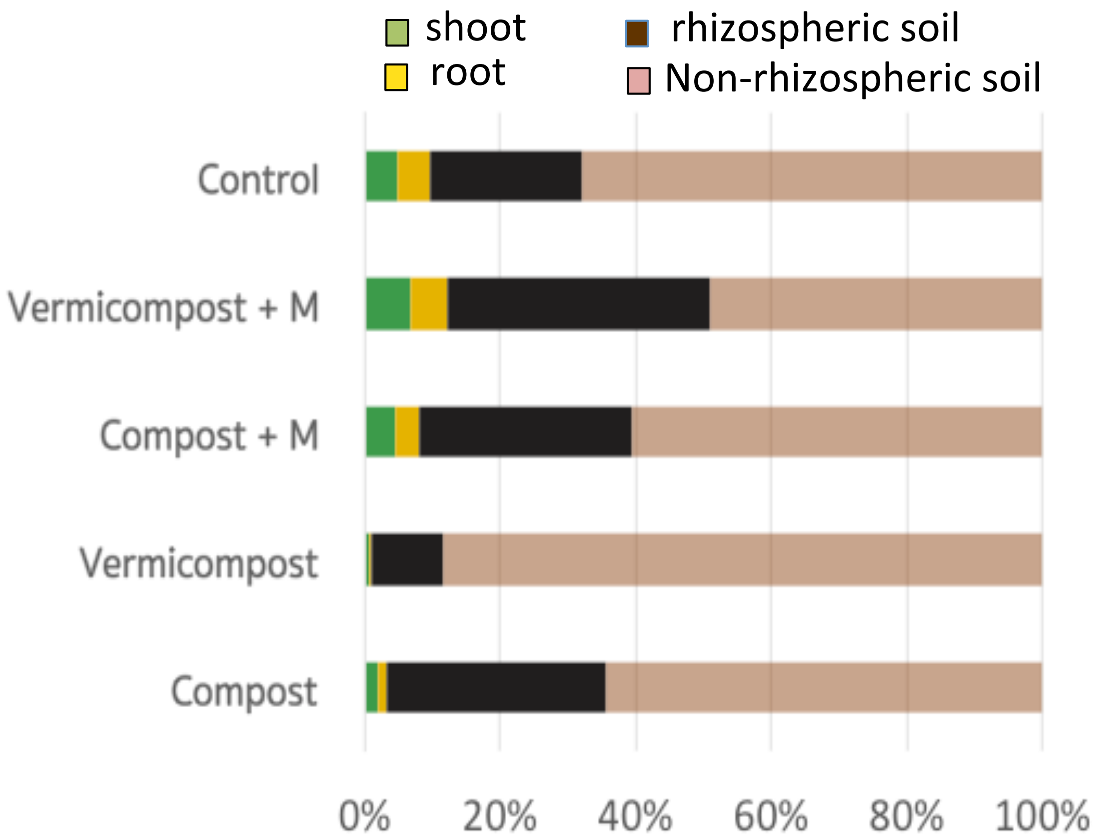
Nanoscale
– C allocation to specific soil
compartments (roots, rhizosphere,
minerals)

Biomass and Carbon distribution

Biomass production



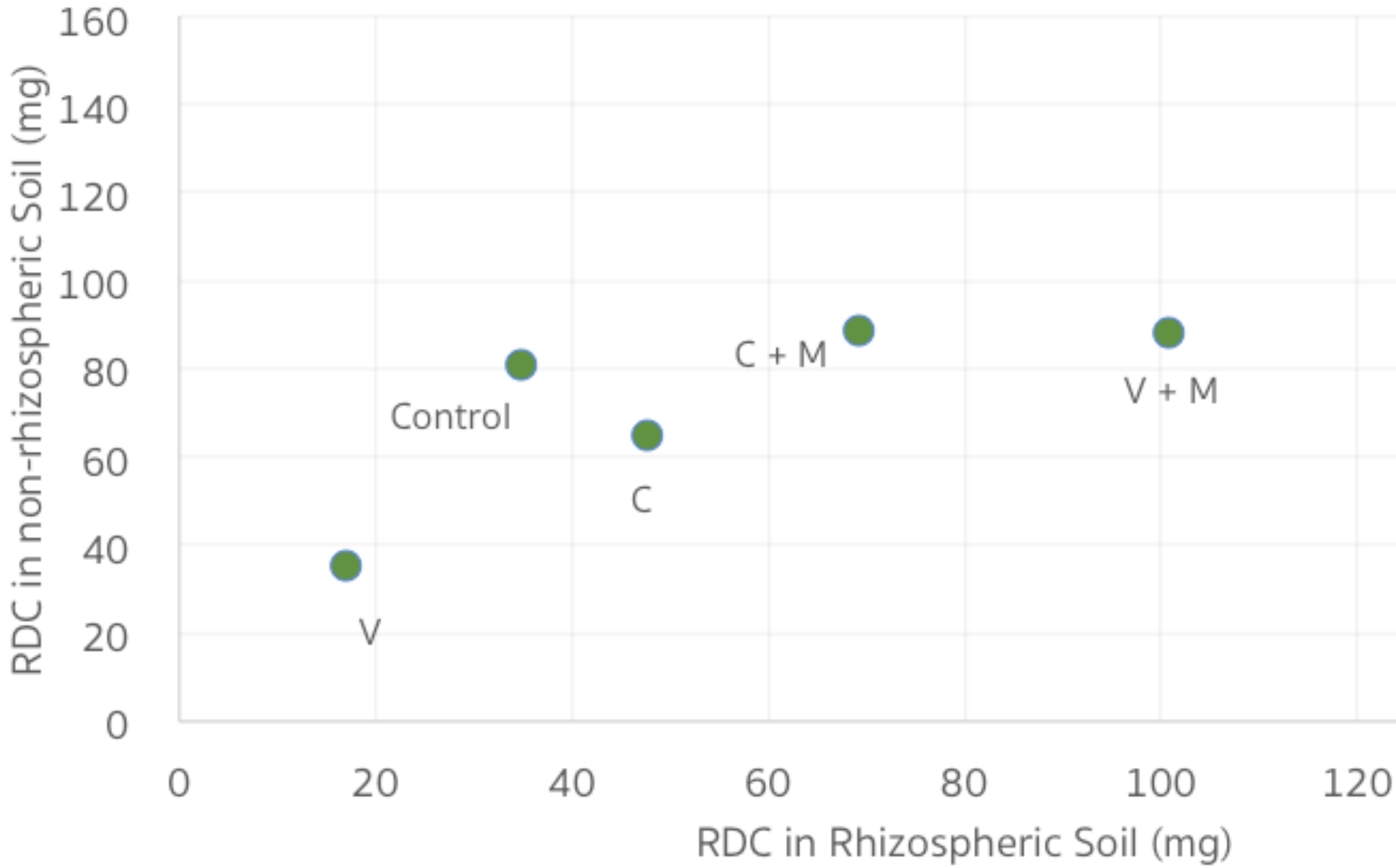
C-distribution in different compartments



Mineral addition during co-(vermi) composting increases biomass production and C allocation to the rhizosphere in the case of vermicompost

Vidal et al., 2020, Geoderma

Labelled C input into soil



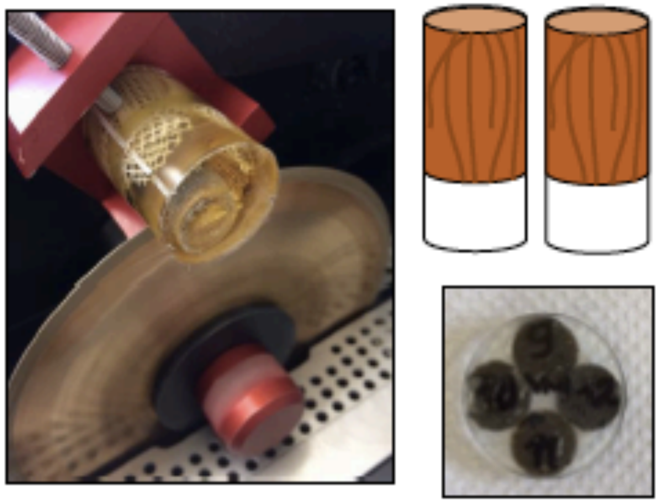
Mineral addition during co-(vermi) composting increases root-derived C input, particularly in presence of worms

Which compartments are affected by this higher inputs? → Submicron investigation

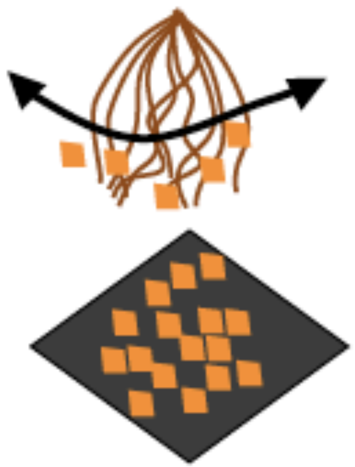
Sampling for submicroscale investigation

Raygrass: vermicompost and co-vermicompost (30% Montmorillonite)

Non-distructive sampling
and resin impregnation



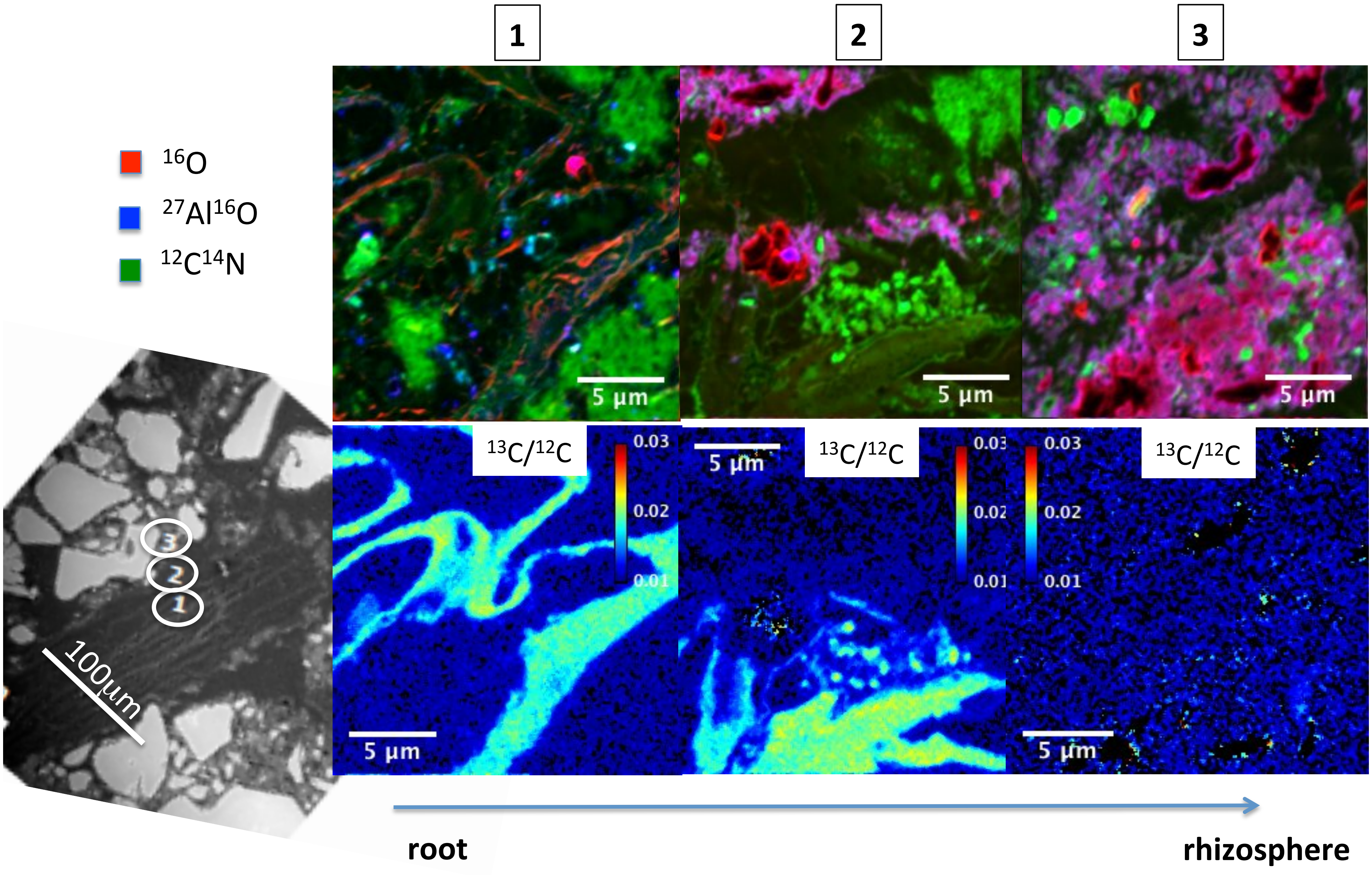
Distructive sampling of rhizosphere
And deposition on silica wafer



Nano Secondary Ion Mass Spectrometry (NanoSIMS)

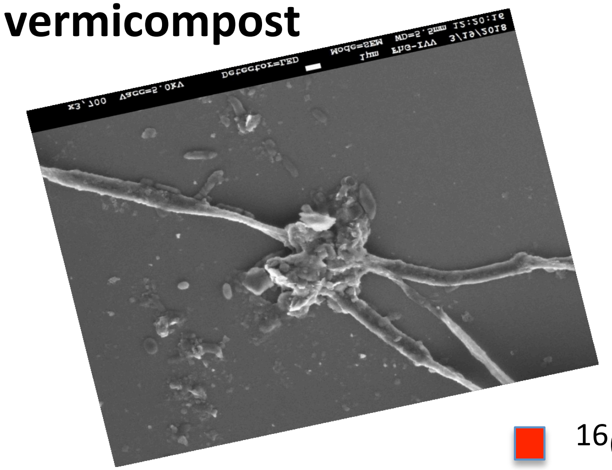
- Elemental content
- Isotope composition

Root sample (co-vermicompost)

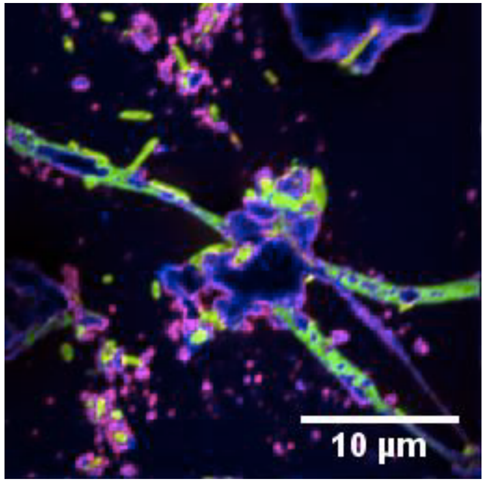


Rhizosphere samples - fungi

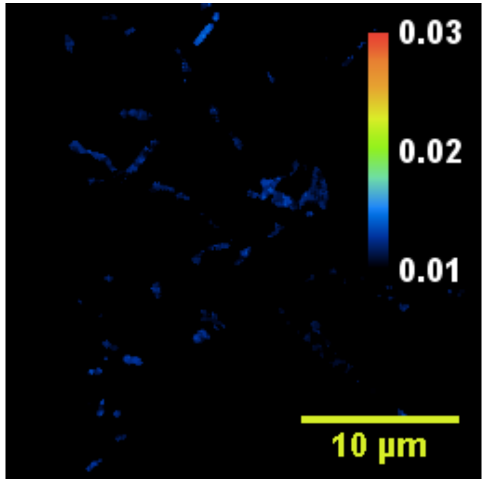
vermicompost



Elemental composition



Stable C isotope composition

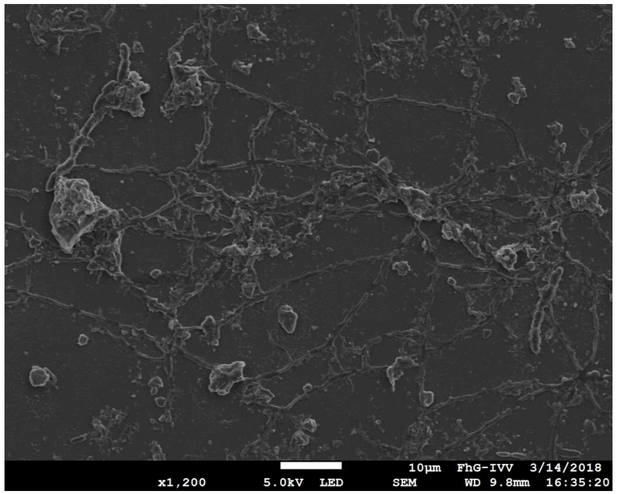


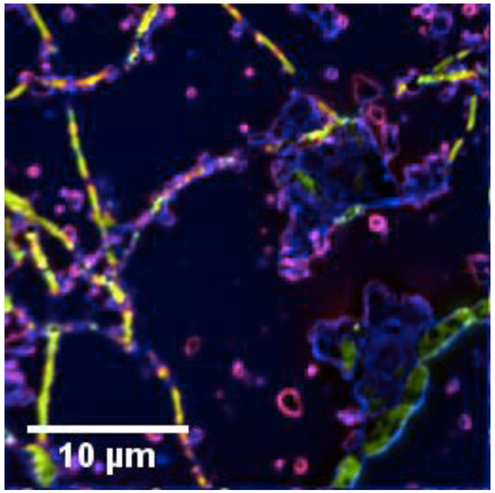
^{16}O

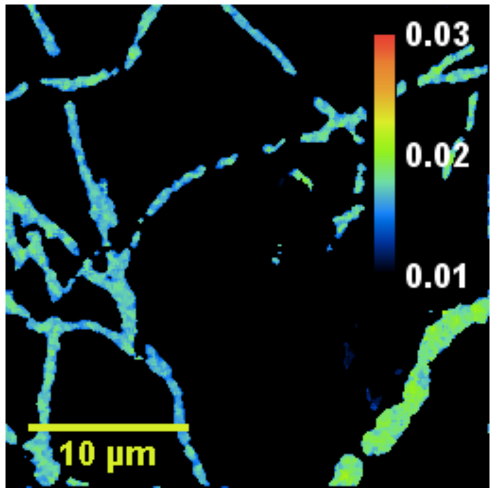
$^{27}Al^{16}O$

$^{12}C^{14}N$

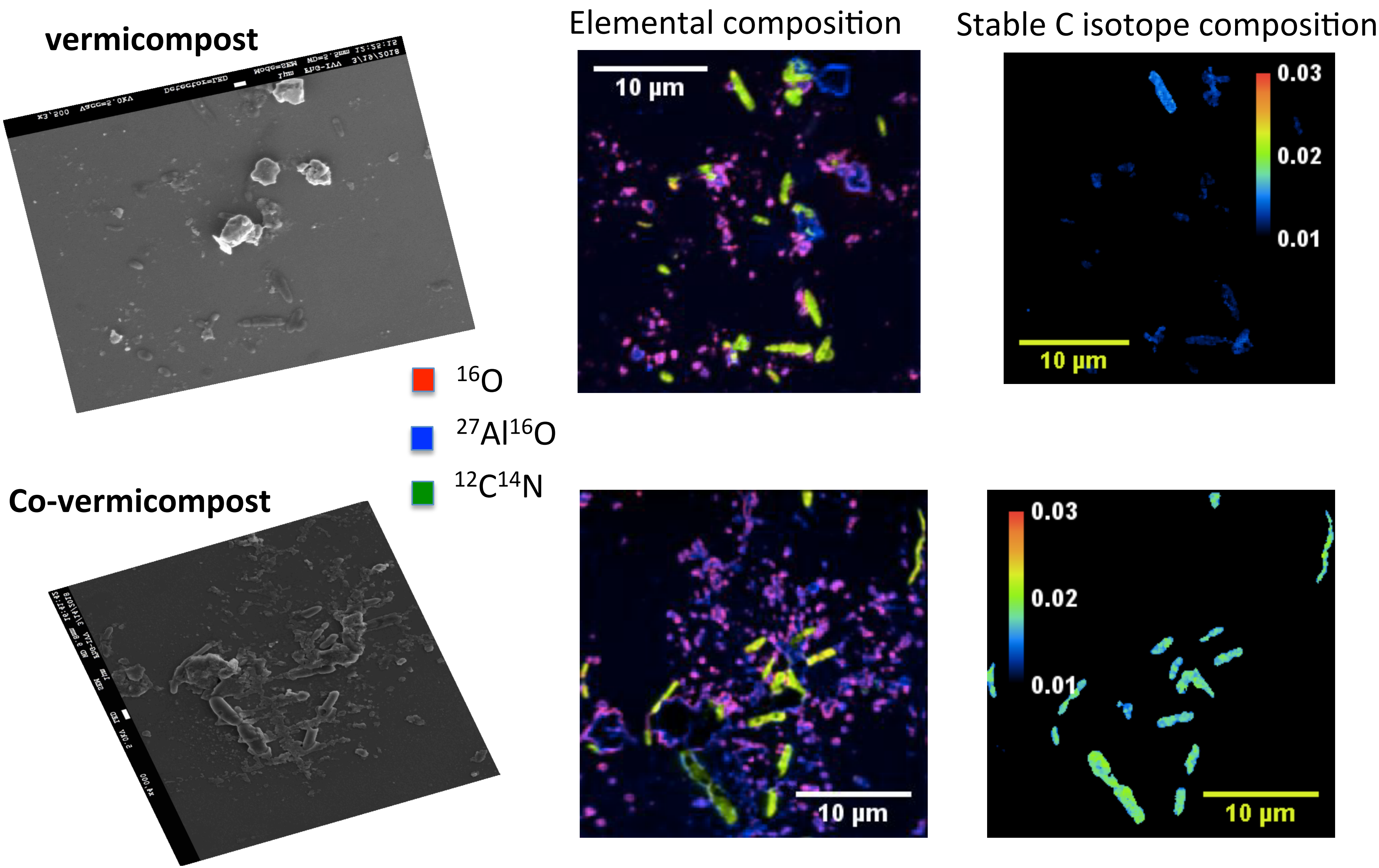
Co-vermicompost



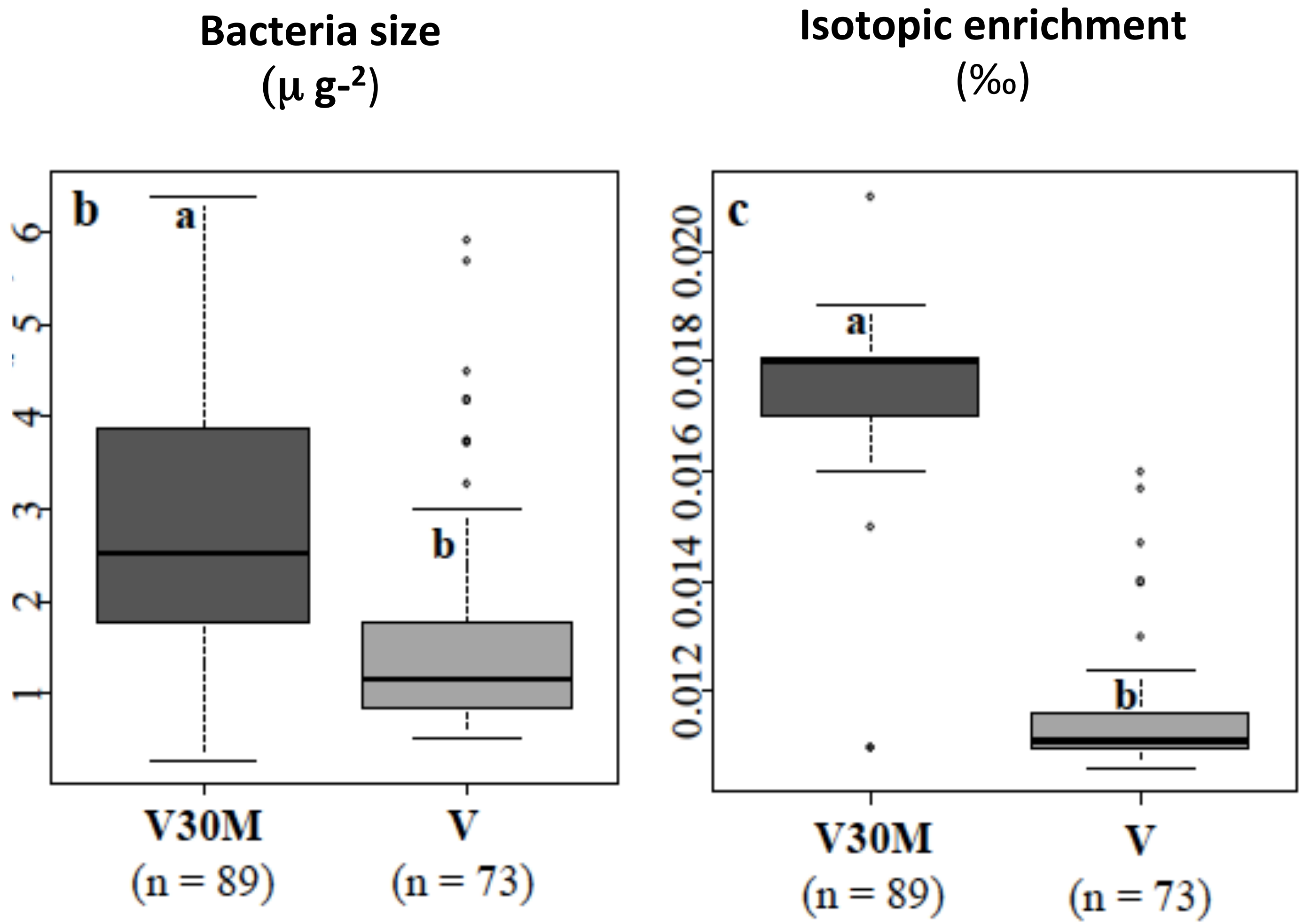




Rhizosphere samples - bacteria



Characteristics of bacteria in the rhizosphere



Bacteria in the rhizosphere of ryegrass grown in soil amended with vermicompost treated with minerals have bigger bacteria living on rhizodeposition

Vidal et al., 2020, Geoderma

Conclusions

- Ecotechnological approaches using earthworms and minerals may be suitable to generate organic fertilisers with low C emissions after field applications

- Plants respond differently to organic amendments produced through composting and vermicomposting with and without minerals

- Addition of minerals and worms during the production of organic amendments changes plant-soil interactions

- These changes may be related to the impact of the organic amendments on the composition and activity of soil microorganisms in the rhizosphere

To efficiently implement ecotechnological strategies to increase ecosystem services of organic amendments after soil application, we need deeper understanding of these processes