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# Disentangling the effects of litter quantity and quality on soil biota structure and functioning: *application to a cultivated soil in Northern France*

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# Impacts of cultural practices on soil biota

## Cultural practices



Alteration

Alteration



## Soil organisms

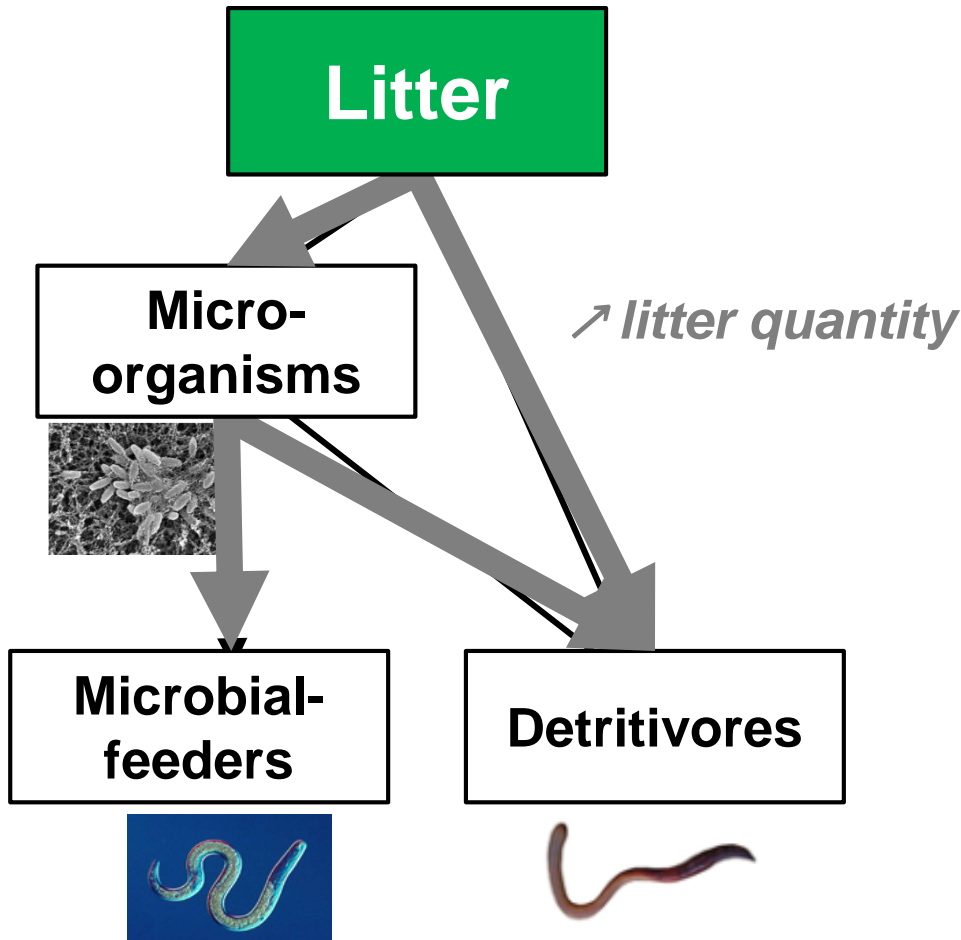
?

## Soil functions:

- Respiration versus C storage
- Nutrient recycling ...

# Litter quantity effects on soil food web

Crop residues → Main trophic resource for arable soil organisms (Kim & Dale, 2004)



Δ quantity:  
crop residues exportation / restitution



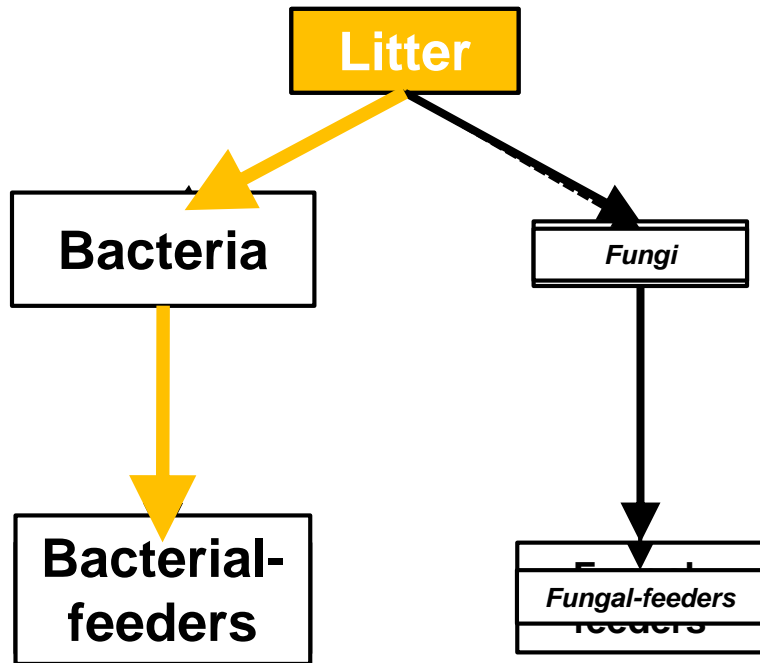
↗ Microbial biomass  
(Spedding et al., 2004; Govaerts et al., 2007)

→ Few information at the higher trophic levels

*Is litter quantity increasing the biomass of soil fauna?*

# Litter quality effects on soil food web

Crop residues → Main trophic resource for arable soil organisms (Kim & Dale, 2004)



↗ litter quality

$\Delta$  quality:  
choice of the crop in the rotation  
(Sauvadet et al., 2016)



→ Few information on fauna in cultivated soil

*Is litter quality increasing the bacterial energy channels?*

## *How can litter quantity and quality affect soil food web composition and functions in cultivated soils?*

### Litter incorporation (0-15 cm) into 8 m<sup>2</sup> plots (4 blocks)



- Without litter
  - 5 t.ha<sup>-1</sup> Pea
  - 10 t.ha<sup>-1</sup> Pea
  - 10 t.ha<sup>-1</sup> Barley
- Labile – high quality litter
- Quantity effect
- Quality effect
- Recalcitrant – low quality litter

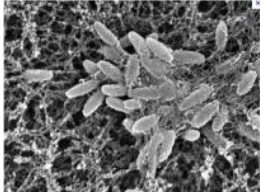
→ Results presentation after 7 months

# Material and methods

## Food web composition ( $mg\ C \cdot m^{-2}$ )

**Bulk soil 0 – 10 cm**

**Total microorganisms & fungi**



Microbial biomass C & Ergosterol

**Soil corers 5 cm  $\varnothing$  – 10 cm depth**

**Nematodes**



Baermann extraction

**Collembola**



Berlese-Tullgrenn extraction

**Mites**



**Hand sorting** (soil cubes 25 cm x 25 cm x 25 cm)

**Earthworms**



**Macroarthropods**



## Food web functions

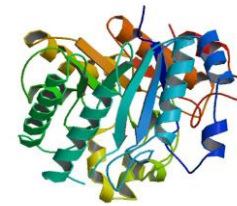
**Incorporated litterbags (8cm depth)**

**Litter mass loss**



**Bulk soil 0 – 10 cm**

**Soil N mineral content**  
**Enzymatic activities** (Bell et al., 2013)

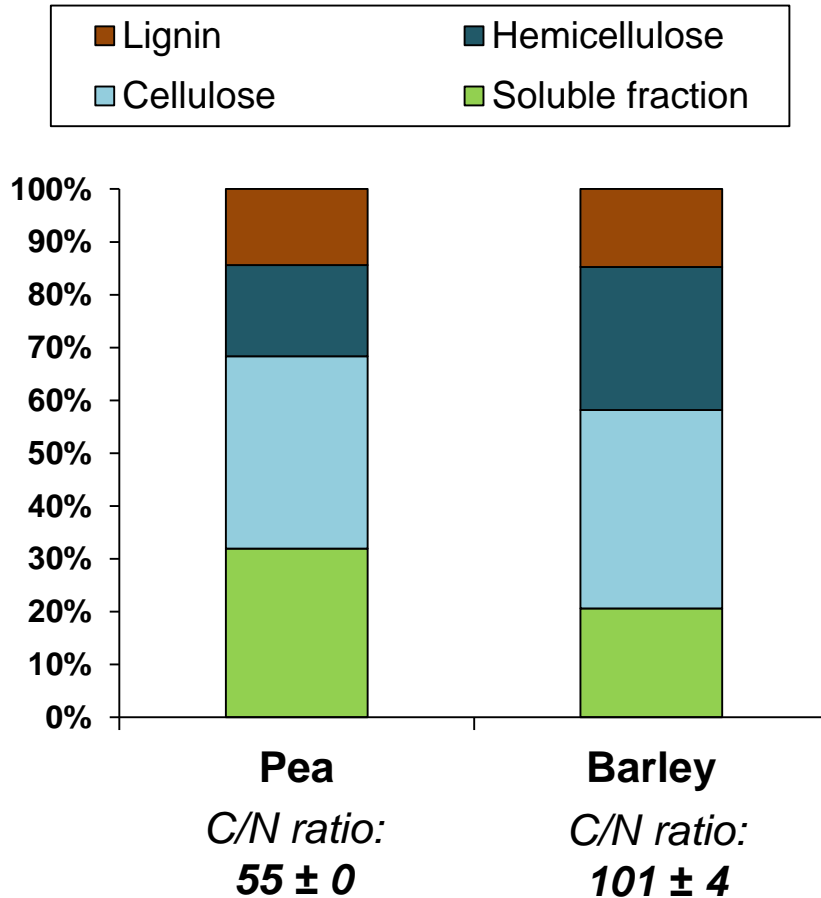


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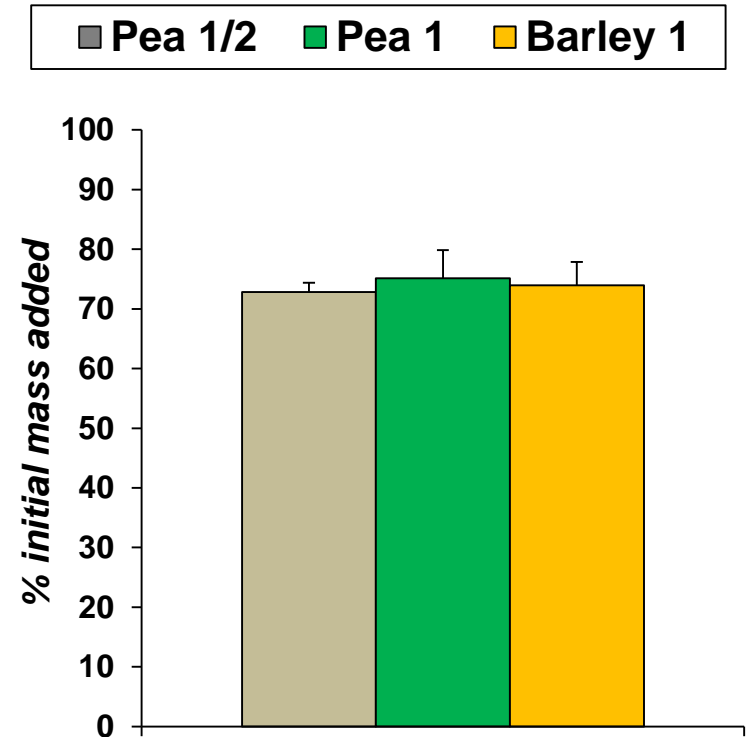
- C hydrolytic enzymes
- N hydrolytic enzymes
- Oxidative enzymes

# Litter decomposition

## Litter initial qualities



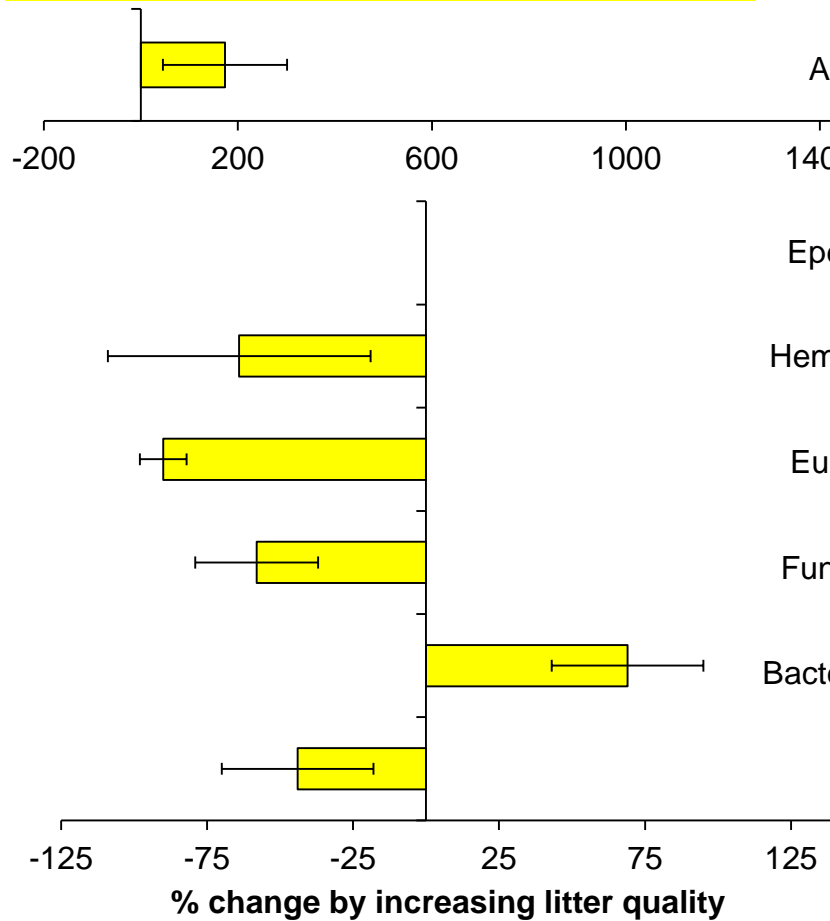
## Litter mass loss after 7 months



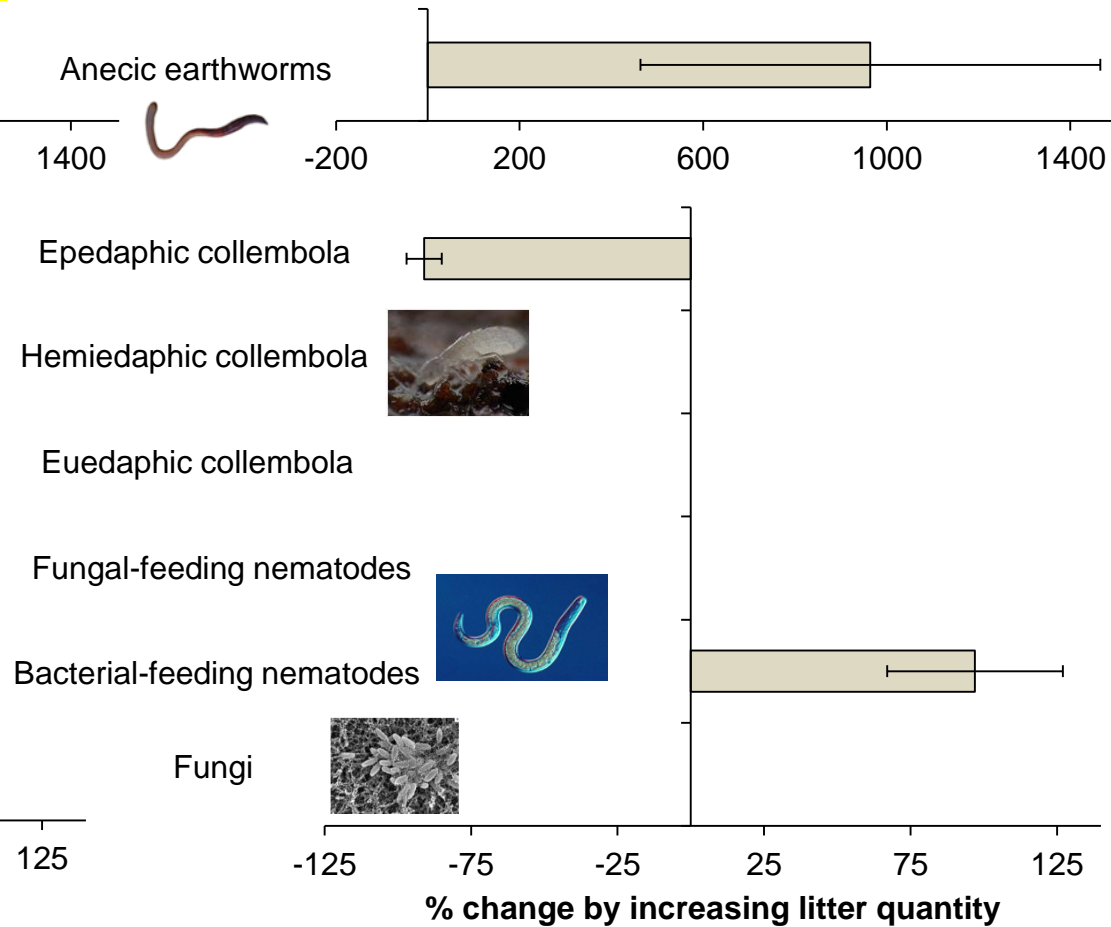


# Quality – quantity effects on soil food web composition

**Quality effects: Barley → Pea  
10t.ha<sup>-1</sup>**

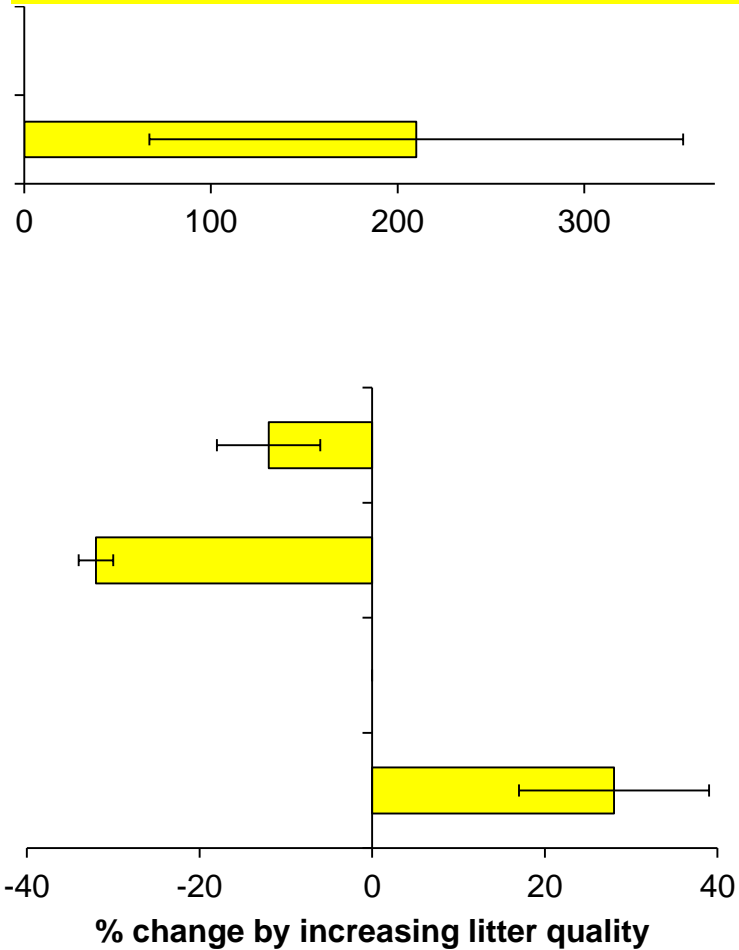


**Quantity effects: Pea  
5 t.ha<sup>-1</sup> → 10 t.ha<sup>-1</sup>**

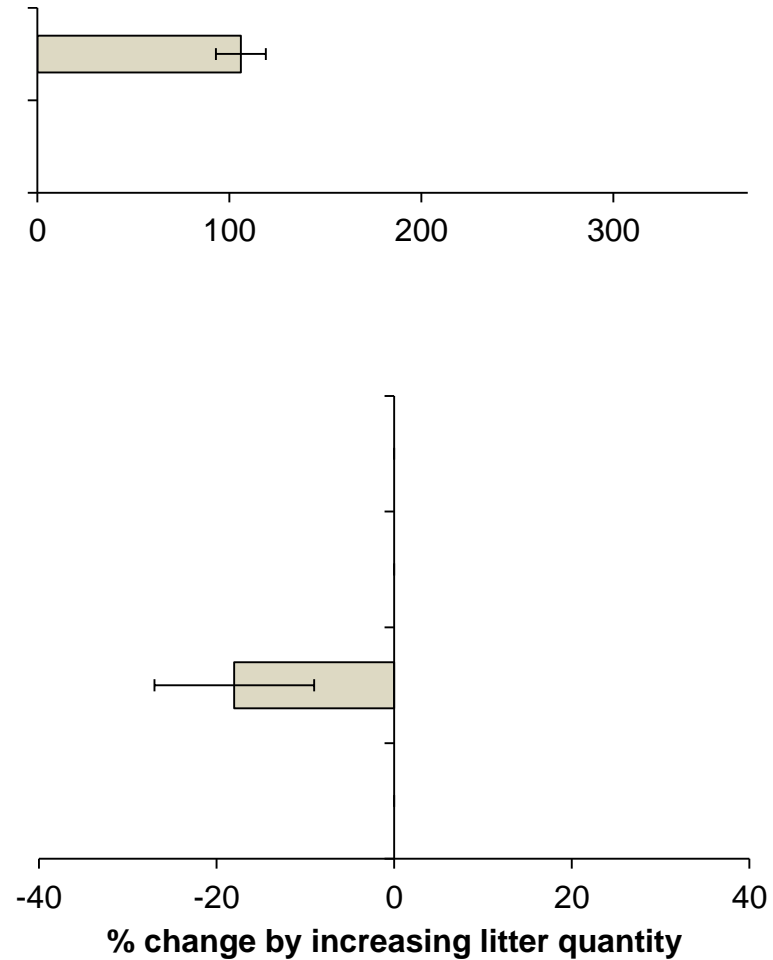


# Quality – quantity effects on soil food web functions

## Quality effects: Barley → Pea 10 t.ha<sup>-1</sup>



## Quantity effects: 5 t.ha<sup>-1</sup> → 10 t.ha<sup>-1</sup>

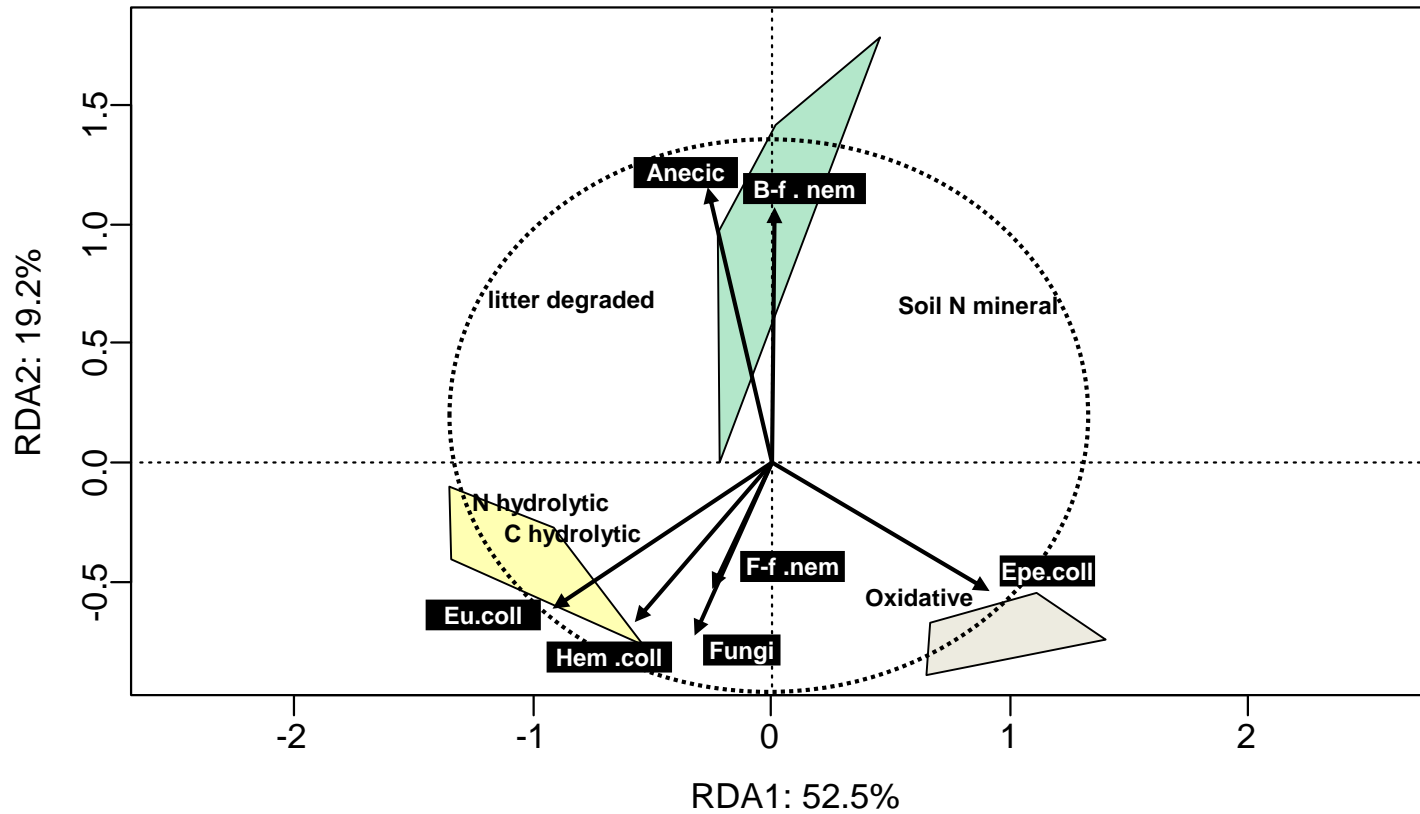


# Linking soil food web composition and functions

5 t.ha<sup>-1</sup> Pea

10 t.ha<sup>-1</sup> Pea

10 t.ha<sup>-1</sup> Barley



↗ Litter quality

↘ fungal : bacterial pathway

6 groups impacted  
Amplitude change  $\approx 85\%$

↘ N enzymatic demand from biota

*Selection of biota with different N acquisition strategy?*

↗ Litter quantity

↗ detritivores size

3 groups impacted  
Amplitude change  $\approx 385\%$

↗ amount of litter degraded by biota

*Long term impact on soil C?*

**Possibility to use litter addition in specific quantity and/or quality to favor one specific ecosystem service or restore one specific functional group?**

# Acknowledgments

## Projet SOFIA (Soil Functional diversity as an indicator of sustainable management of Agroecosystems)

Million S. & F., Alavoine G., Thiébeau P., Delfosse O., Habrant A., Portelette A., Chiter K., Henneron L., Brunet N., Chauchard B., Villenave C., Recous S., Lashermes G.



# Acknowledgments

## Poster: session 34



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Context	Objectives
Anthropogenic pressures on agricultural soils are known to alter their biodiversity, which may affect the capacity of ecosystems to deliver functions and services according to the hypothesis on diversity – function relationship. Cropping systems is fueling belowground biota through the litter supplied, which varies in quality from year to year.	<ul style="list-style-type: none"> <li>Studying the impacts of the decomposition of litter contrasting qualities on soil micro-food web communities.</li> <li>Comparing the relationships between community structure and functioning for the two types of litter and with or without an ecosystem engineer (<i>L. terrestris</i>).</li> </ul>

Study approach		
Soil sampling in the Estrees-Mons SOERE	Incorporation of litter Maize roots → Ro Maize leaves → Le No addition → Co	Incubation at 15°C in microcosms
Variables followed: at 0, 15, 35 and 91 days after incubation (n=4)		
<ul style="list-style-type: none"> <li>Litter decomposition: C mineralization &amp; litter chemical quality (sugars, lignin and soluble)</li> <li>Soil communities: Bacterial and fungal communities (16S and 18S pyrosequencing); Nematodes communities (Baermann extraction)</li> <li>Soil enzymatic activities: hydrolytic C (<math>\beta</math>-glucosidase, CBH, <math>\beta</math>-xylosidase) and oxydative (phenol oxydase and peroxydase)</li> </ul>		

Fig 1: Communities dissimilarities from soil without litter addition.

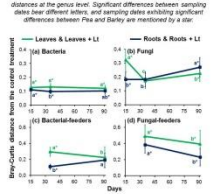


Fig 2: Enzymatic efficiencies.

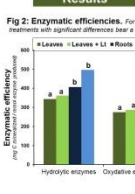
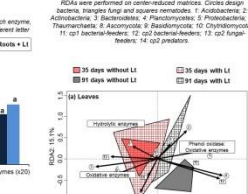


Fig 3: Redundancy analyses (RDAs) of enzymes constrained by the main micro-food web components.



**Discussion and Conclusions**

Bacterial pathway was more differentiated with leaves than roots addition for each sampling date (Fig 1), supporting the common paradigm that this pathway better develops on labile compounds. On the other hand, despite our expectation, fungal community was more differentiated at the earliest stage of decomposition with leaves addition (Fig 1), due to the preferential increase of Ascomycota taxa (Sauvadet et al., 2016), which are known as cellulolytic fungi.

We found contrasting relationships between soil biota structure and functions for leaves and roots decomposition (Fig 2). We assumed that this contrast contributed to the better enzymatic efficiencies for roots degradation (Fig 2). Overall, the presence of *L. terrestris* did not change microbial community structure (data not shown). However, enzymatic efficiency of some hydrolytic enzymes were slightly improved (Fig 2) and altered the relationships between structure and functions (Fig 3). We assumed that *L. terrestris* endogenous biota took over a part of the decomposition otherwise realized by soil microorganisms.

Acknowledgment: the ANR project SCOFIA which financed this work, the research teams of INRA Rennes/Dijon and of Rouen/Rennes Universities.

## More informations:

- Sauvadet et al. (2016) Applied Soil Ecology, 107: 261-271
- Sauvadet et al. (2016) Soil Biology & Biochemistry 95: 262-274

# Thank you for your attention