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Nematode communities as soil quality indicators in agroecosystems - Sequencing approach

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H2020-Project iSQAPER: Interactive Soil Quality Assessment in Europe and China for productivity and environmental resilience

iSQAPER
Interactive Soil Quality Assessment

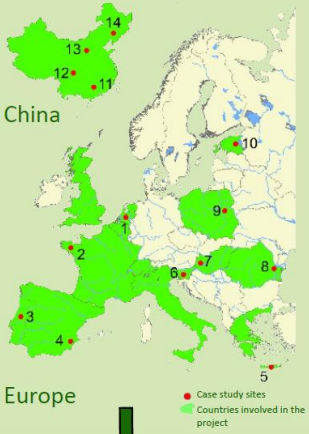
Good soil quality is of fundamental importance to both local and global food production and to ecosystem resilience.

Agricultural soils world-wide are subject to threats and pressures including: increasing demand for food and biofuels, changing diets, land degradation and associated productivity decline, all made worse by climate change.

Reliable knowledge and data help land users assess their soils and make well-informed decisions about its use. When information on alternative land use practices is easily available, it supports farmers in improving their land management.

Innovative methods to assess soil quality in different pedo-climatic zones, integrating soil science, agricultural and land management practices.

Soil quality indicators tailored for and tested by farmers for farmers in Europe and China.



The app will be developed, tested, evaluated and improved by farmers, scientists, practitioners, agricultural service providers and policy makers.

An app for mobile devices anywhere in the world, providing location-specific soil quality information and sustainable land use management options.

Information about the environmental footprint of farming activities, options for sustainable land use and the effects of widespread adoption of sustainable land practices generated from existing databases and shared among farmers, scientists, regional and national policy makers.

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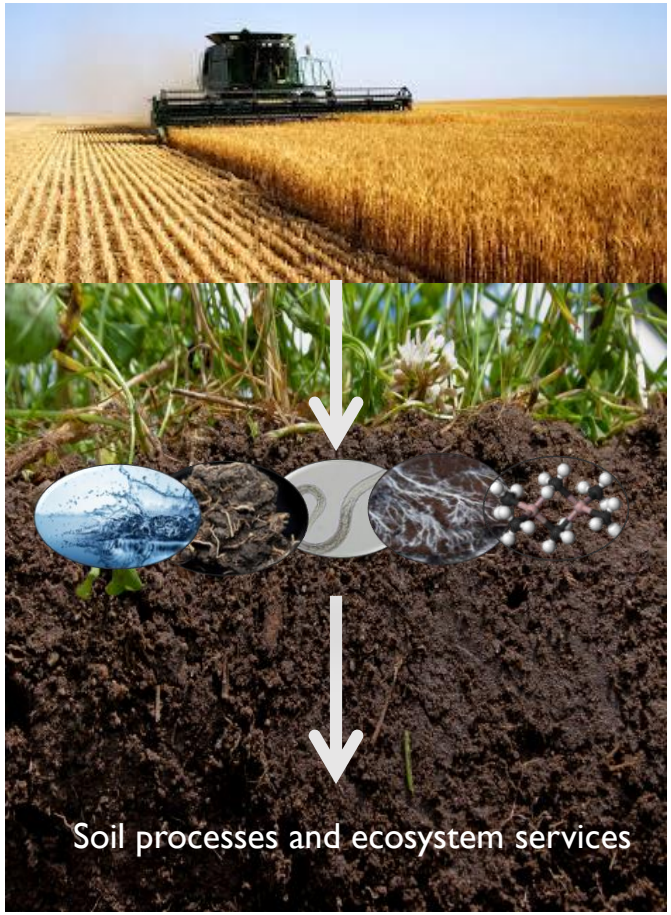
European Commission

Literature review: Soil quality concepts



Traditional main interest in agricultural production and inherent soil properties

↓

Multifunctionality and dynamic soil properties (management)

↓

"The capacity of a soil to function within ecosystem and land-use boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health."

(Doran & Parkin, 1994; 1996)

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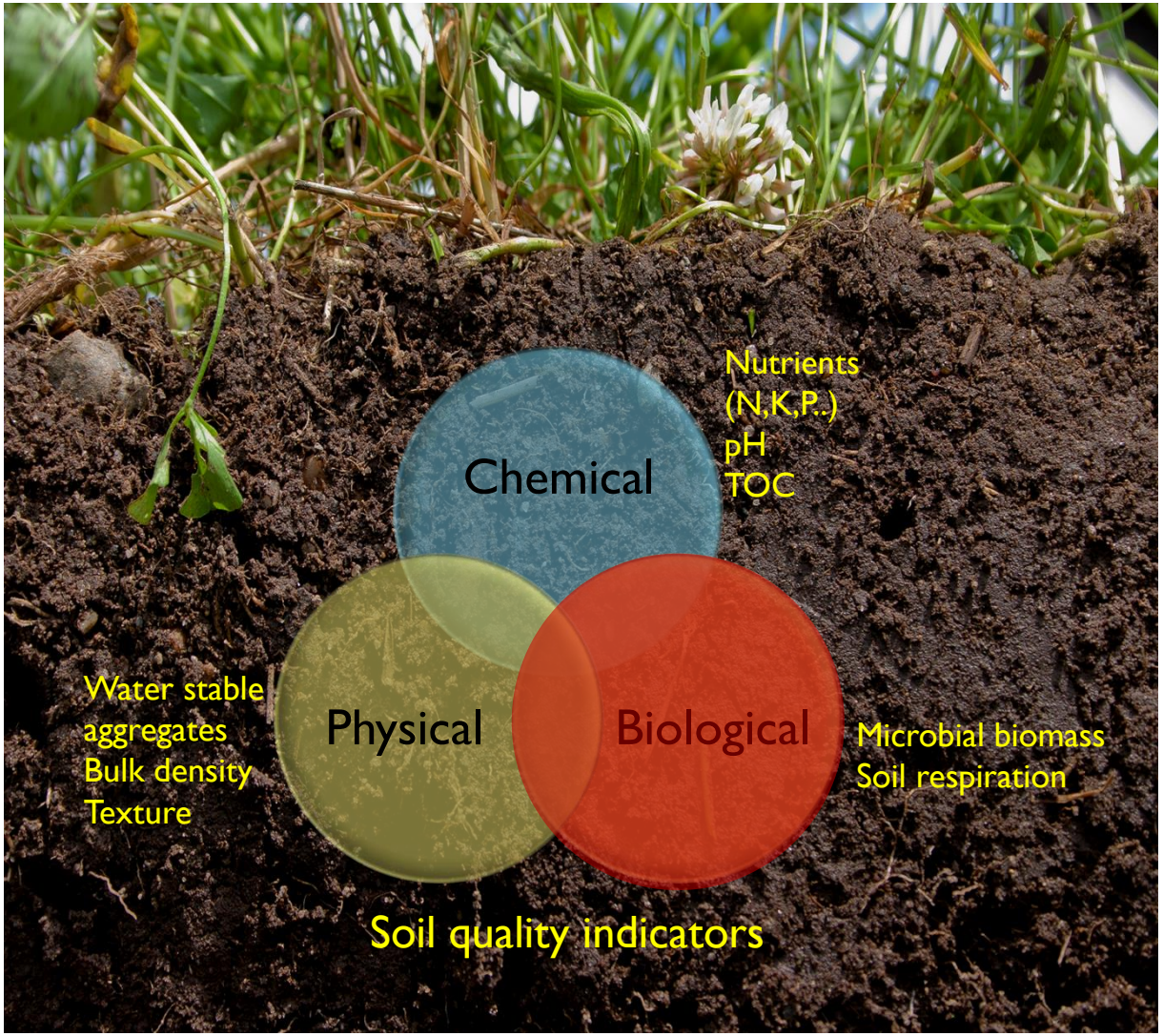
Bünemann et al., 2018

How to measure soil quality?



- Easily measurable
- Reproducible
- Inexpensive
- Interpretable
- Sensitive
- Correlated with soil functions

Larson and Pierce, 1994; Faber et al., 2013; Bünemann et al., 2018

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Novel soil quality indicators

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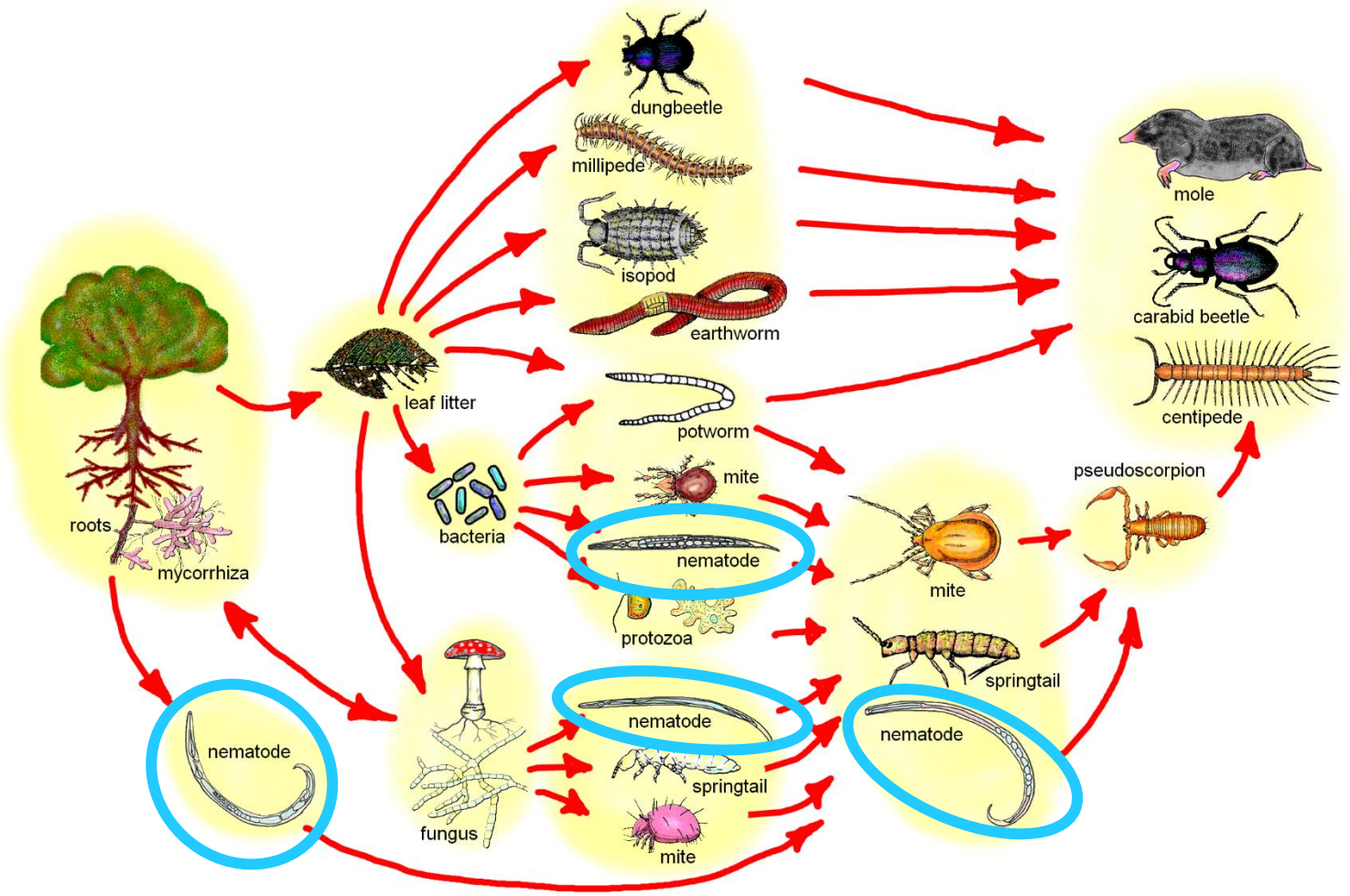
PhD Aim

Assess the suitability of novel soil quality indicators in agricultural systems.

Assess the sensitivity of nematode communities, characterized with molecular methods, to management practices and their linkage with other soil quality indicators (proxy for soil functions).

Nematodes as soil quality indicators



- Key role in the food web
- Link with soil processes
- Ubiquitous
- Sensitive
- Functional groups
  - *Trophic*
  - *Life strategies (c-p scale: 1 to 5)*
- Food web indices
  - *Maturity index*
  - *Structure index*
  - *Channel index*
  - *Enrichment index*

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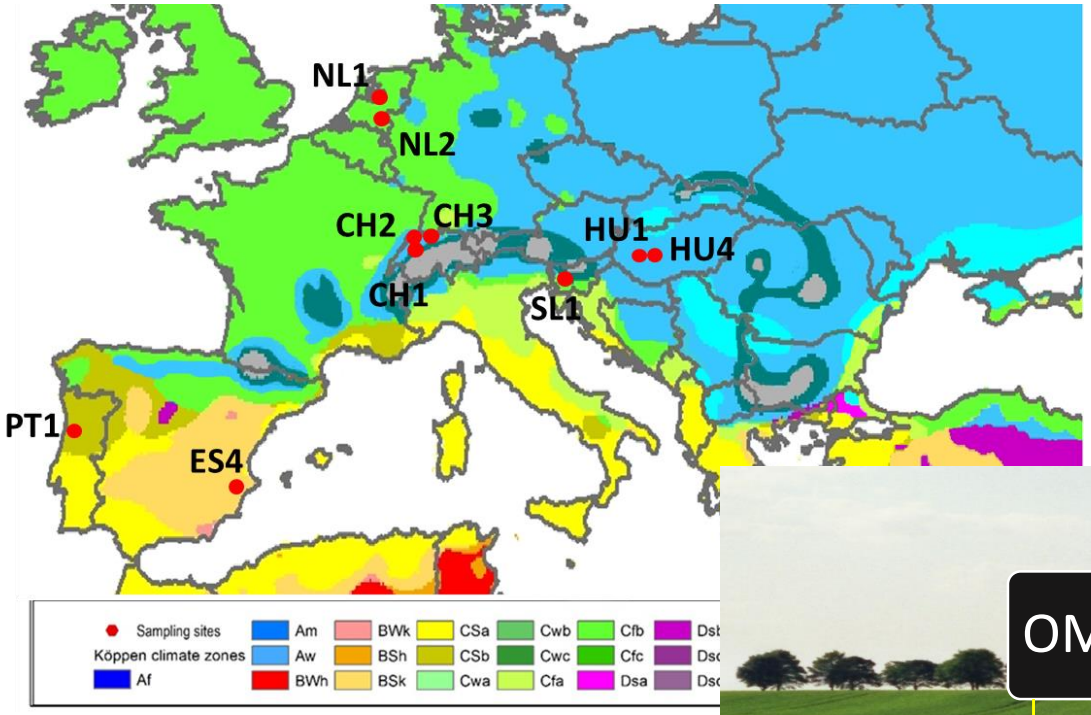
Molecular methods

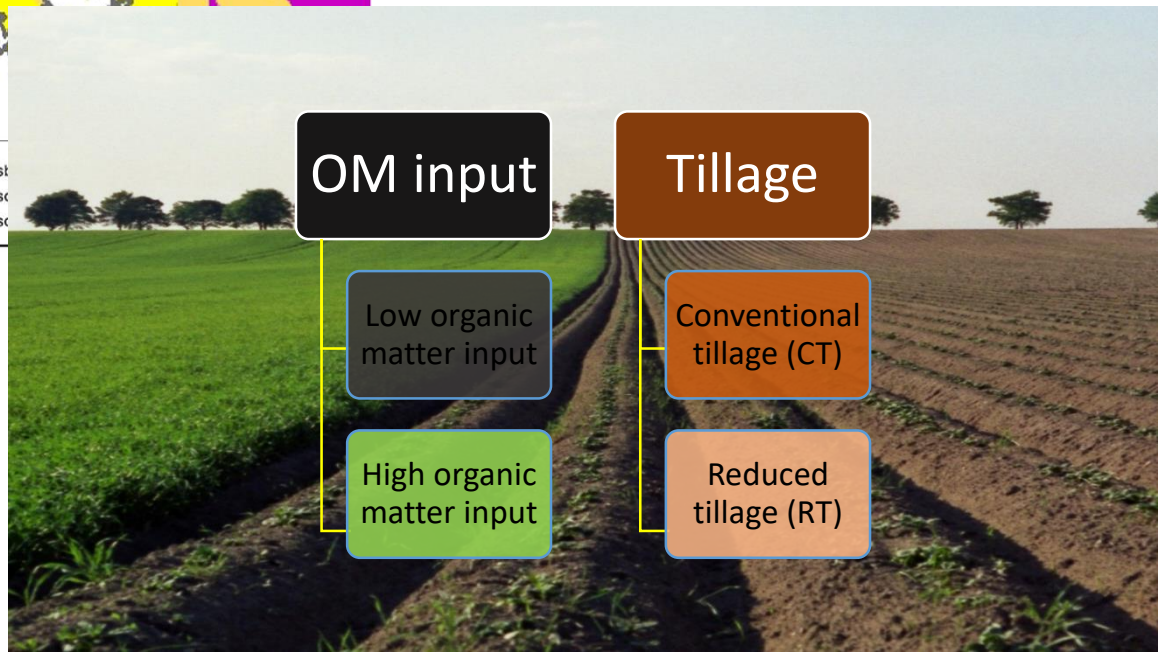
Why?

- High-throughput application
- Fast development and increased application
- Fast and accurate description of biodiversity (cryptic species)
- No need of specialist for morphological characterisation
- Reducing costs
- Targeted study

(Ahmed et al., 2015; Geisen et al., 2018)

Long-term field experiments and Management





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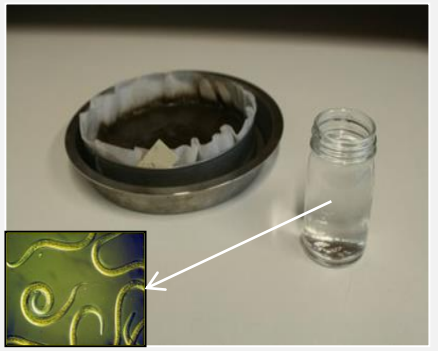
Nematode DNA extraction

100 g fresh soil

Nematode extraction

Oosterbrink elutriator

Nematode solution



Concentration

DNA extraction

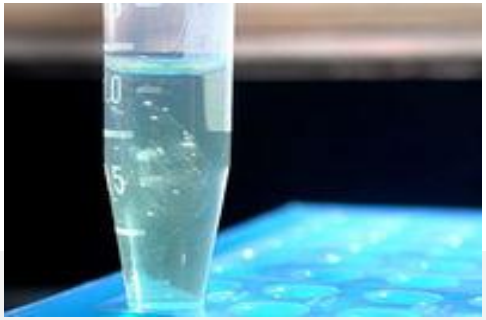
Lysis

DNA purification

Glass fibre column-based

Vervoort et al., 2012

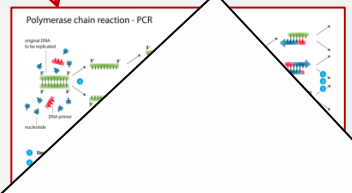
General primer for eukaryote used



DNA stored at -20˚C and -80˚C

18S SSU rDNA
(Geisen et al., 2018)

PCR



GenomeQuébec

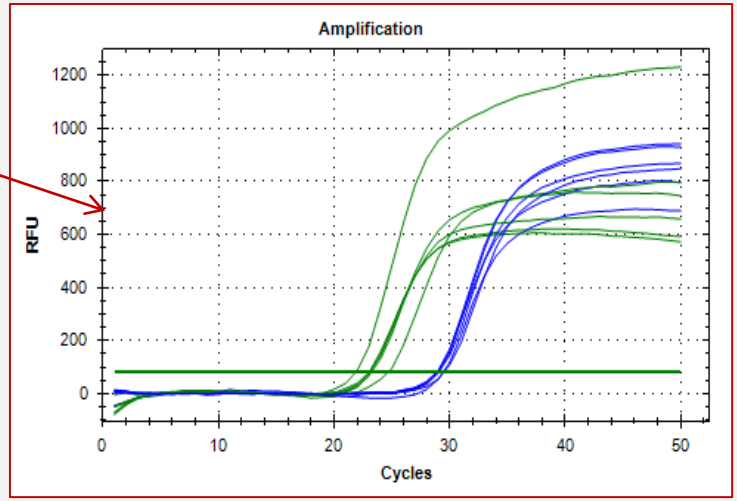
id relative

ce

SSU rDNA

qPCR

Quantification:
- Total nematodes
- Specific taxa
(Vervoort et al., 2012)



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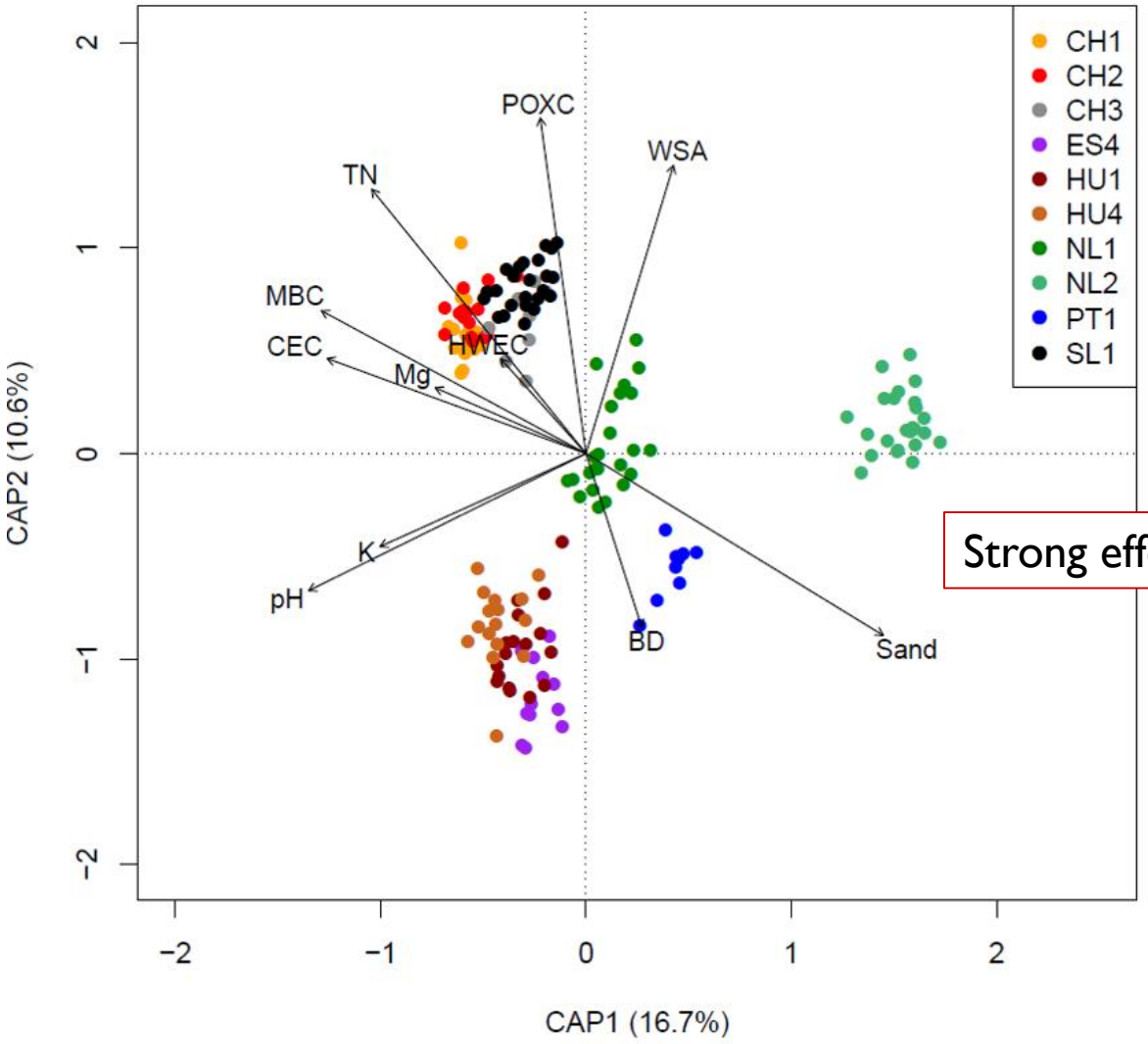
Nematode community analysis
Constrained analysis of principal coordinate (CAP)

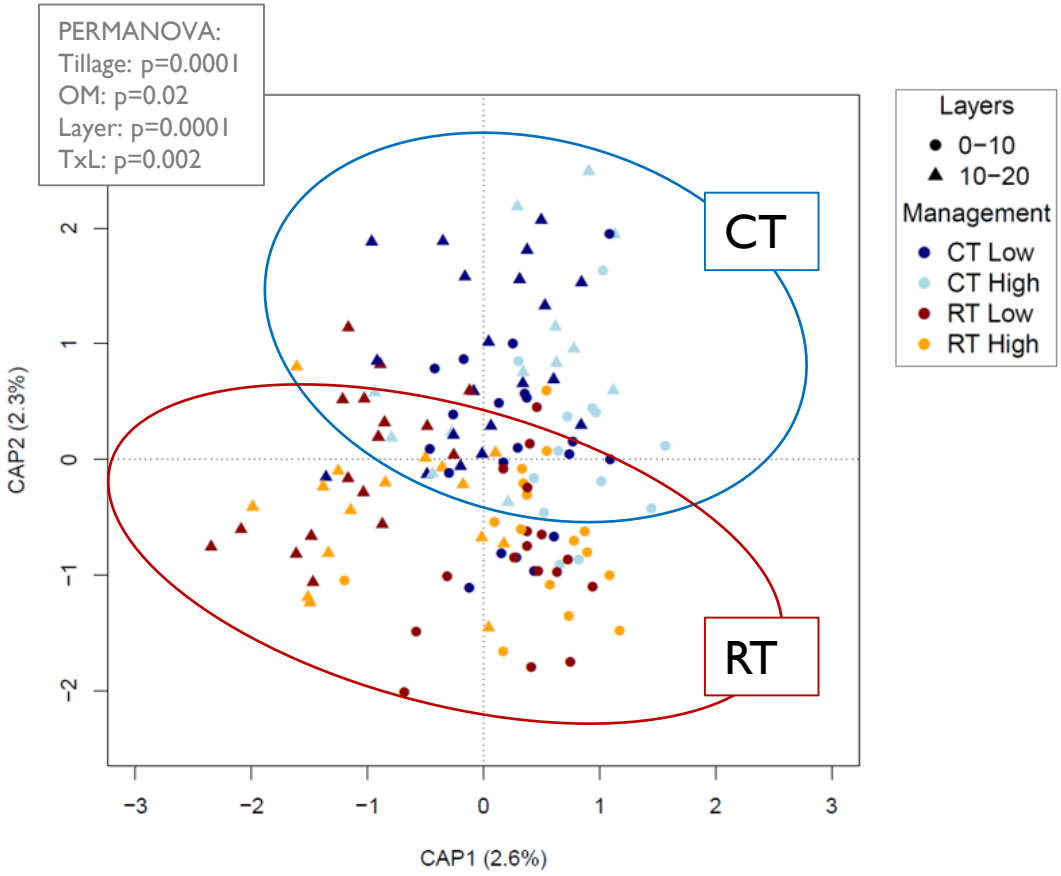
PERMANOVA:
Site: p<0.0001



Strong effect of the site!

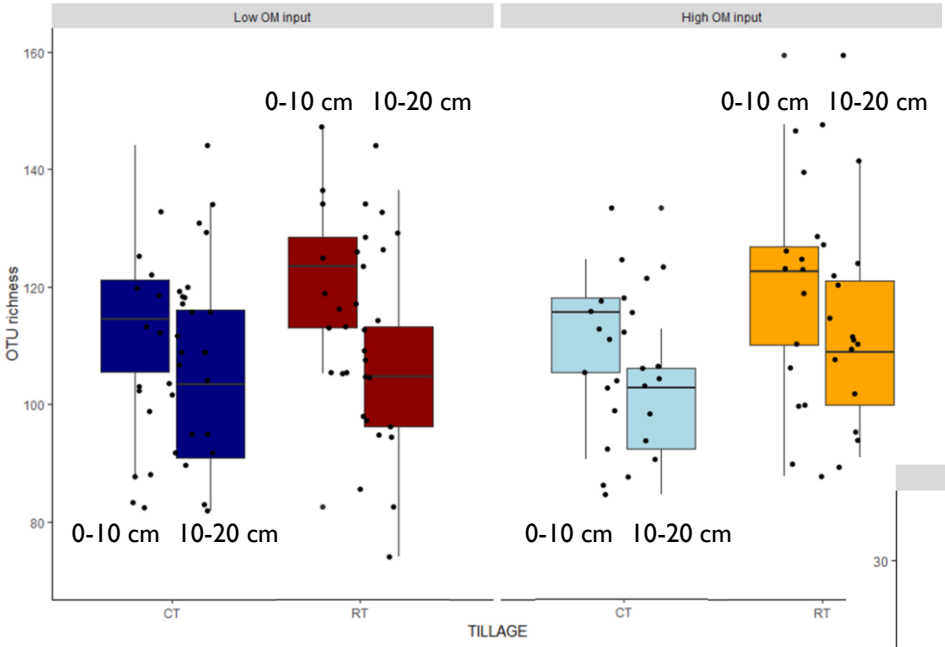
Bongiorno et al, 2019. Molecular Ecology

Tillage and OM addition affect nematode community composition - CAP



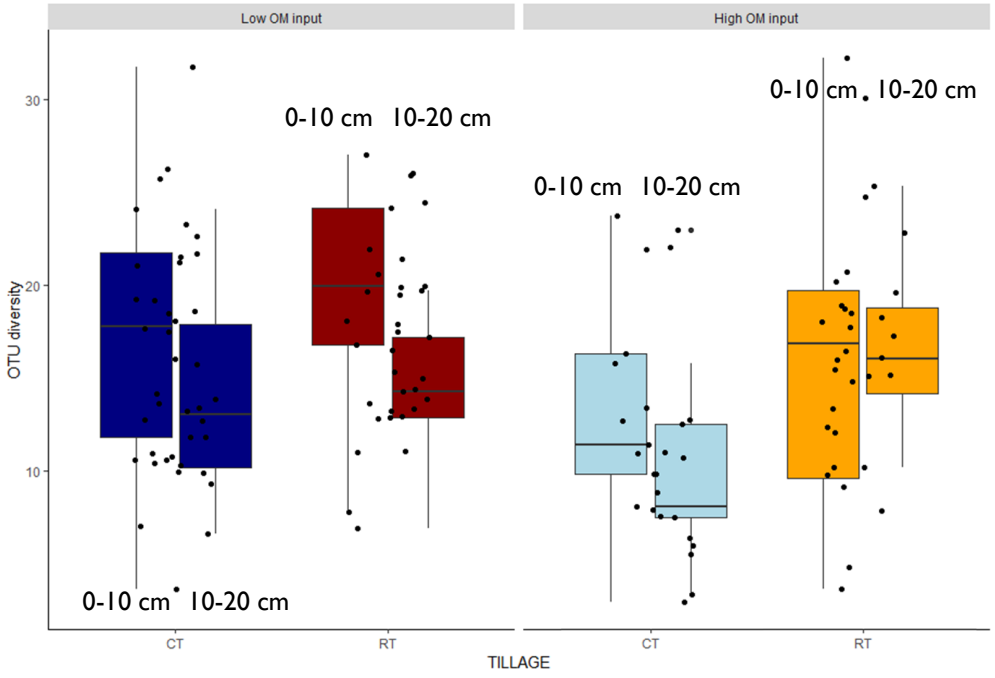
Effect of tillage higher than OM additions.

Higher OTU richness and diversity in reduced tillage compared to conventional tillage



Mixed model results:
Tillage: p=0.02
OM: p=0.13
Layer: p=<0.0001

Mixed model results:
Tillage: p=0.004
OM: p=0.05
Layer: p=0.007



Total and labile carbon, total N, available K, microbial biomass and respiration, and BD most explained nematode abundance and richness

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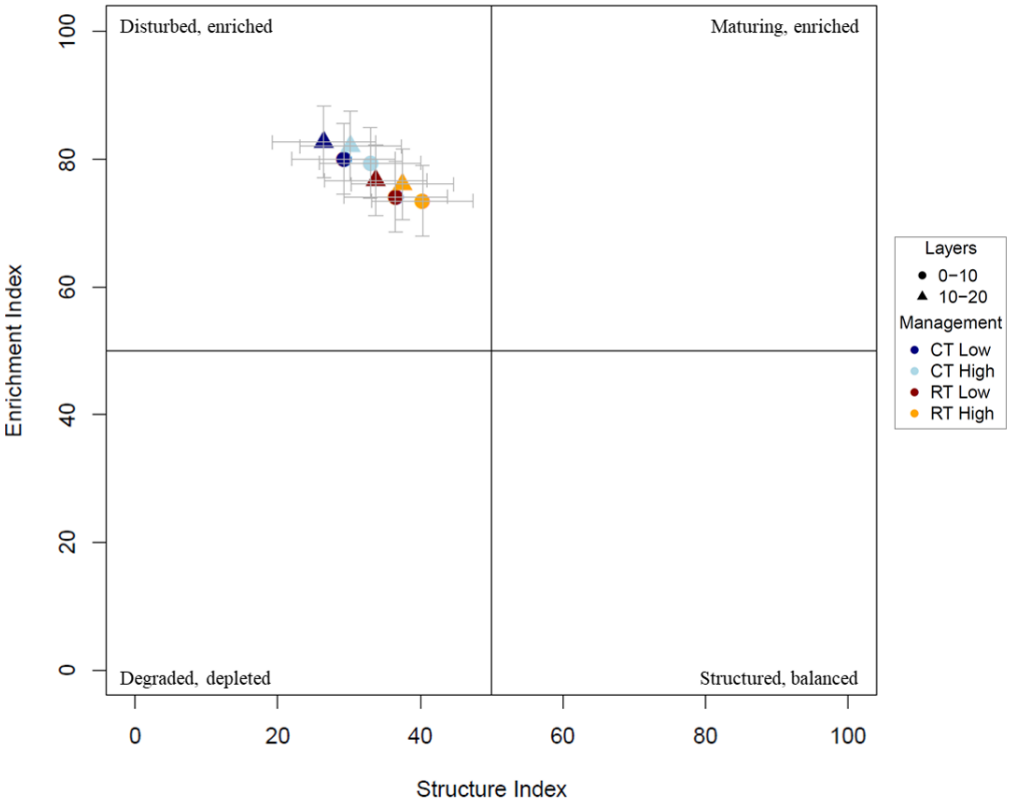
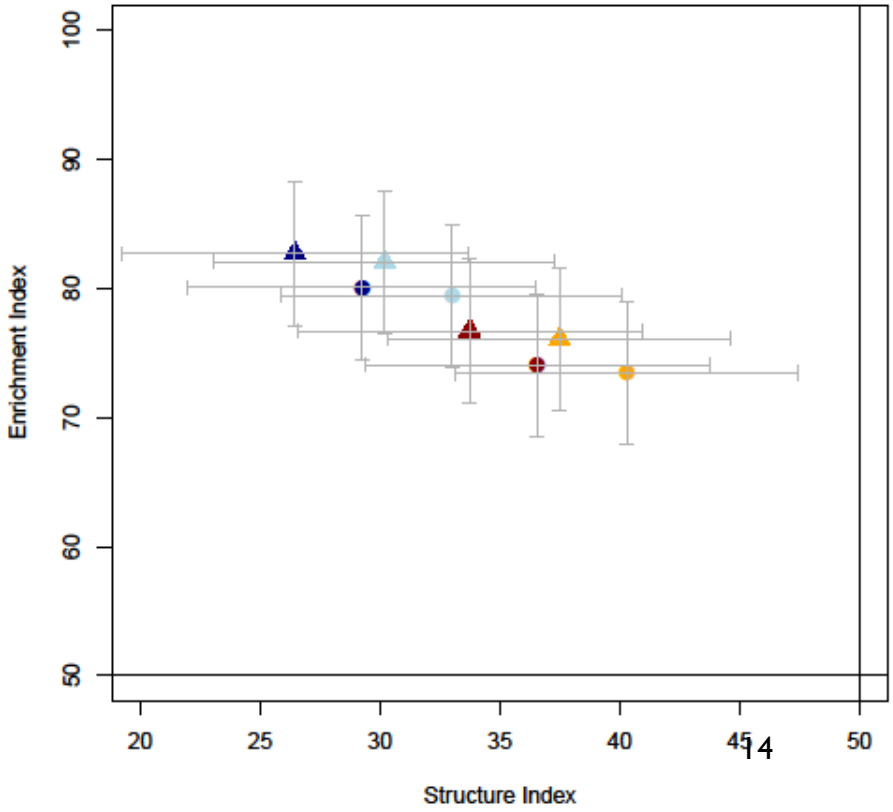
Tillage and OM addition affect food web indices



Reduced tillage had higher structure (SI) and stability (MI), lower enrichment (EI) and enhanced channel index (CI) while OM had lower CI and higher bacterivorous nematodes (% and total numbers)



But….reduced tillage had higher herbivorous nematodes (% and absolute numbers)

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Summary

- Effect of management found despite the high variation in LTEs
- Stronger effect of tillage than OM addition
- RT increased nematode richness, diversity, maturity index (MI), structure index (SI), channel index (CI), and herbivorous nematodes
- High OM addition decreased CI and increased bacterivorous nematodes
- Total and labile C, available K and microbial parameters explained nematode diversity and structure
- No useful indicator OTUs found

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Discussion and conclusion

- Importance of positive soil quality conditions and negative effects created by the reduced tillage (more oligotrophic system)
- High organic matter addition favoured a more copiotrophic system (lower CI and more bacterivorous nematodes)
- Tillage exerts a strong influnce on nematodes, OM nature probably more important → need to characterize better OM addition quality
- Very disturbed system → no indicators OTUs found
- Nematode communities suitable soil quality indicator, but challenges: optimization and standardization, analysis, interpretation

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Pros

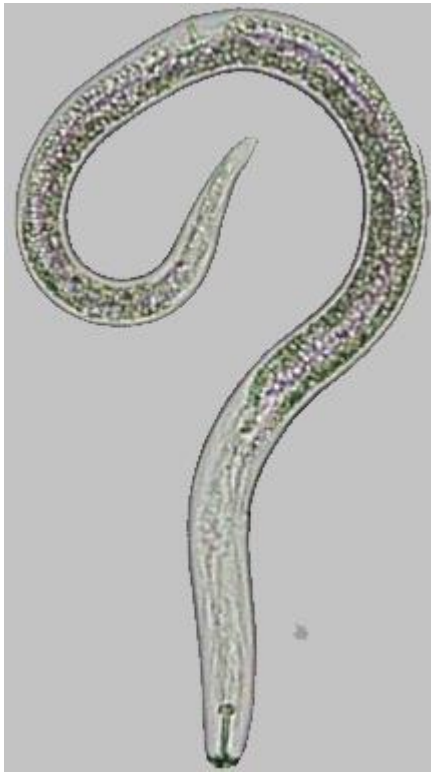
- All the eukaryotes are targeted (majority of nematodes and possible parasites)
- Possible detection of juveniles and cryptic species
- No need of taxonomic specialist
- Cheaper than morphological methods
- Food web indices and trophic groups give an idea of functioning
- Found patterns in agreement with morphological characterisation

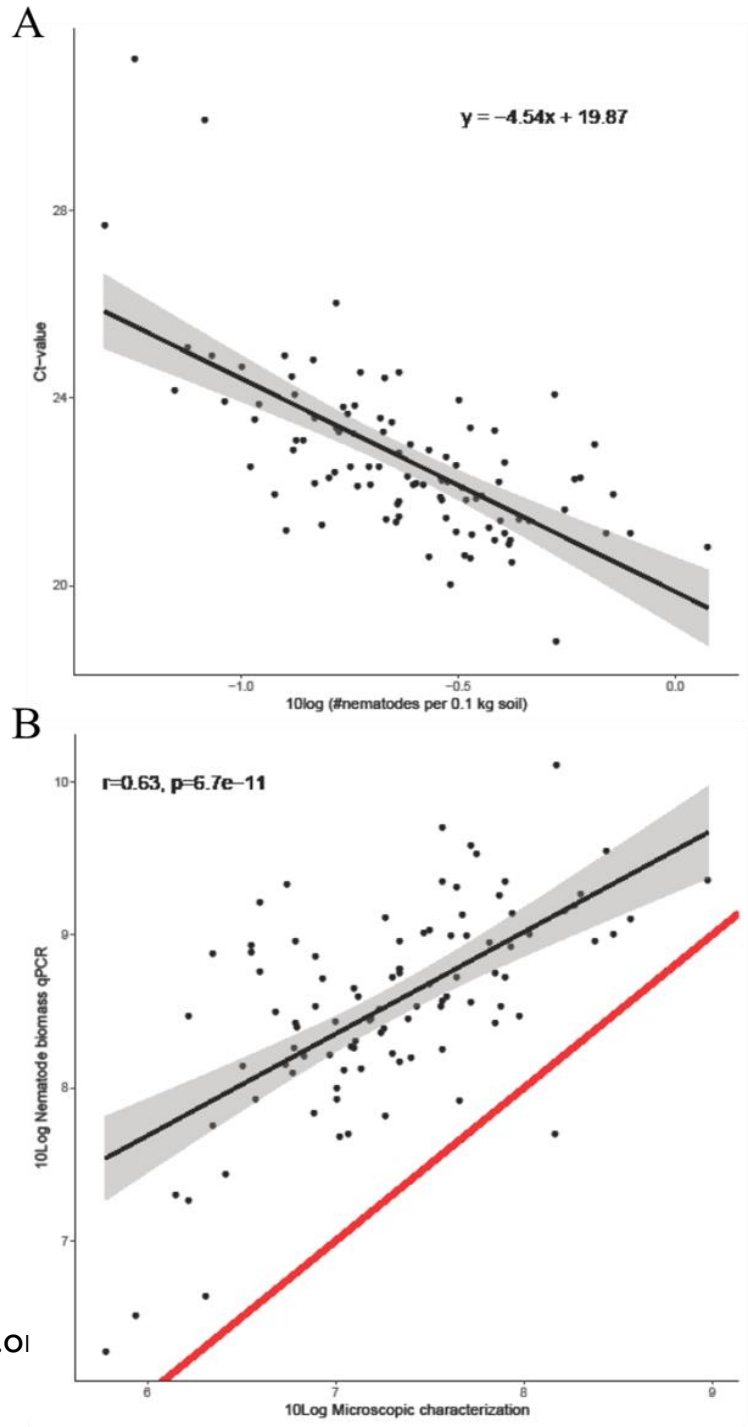
Cons

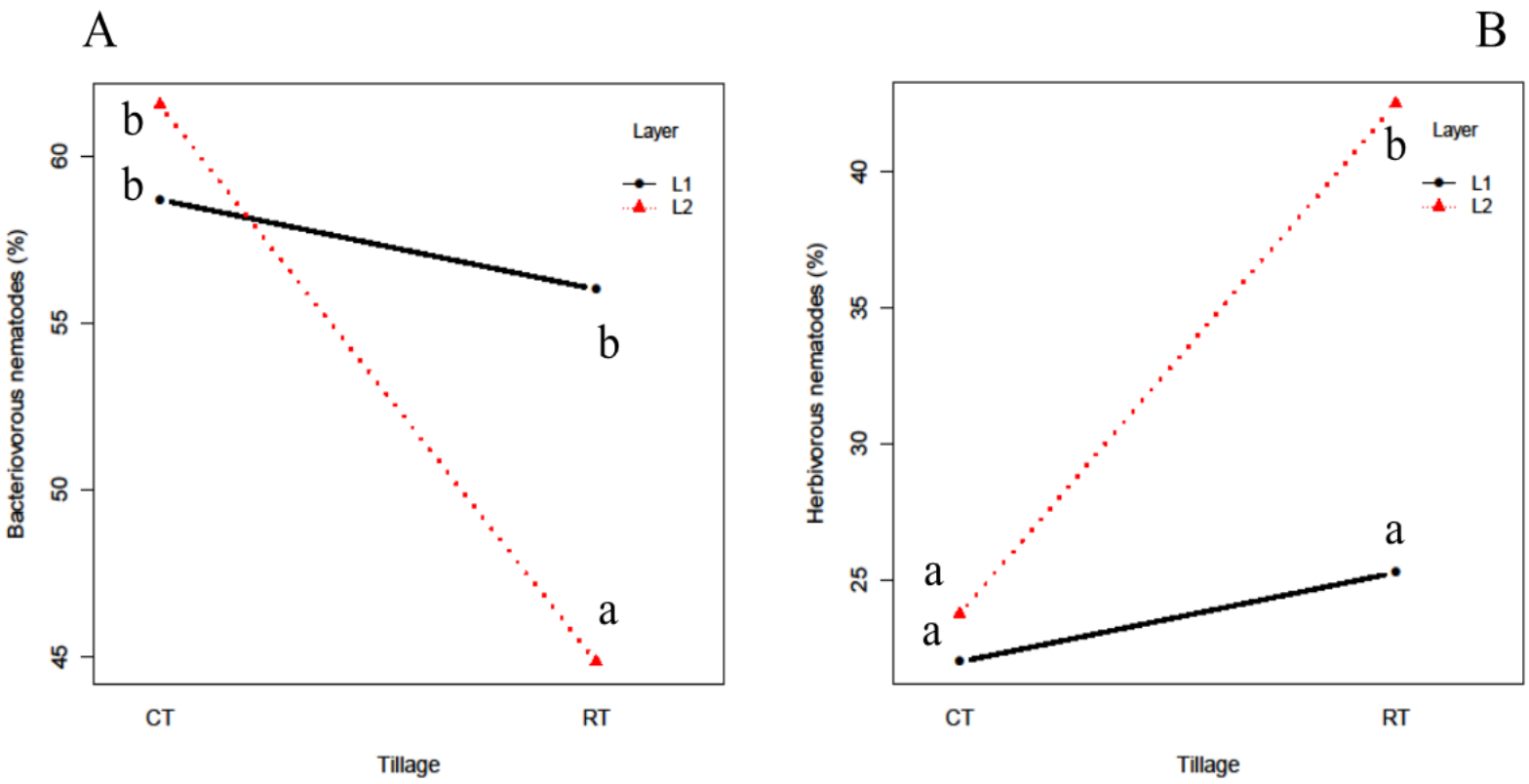
- Multiple copies of the targeted region dependent on the size of the nematodes (relative abundances)
- Discrepancies with morphological identification (new species?)
- Database not complete (NA=difficult to assign ecological relevant groups)
- Targeted region very long (problem with bioinformatics)
- Specialist needed for analysis and bioinformatics
- Variable taxonomy depending on the pipeline

Thank you for the attention!

Questions?




A
y = −4.54x + 19.87
Ct−value
28
24
20
−1.0
−0.5
0.0
10log (#nematodes per 0.1 kg soil)
B
r=0.63, p=6.7e−11
10Log Nematode biomass qPCR
10
9
8
7
6
7
8
9
10Log Microscopic characterization


A
B
Bacteriovorous nematodes (%)
Herbivorous nematodes (%)
Tillage
CT
RT
Layer
L1
L2
a
b