An experimental test of the effect of management strategies and rotation on plant-pathogen suppression by soil microbial communities

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DLO, CETIOM, JKI, CNR, SoilCares Research

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Aim: explore the response of soil microbial communities to existing management actions, and consider their role in suppressing pathogens.

Field trial:

- Site: Cambrai, N-France (CETIOM)
  - Silt loam, trial started 2009

- Cropping system:
  - Ploughing (control) x reduced tillage (innovative system)
  - Winter wheat based rotation, 3 full replicates (36 plots)

- Sampling:
  - 2011-2012 and 2012-2013; November & April
  - Always in winter wheat (WW); soil and root samples
Experimental design

Aims of this trial: saving energy, labour, pesticides, mineral N, greenhouse gas emissions
Measurements:

- Field, crop, yield, soil sampling for all partners (CETIOM) - Xavier Pinochet
- Disease suppression & antagonistic *Lysobacter* spp. (DLO) – Joeke Postma
- Bacterial & fungal communities (JKI) – Kornelia Smalla, Holger Heuer
- Arbuscular mycorrhizal fungi (CNR) - Erica Lumini, Valeria Bianciotto
- Nematode community structure (SoilCares Research) – Aad Termorshuizen
Field, crop, yield

Innovative system, reduced tillage ↔ control:
• Lower N fertilization (110 – 134 N)
• Lower GHG emission (- 11%)
• Reduced labour (3.45 – 5.13 h)
• Less chemical treatments (3.5 – 4.3 TFI), mainly due to less fungicide applications.
• Limited yellow rust & Septoria in 2011-12
• 15% reduction of grain yields of winter wheat.
Disease suppression

Bioassays: soil samples + wheat + added pathogens:

- *Pythium ultimum*
- *Rhizoctonia solani AG8*
- *Gaeumannomyces graminis var. tritici*
- *Microdochium nivale*
Germination is only reduced by *Pythium*, but no consistent results in 2011 and 2012.

More root rot by *Rhizoctonia* in reduced tillage system in 2011 & 2012; no differences for the other diseases.
Microbial communities

- Communities of fungi & bacteria (fingerprints):
  - Strong crop effects in the rhizosphere.
  - Evidence for a lasting effect of the preceding crop on the bulk soil communities in autumn.
  - Only weak evidence for a tillage effect:
    - Soil bacterial fingerprints after WOSR had separate clusters for tillage and no tillage.
    - Soil fungal fingerprints after sugar beet had separate clusters for tillage and no tillage.
- Colony-forming units did not give evidence for crop or tillage effects.
Antagonistic bacteria

• Antagonistic isolates and functional genes (*phlD*, *phz*, *prnD* and *pltC*) did not give evidence for crop or tillage effects.

• Antagonistic *Lysobacter* spp.:
  – Isolates that inhibit *Rhizoctonia*.
  – Often lower numbers in spring than in autumn.
  – But no-till (WOSR) has high numbers in spring!

![Dynamics of Lysobacter in soil](chart.png)
Arbuscular mycorrhizal fungal communities

- Winter wheat root fragments showed a low mycorrhization level (1-2%).
- The soil AMF community was dominated by *Glomeraceae* followed by *Diversisporaceae* and *Gigasporaceae* families.
- A phylogenetically diverse not yet identified *Glomeraceae* community was present.
- Tillage effect:
  - ploughed treatments favoured taxa of *Glomeraceae* and *Acaulosporaceae*.
  - reduced tillage favoured taxa of *Gigasporaceae*, *Diversisporaceae* and *Claroideoglomeraceae*.
Nematodes

• Preceding crop had a stronger selection pressure on the nematode community than system treatment (ploughed x reduced tillage).

• Crop effect:
  – Higher numbers of bacterivorous *Eucephalobus*, omnivorous family of *Dorylaimoidea*, and plant parasitic *Pratylenchus* with WOSR as preceding crop.

• Tillage effect:
  – The fungivorous nematodes occurred in higher densities in the ploughed than in the reduced tillage system.
  – The number of omnivorous nematodes tended to be higher in the ploughed treatments (regarded as positive soil quality attribute).
Summary

Effect of rotation & tillage on disease suppression & soil microbial communities

• Field trial: reduced tillage (innovative system):
  – Reduced chemical inputs
  – 15% yield reduction (2nd, 3rd year after start of trial)
  – Soil is less suppressive to *Rhizoctonia*
  – No differences in suppressiveness to other diseases

• Microbial communities:
  – Shifts are demonstrated for different groups of organisms, using different techniques
  – Due to preceding crop and/or tillage system ⬛️⬜️⬜️⬜️
Reduced tillage system:

- Diseases: Rhizoctonia suppression <
- Shift in fungi after SB
- Shift in bacteria after WOSR
- Lysob. after WOSR >
- Fungivorous < Omnivorous >

Preceding crop: after WOSR

- Strong crop effect in rhizosphere of WW
- Glomeraceae >
- Eucephalobus > Dorylaimoidea > Pratylenchus >
Conclusions

PURE:
• Combining different available expertises
• 1 location, 1 crop, 1 soil type as example
• Microbial shifts already visible after 2 yrs of trial
• => potential for biological indicators

SOIL:
• Complex, many factors interact, slow processes
• Many soil borne diseases & sensitive crops
• Reduction of pesticides and soil disinfestation
• IPM & sustainable soil management are crucial!
2015

International Year of Soils

The promotion of sustainable soil and land management is central to ensuring a productive food system, improved rural livelihoods and a healthy environment.

IPM of (soil-borne) pests & diseases
Thank you for your attention!

WP10.1: Soil-team

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