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.

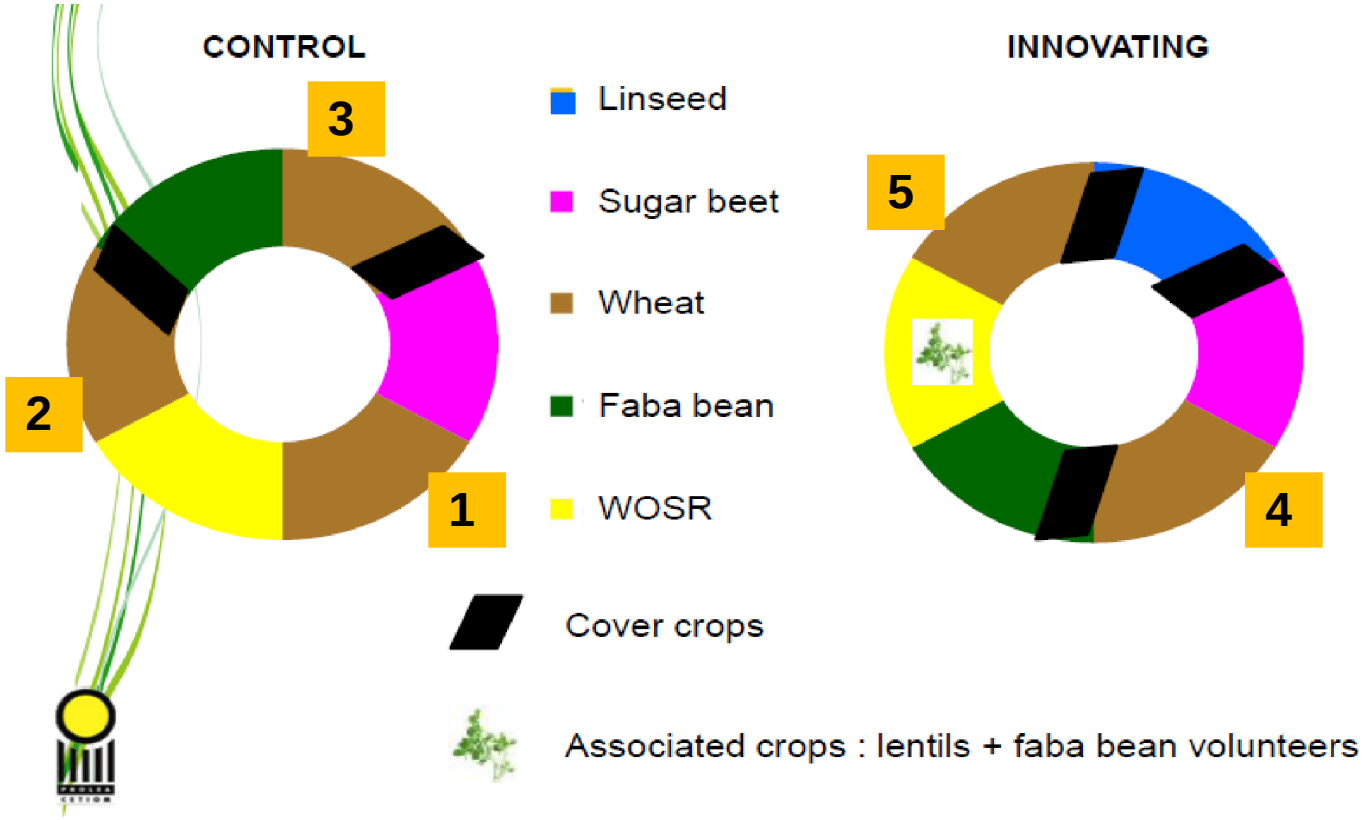
Field trial:

- 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

Ploughing

Reduced tillage



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

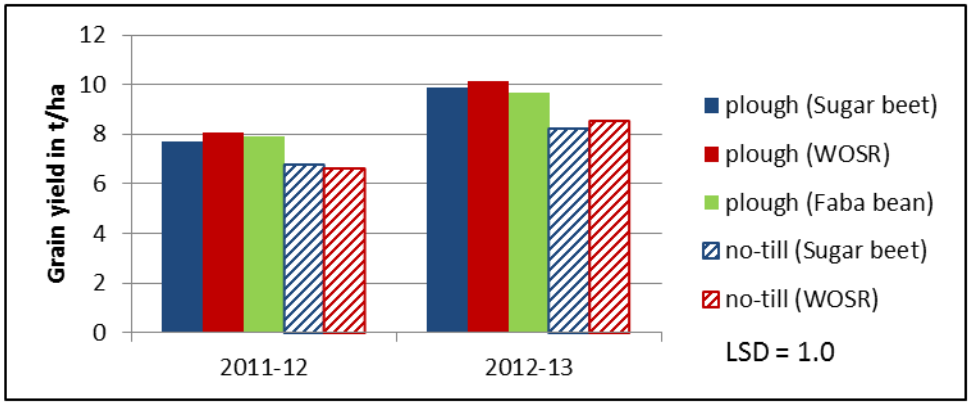
Measurements:

- 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

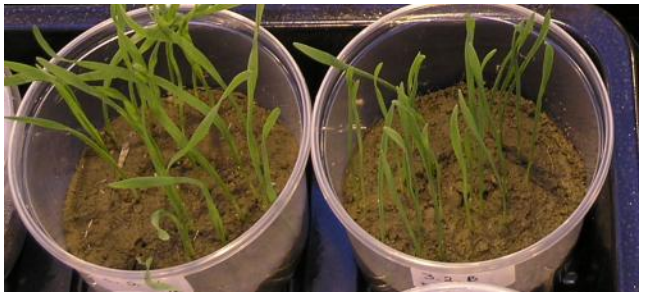
Field, crop, yield

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

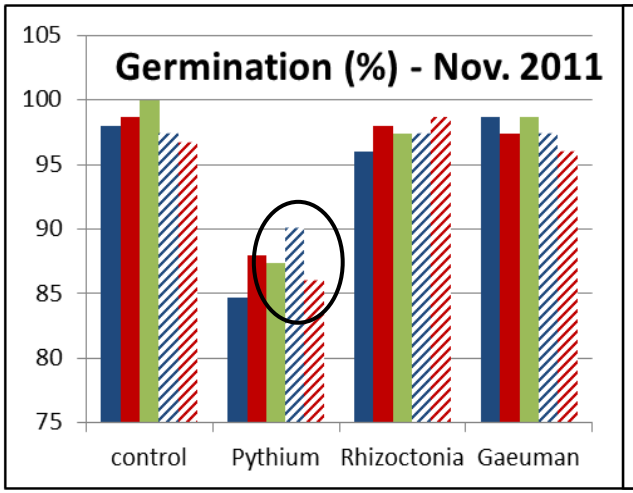


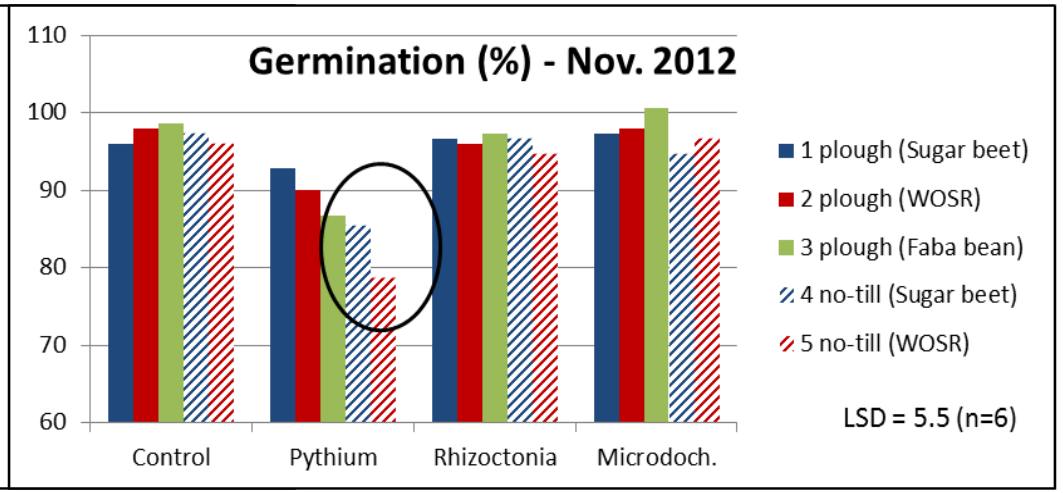
Germination & plant growth

Bioassays: soil samples + wheat + added pathogens:

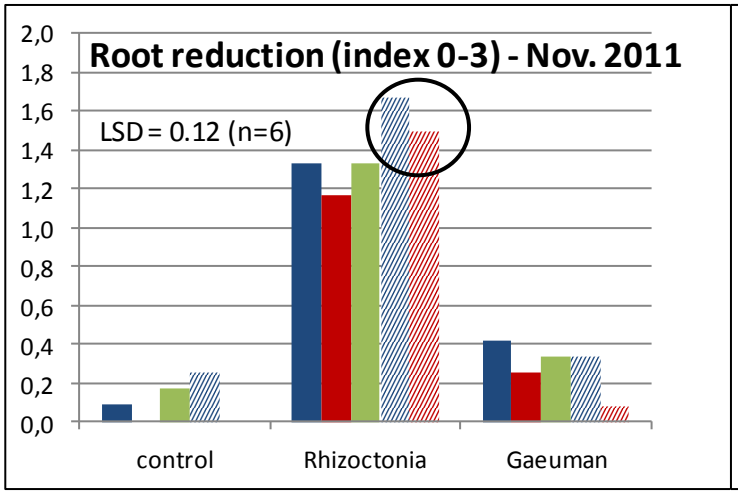
- *Pythium ultimum*
- *Rhizoctonia solani* AG8
- *Gaeumannomyces graminis* var. *tritici*
- *Microdochium nivale*

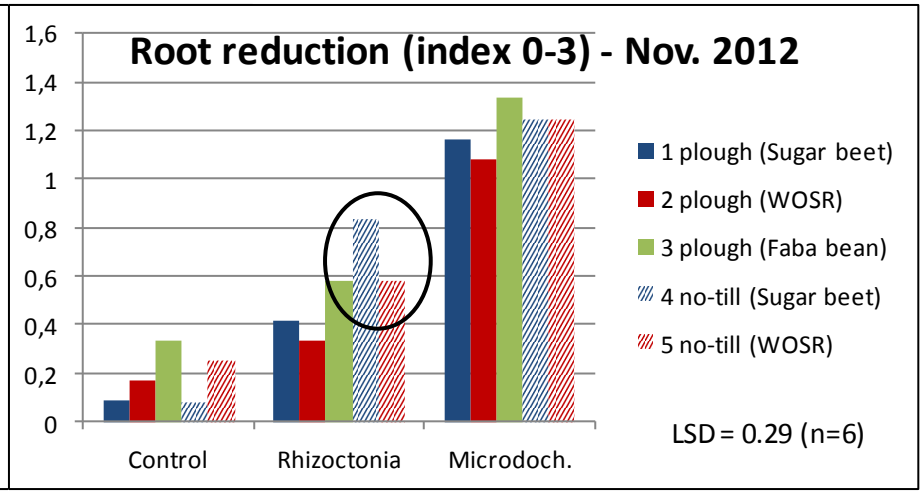
Germination is only reduced by *Pythium*, but no consistent results in 2011 and 2012



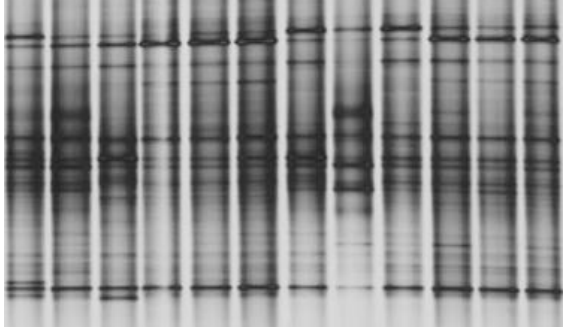


More root rot by *Rhizoctonia* in reduced tillage system in 2011 & 2012; no differences for the other diseases





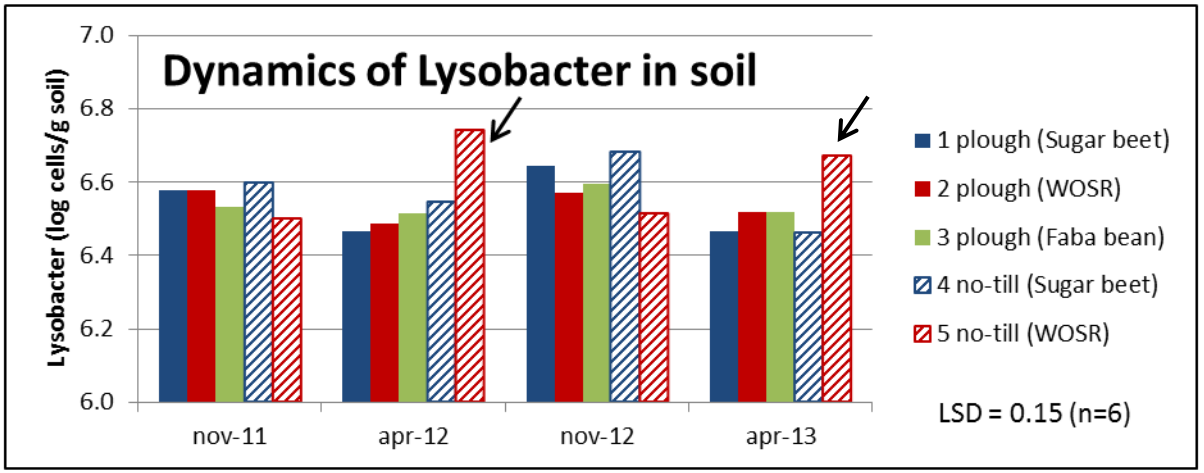
Microbial communities



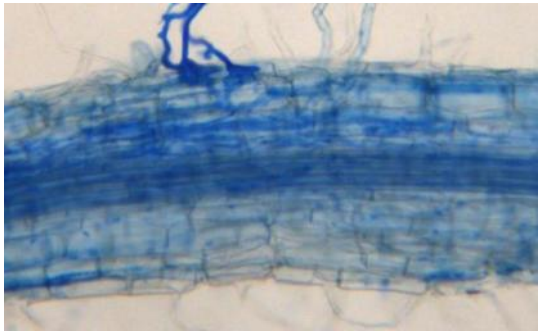
- Communities of fungi & bacteria (fingerprints):
  - Strong crop effects in the rhizosphere.
  - Evidence for a lasting effect of the preceding crop on the bulk soil communities in autumn.
  - Only weak evidence for a tillage effect:
    - Soil bacterial fingerprints after WOSR had separate clusters 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!

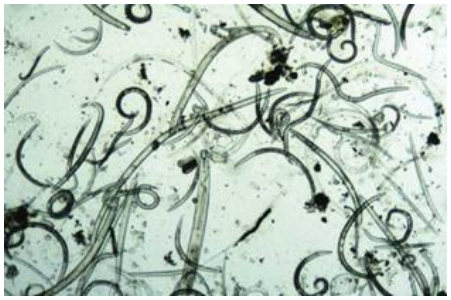


Arbuscular mycorrhizal fungal communities



- 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

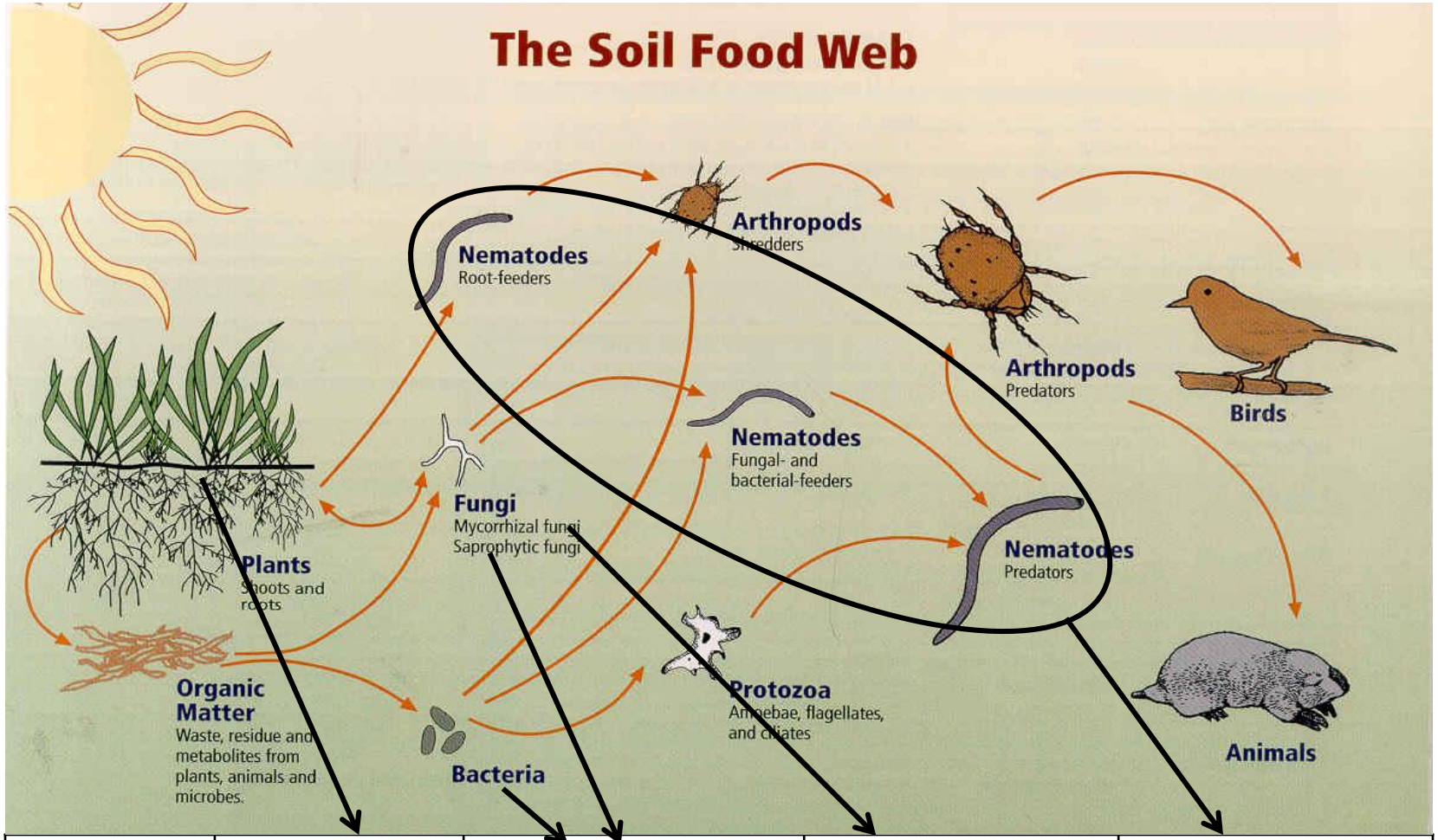


- Preceding crop had a stronger selection pressure on the nematode community than system treatment (ploughed x reduced tillage).
- Crop effect:
  - Higher numbers of bacterivorous *Eucephalobus,* omnivorous family of *Dorylaimoidea*, and plant parasitic *Pratylenchus* with WOSR as preceding crop.
- Tillage 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 $\rightarrow\rightarrow\rightarrow\rightarrow$



Reduced tillage system:	Diseases: Rhizoctonia suppression <	Shift in fungi after SB Shift in bacteria after WOSR Lysob. after WOSR >	Glomeraceae < Acaulospor. < Gigasporaceae > Diversispor. > Claroideoglom. >	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

IPM of (soil-borne) pests & diseases

Thank you for your attention!

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