ASEA

Agroecology in SouthEast Asia

1st ASEA PhD Days

Virtual meeting

1st - 2nd December, 2021 | 14:00-17:00 GMT+7

A view on the **soil food web** in the rhizosphere of **rice** infected by **plant-parasitic nematodes** under **conservation agriculture**

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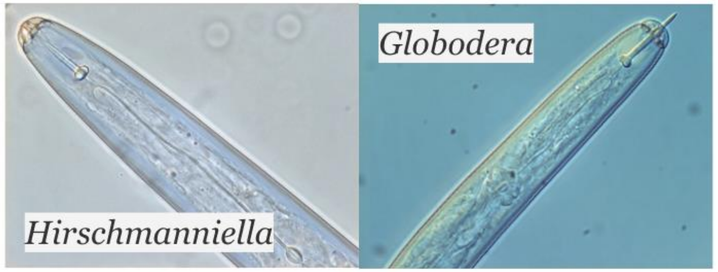
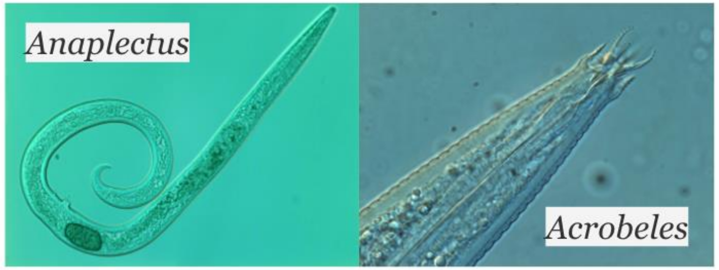
1st ASEA PhD Day | 1st - 2nd December 2021

INTRODUCTION - Soil nematodes - Their trophic modes

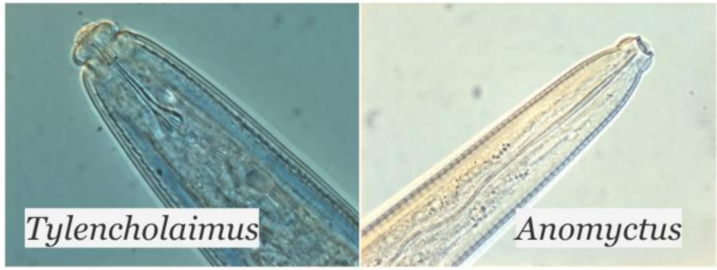
- Phytophages



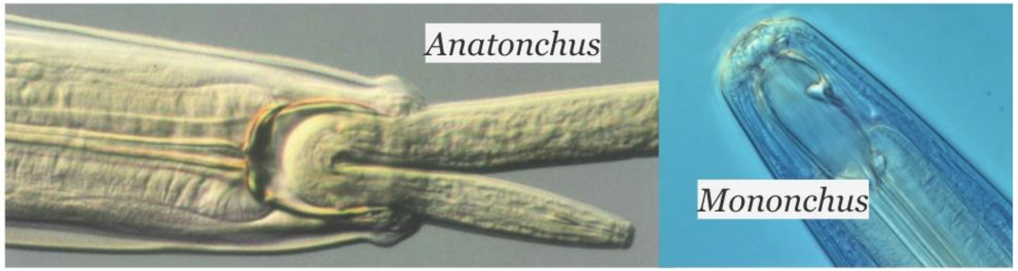
- Bacterivores



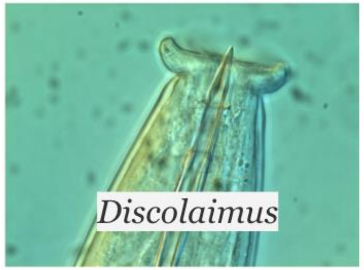
- Fungivores



- Carnivores

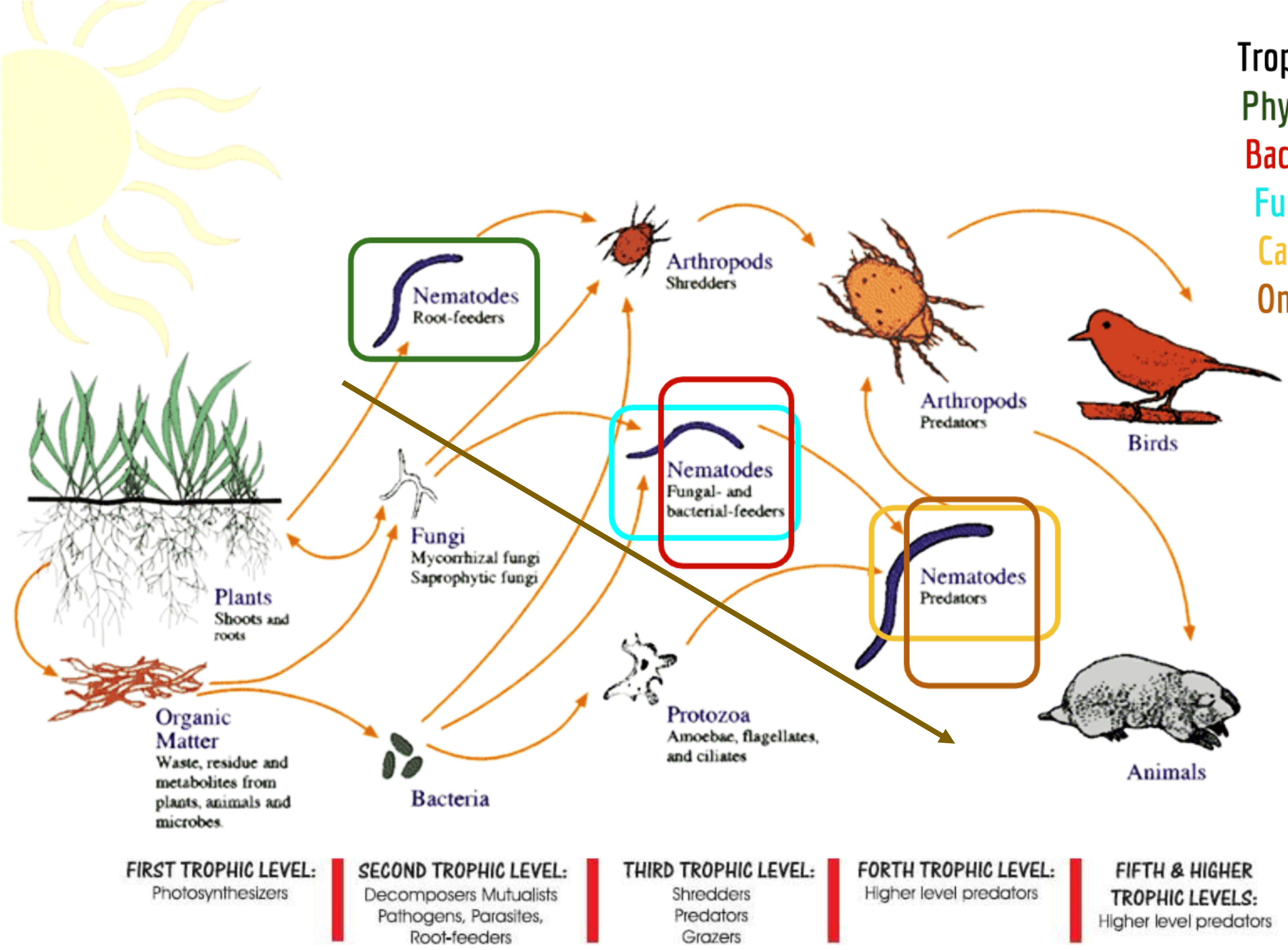


- Omnivores



Pictures from the Wageningen University & research website

INTRODUCTION - Soil nematodes - Within the food web



Adapted from Orgiazzi *et al.* (2016), Global Soil Biodiversity Atlas

Trophic guild:
Phytophages
Bacterivores
Fungivores
Carnivores
Omnivores

Life strategy:
colonizer-persister scale
cp1 = fast reproducers
↓
cp5 = highly sensitive to perturbations

Nematodes = excellent bioindicators of the soil health and functioning
(Bongers & Ferris, 1994)

Soil health is dependent on the maintenance of four major functions:

- carbon transformations
- nutrient cycles
- soil structure
- **regulation of pests and diseases**

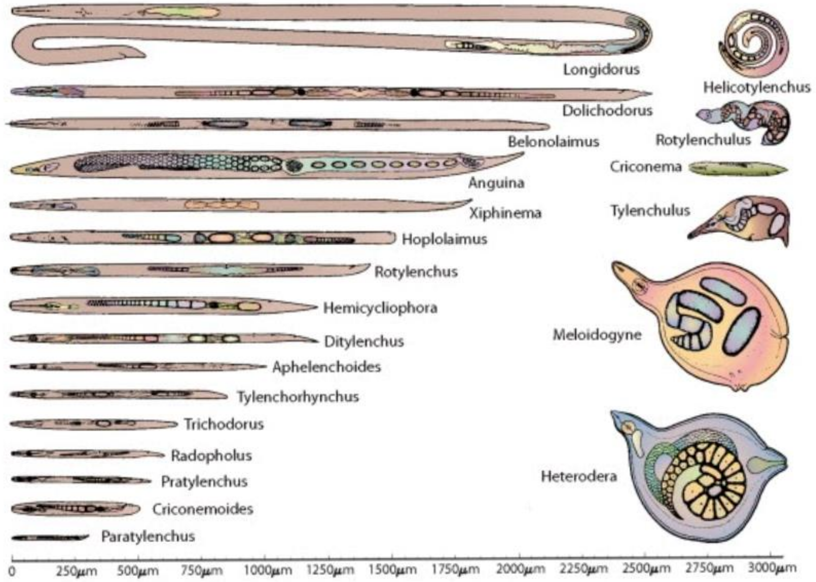
(Kibblewhite *et al.*, 2008)

INTRODUCTION - Plant-parasitic nematodes (PPNs)

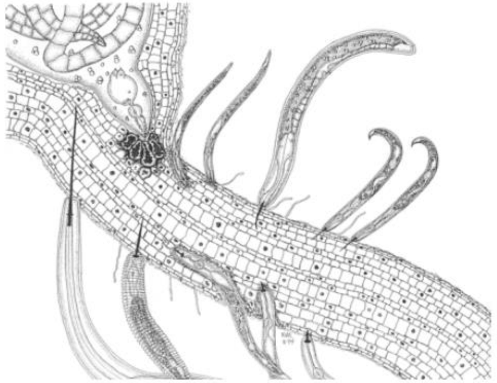
- **22 genera** of plant-parasitic nematodes = about **4,100 species** (Decraemer and Hunt, 2006) = 15% of the total number of nematode species currently known (Fuller *et al.*, 2008)
- **stylet** (*i.e.* a mouth spear) used to feed on plant cells and to inject molecules hijacking plant metabolism
- **important crop losses** = about $US80 billion globally each year (Nicol *et al.*, 2011)
- major losses are inflicted by **obligatory parasites** (Jones *et al.*, 2013)
  - root-knot nematodes (= *Meloidogyne* spp.)
  - cyst nematodes (= *Globodera* spp. and *Heterodera* spp.)
  - root lesion nematodes (= *Pratylenchus* spp.)

sedentary

migratory



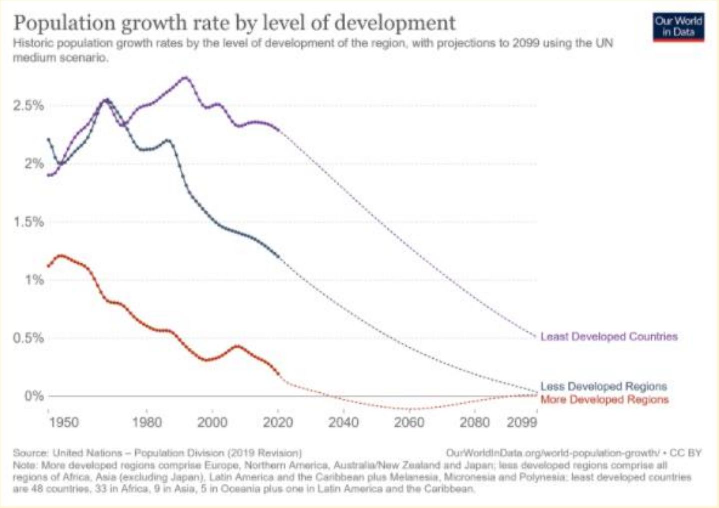
Agrios (2005), Plant Pathology



https://bpp.oregonstate.edu

CONTEXT - The plant-parasitic concern in rice fields is increasing

Socioeconomic conditions



⇒ Modifications of agricultural practices

⇒ **Crop intensification** (Stukenbrock and McDonald, 2008)

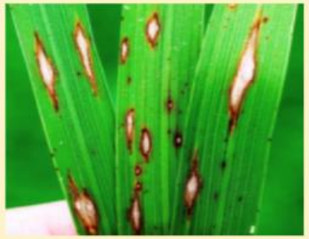
⇒ Biodiversity loss (Keesing *et al.*, 2010)

Plant-parasitic concern

⇒ **Emergence of the disease** caused by *Meloidogyne graminicola* (Ravindra *et al.*, 2017)

® Bellafiore

⇒ Higher susceptibility to other diseases (Kyndt *et al.*, 2017)



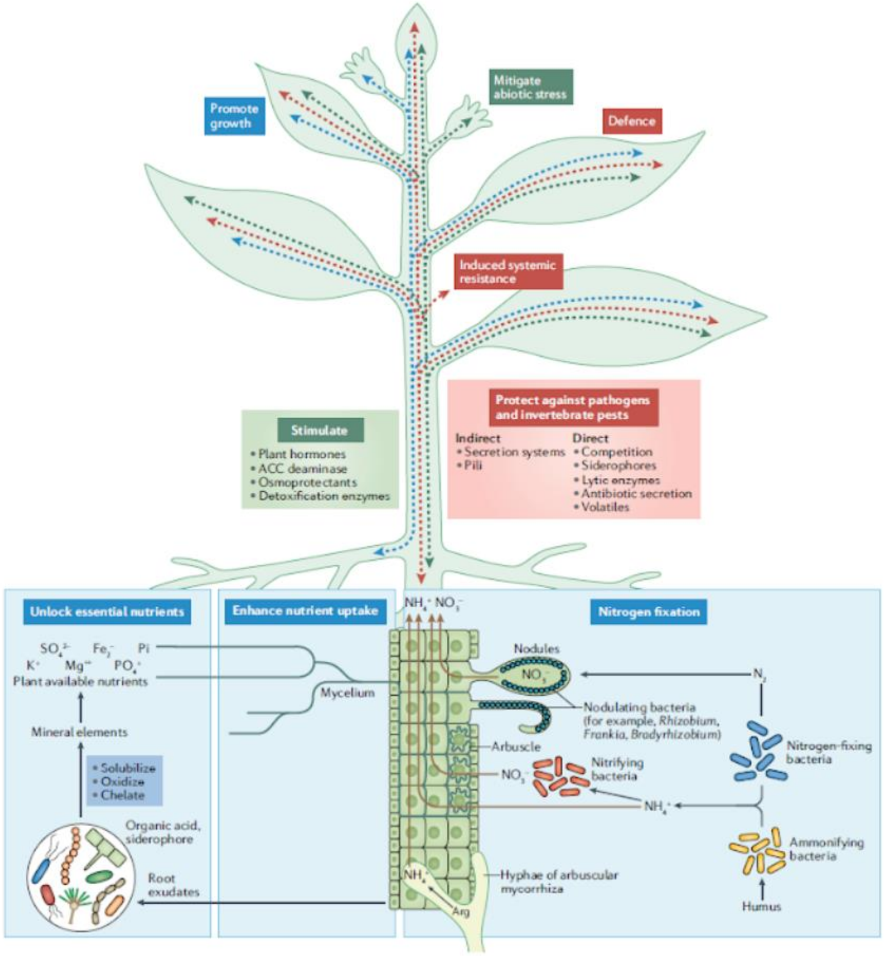
Environmental conditions

- Pesticide limitations (FAO Codex standards, 2020)
- Water shortage (De Waele and Elsen, 2007)

⇒ **Low disease control**

CONTEXT - The microbiodiversity can improve plant health

- Microbiota = the totality of the microbial communities in a specific environment
- The root-associated microbiota emerges as a novel trait that **extends the capacity of plants to adapt to the environment** (Bulgarelli *et al.*, 2013)
- phytobeneficial effects with microbes
  - growth promotion
  - abiotic stress control
  - defence against pathogens and pests
- Pathogens can cause little damage to plants thanks to a consortium of microbes in disease suppressive soils (Topalovic *et al.*, 2020)
- ⇒ Agricultural systems promoting **microbiodiversity** such as soil conservation agriculture are brought forward.



Trivedi *et al.* (2020)

STUDY - Material & methods

- 1 field managed under 2 types of **practices**:
  - CA (no tillage + cover crops)
  - CT (conventional tillage + no cover crop)
- 4 rice **varieties**:
  - *O. sativa indica* (IR504 and IR64)
  - *O. sativa japonica* (Azucena and Zhonghua 11)

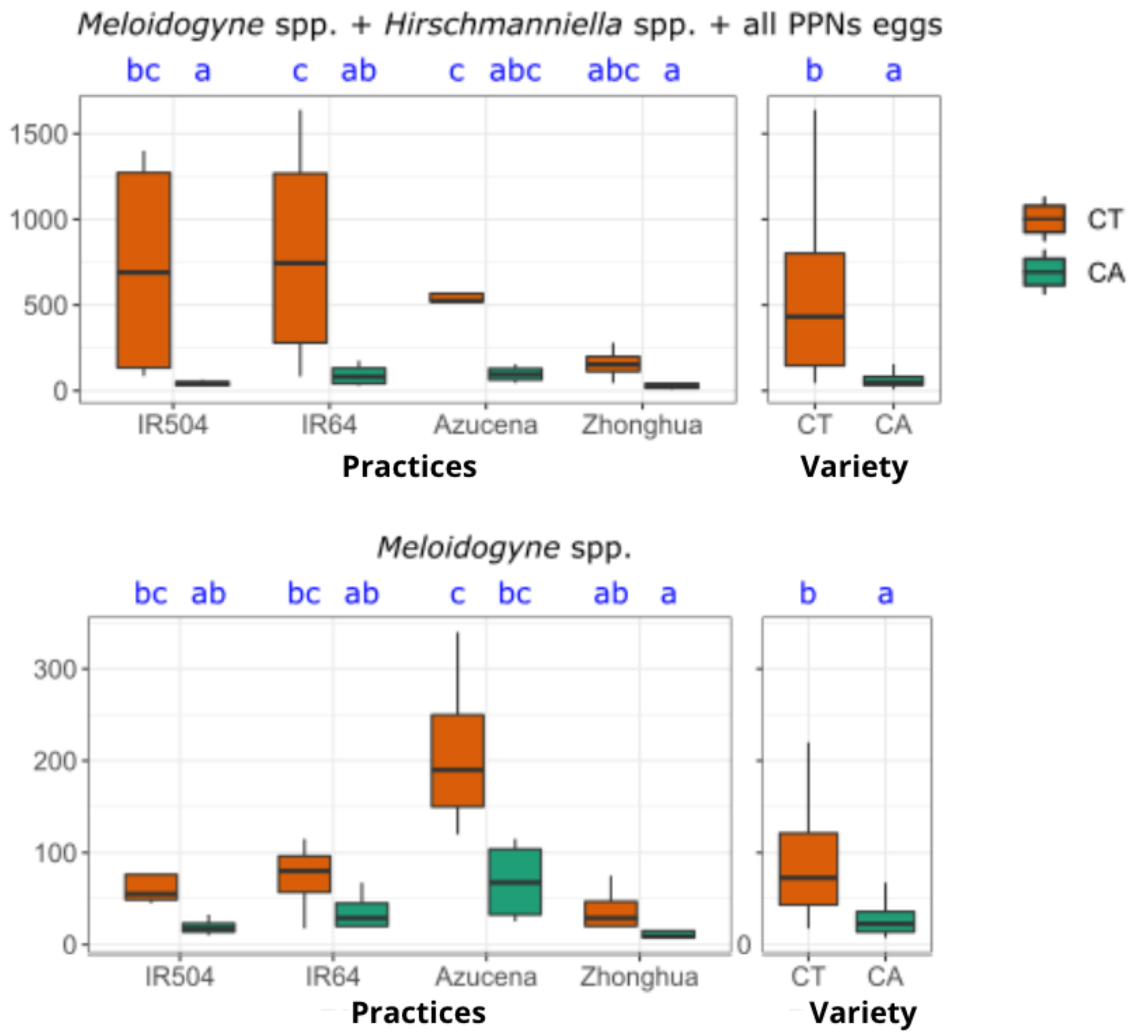
- What is the potential of conservation agriculture to reduce the abundance of plant-parasitic nematodes?
- What are the effects of the **practices** + **variety** on the **communities of microorganisms** in the rhizosphere?

⇒ A view on the soil food web

- bacteria (11,919 SVs)
- fungi (2,062 SVs)

- nematodes (33 families ⊃ 6 species)

STUDY - Effect of CA on the **abundance of PPNs in roots**



Meloidogyne spp. and *Hirschmanniella* spp. = most dominant plant-parasitic nematodes (Suong *et al.*, 2019) extracted from rice roots

→ **Significant effects** of the **agrosystem components**:

- **practice**: **CA** < CT (- 88 %)
- **cultivar**: **Zhonghua** < other cultivars

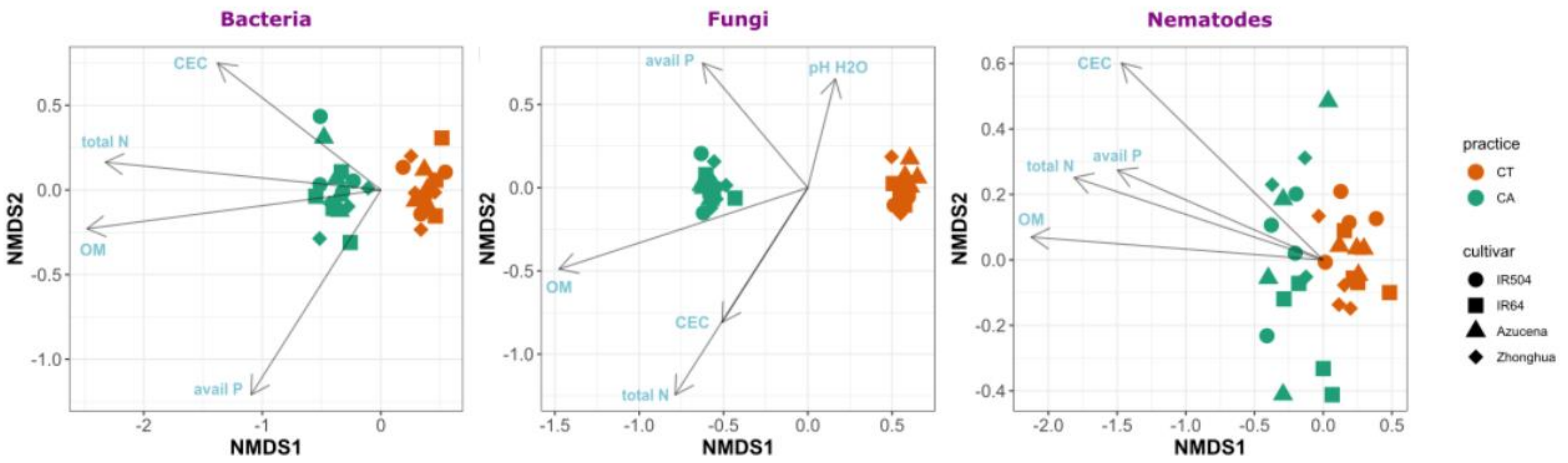
STUDY - Effect of CA on the **soil properties**

Soil properties	CT		CA
pH H_2O	5.32 ± 0.09		5.23 ± 0.16
available P (ppm)	13.85 ± 3.34	+34% →	18.57 ± 4.02
exchangeable K (meq / 100 g)	0.29 ± 0.05	+10% →	0.32 ± 0.04
total N (%)	0.030 ± 0.008	+103% →	0.061 ± 0.011
OM (g / kg)	0.95 ± 0.28	+109% →	1.99 ± 0.27
CEC (meq / 100 g)	8.78 ± 2.01	+30% →	11.41 ± 2.19

→ Most soil properties are improved: *e.g.* enrichment of nutrients NPK and OM.

→ **Significant effect** of the **practices**: **CA** › CT

STUDY - Effect of CA on the **diversity of the rhizosphere communities**

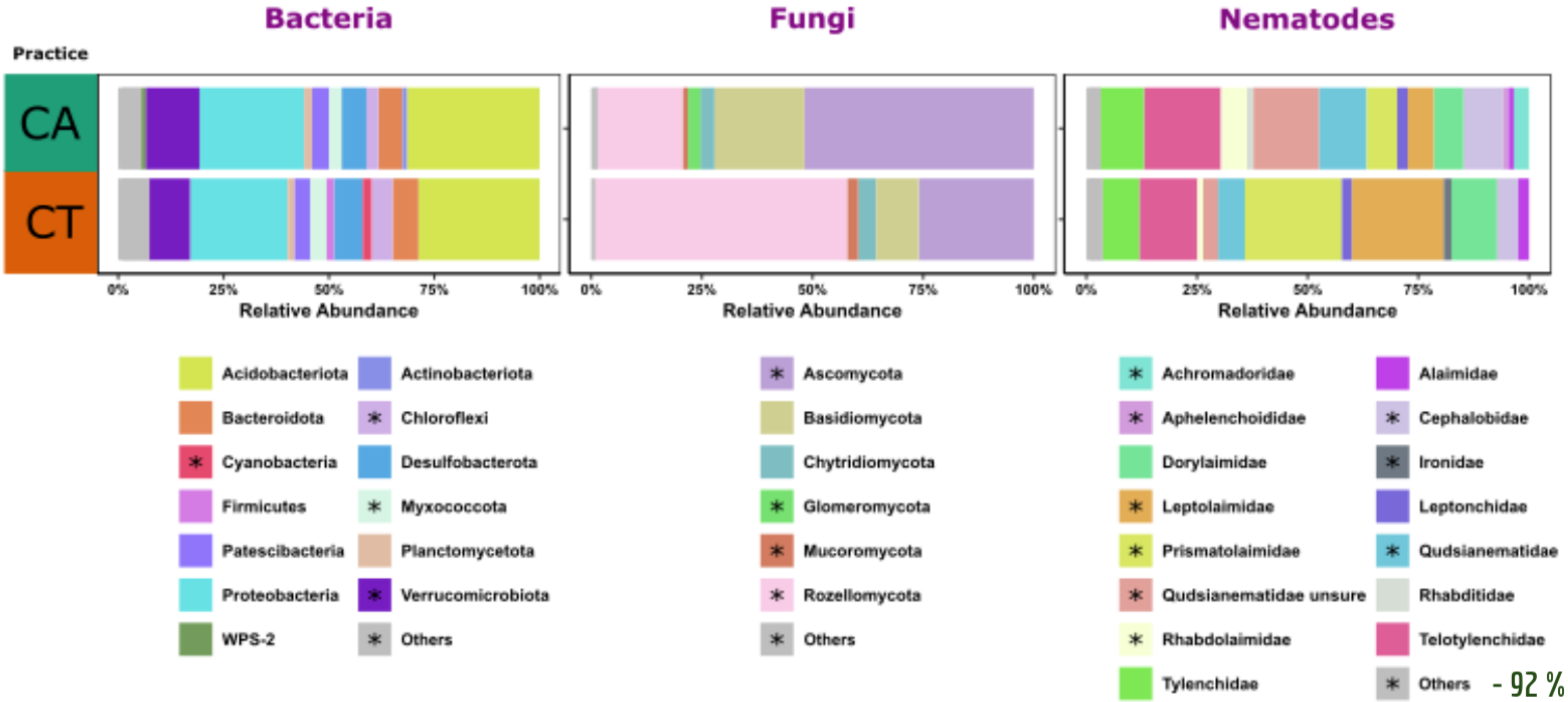


Structure: shift accounting for about 25% of the variability and correlating with improvement of soil properties

Richness:

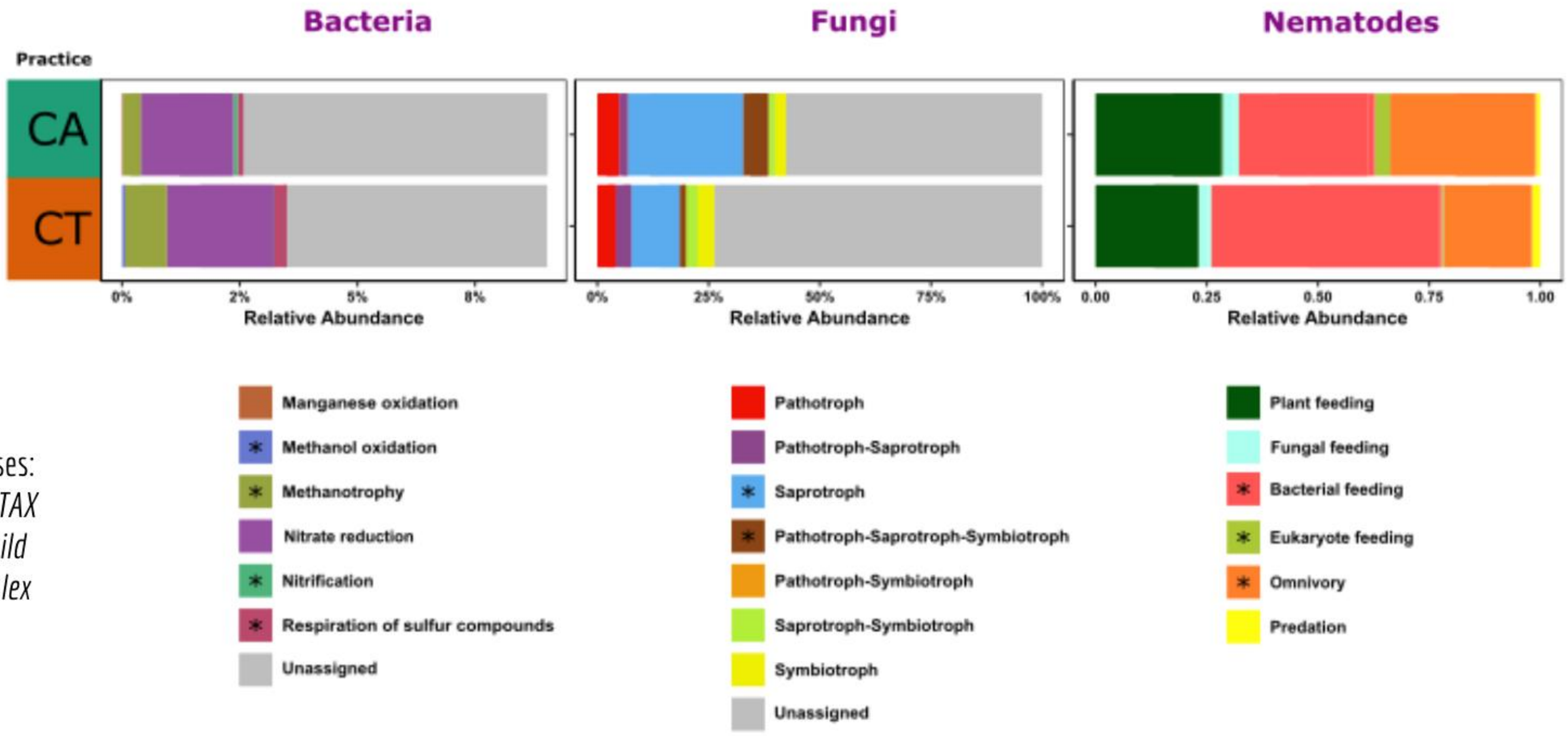
+ 3 % for bacteria
+ 38 % for fungi
+ 7 % for nematodes (not significant)

STUDY - Effect of CA on the **diversity of the rhizosphere communities**



- 92 % *Pratylenchidae*

STUDY - Effect of CA on the **relative abundances of guilds**



Databases:
FAPROTAX
FunGuild
Nemaplex

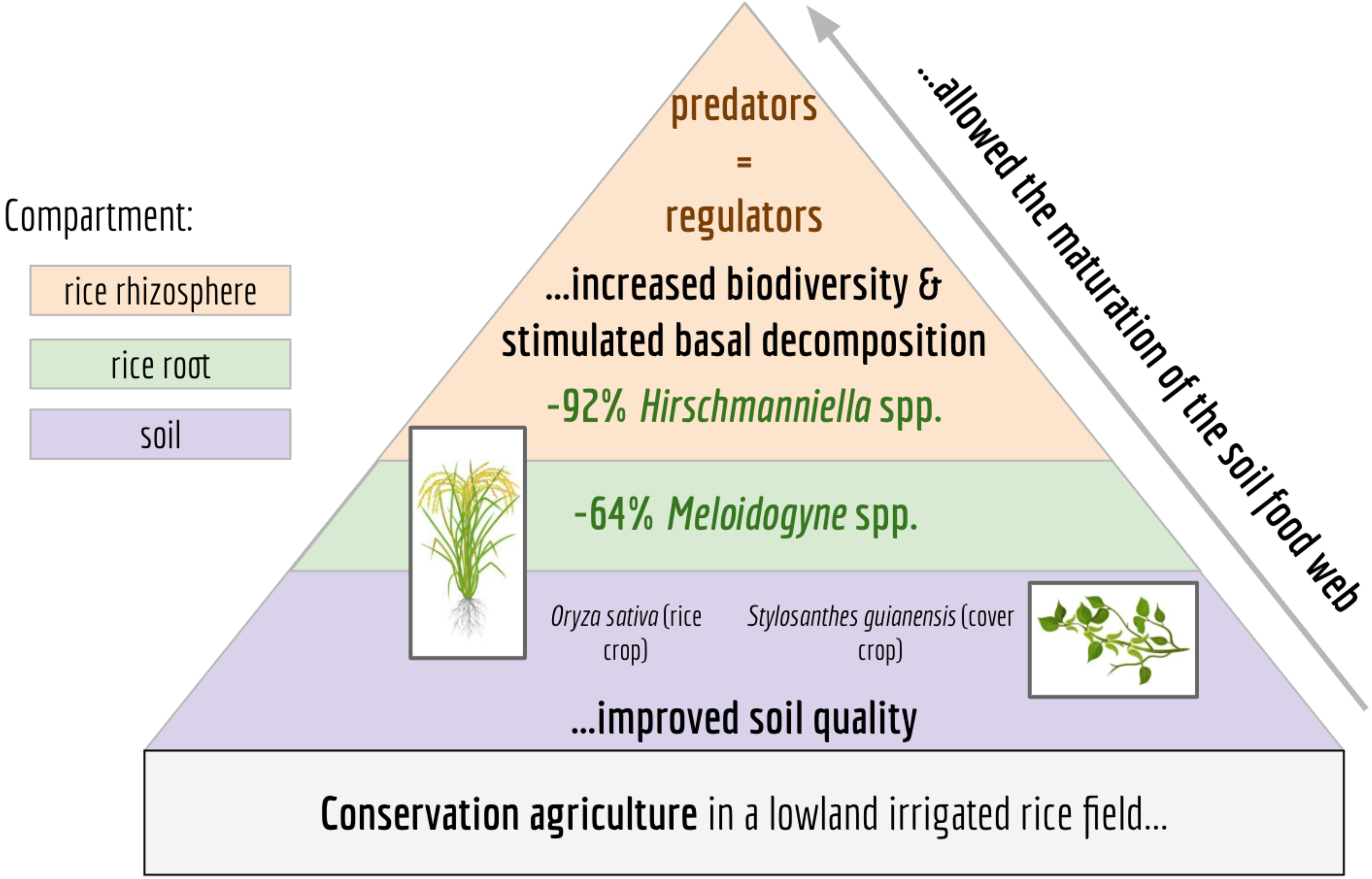
→ + 68% omnivores
→ Shift of abundance toward higher trophic levels

STUDY - Effect of CA on the **structure and enrichment** of the food web

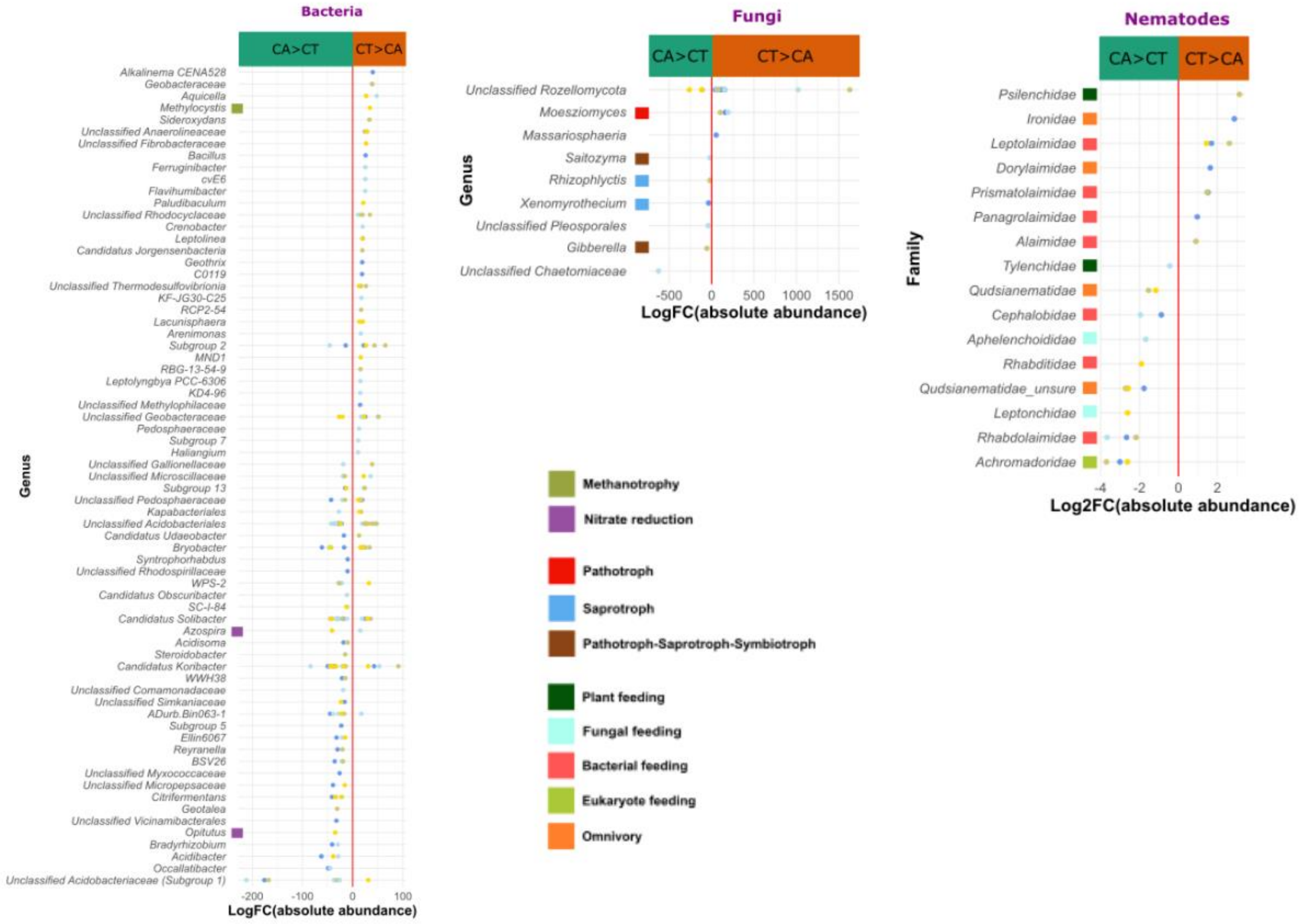
Nematofaunal indices	CT		CA
Enrichment index (EI)	10.4 ±6.8	+138% →	24.2 ±18.5
Index of organic matter decomposition (IVD)	95.1 ±2.9	-6% →	89.6 ±8.0
Structural index (SI)	85.8 ±3.7	+7% →	91.4 ±4.0
Maturity index (MI)	3.0 ±0.1	+10% →	3.3 ±0.2

→ Enrichment of the basal fauna + higher fungal activity
→ Enrichment of persisters (more cp4 and cp5)
→ **Maturation** of the soil food web **positively correlated** with the **reduction** of plant-parasitic nematode abundance in roots
→ Reduction of ***Meloidogyne* spp.** in roots positively correlated with the abundance of **generalists predators** in the rhizosphere

CONCLUSION


Compartment:
rice rhizosphere
rice root
soil
predators
=
regulators
...increased biodiversity &
stimulated basal decomposition
-92% *Hirschmanniella* spp.
-64% *Meloidogyne* spp.
Oryza sativa (rice crop)
Stylosanthes guianensis (cover crop)
...improved soil quality
Conservation agriculture in a lowland irrigated rice field...
...allowed the maturation of the soil food web

PERSPECTIVES



For example:

- *Qudsianematidae* possibly including species described to prey on *Hirschmanniella oryzae* (Bilgrami and Gaugler, 2005)

→ Validate the potential regulation of *Hirschmanniella* spp. by **predatory nematodes**

- 2 fungivorous nematodes
- 2 saprotrophic fungi
- 2 potentially nitrifying bacteria

→ Identify **candidate bacteria** responsible for the reduction of *Meloidogyne* spp. abundance

TAKE-HOME MESSAGE

The reduction of plant-parasitic nematodes is possible with CA in rice fields.

→ Make a continuous monitoring in the experimental field to study the **dynamics of the regulation of plant-parasitic nematodes**, the **suppression of diseaseS** (symptoms and yield measurements) and the **provision of other ecosystemic services**

THANK YOU

The JEAI Healthy Rice consortium

Florent Tivet

Vira Leng

BRIO team

Marie-Liesse Vermeire

Marie Simonin

The PhD days ASEA organisators

The online audience!

SUP - *Meloidogyne graminicola*

"root-knot nematode"

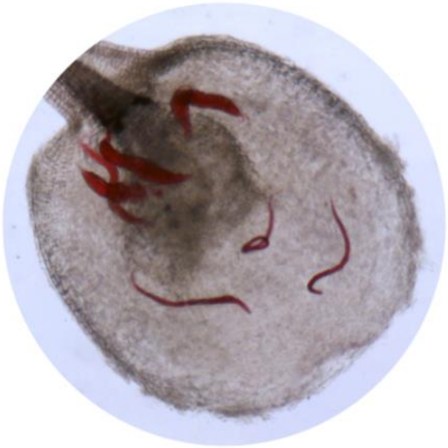
- Sign of the infection: galls mainly formed at the root tips

  → alteration of the root vascular system causes disruption of water and nutrient transport
- Symptoms of the disease: stunting, chlorosis and loss of plant vigour

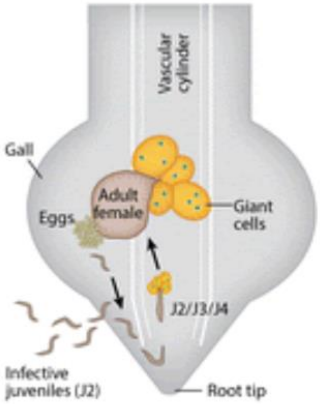
  → poor growth and reproduction ⇒ yield loss
- Host range: over 100 plant species including cereals and grass that are common in fields
- Important host: rice (*Oryza sativa*)
- Life cycle:
  - short (from 19 to 27 days)
  - alternance exophytic and endophytic stages
  - can survive in rice cropping systems

⇒ **Major threat to rice agriculture in Asia** (Mantelin *et al.*, 2017)

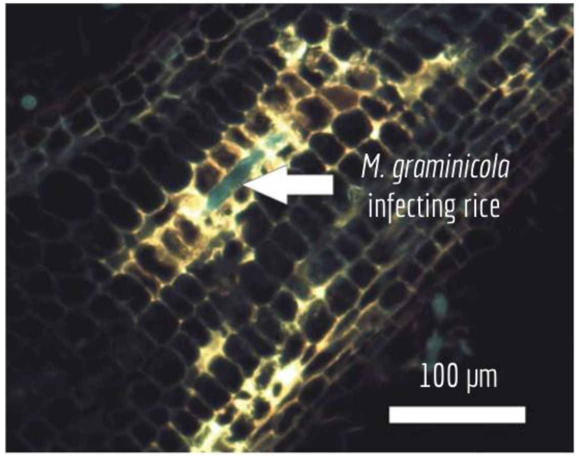
+ alert list in Europe (Rusinque *et al.*, 2021)



Masson *et al.* (2020)

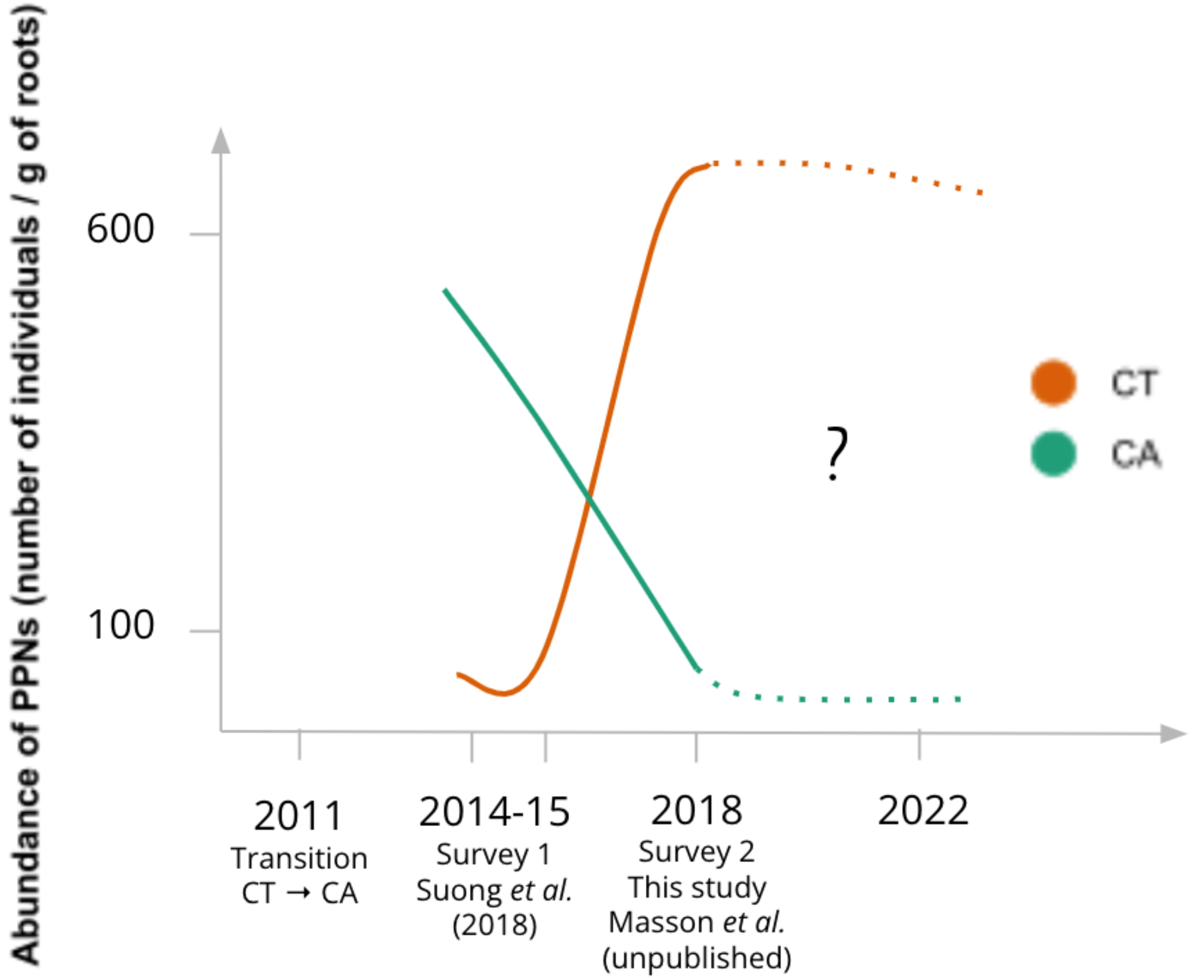


Kyndt *et al.* (2014)



Mantelin *et al.* (2017)

SUP



Abundance of PPNs (number of individuals / g of roots)
600
100
?
CT
CA
2011
Transition
CT → CA
2014-15
Survey 1
Suong *et al.*
(2018)
2018
Survey 2
This study
Masson *et al.*
(unpublished)
2022