Changes of soil structure and earthworm community under different agricultural management

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Soil is an interactive system, in which characteristics are strongly linked.

Earthworms drive soil fertility « Ecosystem Engineers ».

Environmental conditions and human pressures regulated earthworm dynamics.

To better understand interactions between all components of soil.
Industrial scale of production

Increase of the inputs

Intensification of agriculture

New soil conservation management practices are required.

How to sustain soil fertility?

Decrease of soil biodiversity

Decline in soil organic matter

Degradation of soil quality
Soil fauna
Earthworms

1. How is earthworm community influenced by agricultural practices?

Soil structure, Physico-chemical properties of soil

2. How are soil properties and nutrient elements influenced by agricultural practices?
Some questions

• Changes in the earthworm community in different cropping systems?

• Link between agricultural management and earthworms?

• Impact of different agricultural practices on soil properties (Physical / Chemical)?
Study design

- Located in Gembloux, Belgium.
- The experimental design = latin square 4X4 (16 plots: 15*40 m)
- Agricultural practices:
  - Tillage / Restitution (Tillage IN)
  - Tillage / Exportation (Tillage OUT)
  - No-tillage / Restitution (No-tillage IN)
  - No-tillage / Exportation (No-tillage OUT)

Fig. 1. Experimental design, tillage management, and cropping systems.
Experimental protocols

Earthworm sampling

Metallic cylinder (30 cm diameter, 30 cm depth)

Species identification (Key of Cluzeau, 1996)

Counting and weighing of earthworms, preservation in formalin 4%

Excavation of soil blocks

Extraction of earthworms by hand
Experimental protocols

Soil sampling

Composite samples from soil plough layer

Soil analysis

Nutrient elements water-extraction

Total Organic Carbon, pH, …
Impact of agricultural management on earthworm community and physical properties of soil

1. How is earthworm community influenced by agricultural practices?
Fig. 2. Earthworm abundance and biomass in four agricultural managements (mean ± S.D).

No significant difference in earthworm abundance and biomass between the four treatments.
Earthworm abundance and biomass

. Earthworm parameters as abundance and biomass were very low under cultivated soils.

. Earthworm abundance is affected by tillage system and by absence of crop residues.

. Earthworm biomass is not affected by tillage practice but by absence of crop residues.

. The low value of earthworm biomass = large quantity of juveniles (NT).

. High biomass were linked to the presence of *N. caliginosus merdionales* and *L. terrestris* (T).
Earthworm diversity

- 22 species were recorded from parcels.

- *L. terrestris*, *Caliginosus merdionales* and *D. rubida* are the most abundant species.

- Despite their sensitivity, anecic and endogeic species were dominants.

- Sensitivity of epigeic species to wheat monoculture.

Fig. 3. Earthworm species abundance sampled from tilled and no-tilled systems (T: tillage; NT: no tillage; IN: crop residues incorporated in the field; OUT: crop residues removed from the field)
Impact of agricultural management on earthworm community and physical properties of soil

2. How are soil properties and nutrient elements influenced by agricultural practices?
### Soil properties

<table>
<thead>
<tr>
<th>Topsoil (0 to 25/35 cm)</th>
<th>T / IN</th>
<th>NT / IN</th>
<th>T / OUT</th>
<th>NT / OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture*</td>
<td>Silt Loam (Clay: 14-16% ; Silt: 75-80% ; Sand: 5-6%)</td>
<td>Neutral (6.5 – 7.0)</td>
<td>Bulk Density*: T / NT</td>
<td></td>
</tr>
<tr>
<td>pH*</td>
<td>1,1</td>
<td>1,3</td>
<td>1,4</td>
<td>1,3</td>
</tr>
<tr>
<td>0-10 cm</td>
<td>1,1</td>
<td>1,1</td>
<td>1,4</td>
<td>1,5</td>
</tr>
<tr>
<td>10-25 cm</td>
<td>1,1</td>
<td>1,2</td>
<td>1,5</td>
<td>1,4</td>
</tr>
<tr>
<td>25-35 cm</td>
<td></td>
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<tr>
<td>25-35 cm</td>
<td></td>
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</tr>
</tbody>
</table>

Subsoil (35-100 cm): textural B and B to C transition horizons

<table>
<thead>
<tr>
<th>Texture*</th>
<th>Silt Loam (Clay: 20-25% ; Silt: 70-75% ; Sand: 3-6%)</th>
<th>Slightly acidic (6.2 – 6.5)</th>
<th>TOC* (g/100g) / Bulk Density*</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH*</td>
<td></td>
<td></td>
<td>0,1 – 0,5 (decreases with depth) / 1,50 – 1,66</td>
</tr>
<tr>
<td>Structure</td>
<td></td>
<td></td>
<td>Blocky angular to Blocky subangular / Compact</td>
</tr>
<tr>
<td>Blocky angular to Blocky subangular</td>
<td></td>
<td></td>
<td>Compact</td>
</tr>
</tbody>
</table>

Table 1. Primary soil properties in the field trial according to regional practices (T: tillage; NT: no tillage; IN: crop residues incorporated in the field; OUT: crop residues removed from the field).
Nutrient cycling

- **P (mg/kg)**
  - October 2011: 2 mg/kg (T / IN), 4 mg/kg (T / OUT), 3 mg/kg (NT / IN), 5 mg/kg (NT / OUT)
  - March 2012: 3 mg/kg (T / IN), 5 mg/kg (T / OUT), 4 mg/kg (NT / IN), 6 mg/kg (NT / OUT)
  - April 2012: 4 mg/kg (T / IN), 6 mg/kg (T / OUT), 5 mg/kg (NT / IN), 7 mg/kg (NT / OUT)
  - May 2012: 5 mg/kg (T / IN), 7 mg/kg (T / OUT), 6 mg/kg (NT / IN), 8 mg/kg (NT / OUT)
  - July 2012: 6 mg/kg (T / IN), 8 mg/kg (T / OUT), 7 mg/kg (NT / IN), 9 mg/kg (NT / OUT)
  - October 2012: 7 mg/kg (T / IN), 9 mg/kg (T / OUT), 8 mg/kg (NT / IN), 10 mg/kg (NT / OUT)

- **K (mg/kg)**
  - October 2011: 10 mg/kg (T / IN), 12 mg/kg (T / OUT), 9 mg/kg (NT / IN), 11 mg/kg (NT / OUT)
  - November 2011: 12 mg/kg (T / IN), 14 mg/kg (T / OUT), 10 mg/kg (NT / IN), 12 mg/kg (NT / OUT)
  - December 2011: 14 mg/kg (T / IN), 16 mg/kg (T / OUT), 12 mg/kg (NT / IN), 14 mg/kg (NT / OUT)
  - January 2012: 16 mg/kg (T / IN), 18 mg/kg (T / OUT), 14 mg/kg (NT / IN), 16 mg/kg (NT / OUT)
  - February 2012: 18 mg/kg (T / IN), 20 mg/kg (T / OUT), 16 mg/kg (NT / IN), 18 mg/kg (NT / OUT)
  - March 2012: 20 mg/kg (T / IN), 22 mg/kg (T / OUT), 18 mg/kg (NT / IN), 20 mg/kg (NT / OUT)
  - April 2012: 22 mg/kg (T / IN), 24 mg/kg (T / OUT), 20 mg/kg (NT / IN), 22 mg/kg (NT / OUT)
  - May 2012: 24 mg/kg (T / IN), 26 mg/kg (T / OUT), 22 mg/kg (NT / IN), 24 mg/kg (NT / OUT)
  - June 2012: 26 mg/kg (T / IN), 28 mg/kg (T / OUT), 24 mg/kg (NT / IN), 26 mg/kg (NT / OUT)
  - July 2012: 28 mg/kg (T / IN), 30 mg/kg (T / OUT), 26 mg/kg (NT / IN), 28 mg/kg (NT / OUT)
  - August 2012: 30 mg/kg (T / IN), 32 mg/kg (T / OUT), 28 mg/kg (NT / IN), 30 mg/kg (NT / OUT)
  - September 2012: 32 mg/kg (T / IN), 34 mg/kg (T / OUT), 30 mg/kg (NT / IN), 32 mg/kg (NT / OUT)
  - October 2012: 34 mg/kg (T / IN), 36 mg/kg (T / OUT), 32 mg/kg (NT / IN), 34 mg/kg (NT / OUT)

- **Mg (mg/kg)**
  - October 2011: 2 mg/kg (T / IN), 4 mg/kg (T / OUT), 3 mg/kg (NT / IN), 5 mg/kg (NT / OUT)
  - November 2011: 3 mg/kg (T / IN), 5 mg/kg (T / OUT), 4 mg/kg (NT / IN), 6 mg/kg (NT / OUT)
  - December 2011: 4 mg/kg (T / IN), 6 mg/kg (T / OUT), 5 mg/kg (NT / IN), 7 mg/kg (NT / OUT)
  - January 2012: 5 mg/kg (T / IN), 7 mg/kg (T / OUT), 6 mg/kg (NT / IN), 8 mg/kg (NT / OUT)
  - February 2012: 6 mg/kg (T / IN), 8 mg/kg (T / OUT), 7 mg/kg (NT / IN), 9 mg/kg (NT / OUT)
  - March 2012: 7 mg/kg (T / IN), 9 mg/kg (T / OUT), 8 mg/kg (NT / IN), 10 mg/kg (NT / OUT)
  - April 2012: 8 mg/kg (T / IN), 10 mg/kg (T / OUT), 9 mg/kg (NT / IN), 11 mg/kg (NT / OUT)
  - May 2012: 9 mg/kg (T / IN), 11 mg/kg (T / OUT), 10 mg/kg (NT / IN), 12 mg/kg (NT / OUT)
  - June 2012: 10 mg/kg (T / IN), 12 mg/kg (T / OUT), 11 mg/kg (NT / IN), 13 mg/kg (NT / OUT)
  - July 2012: 11 mg/kg (T / IN), 13 mg/kg (T / OUT), 12 mg/kg (NT / IN), 14 mg/kg (NT / OUT)
  - August 2012: 12 mg/kg (T / IN), 14 mg/kg (T / OUT), 13 mg/kg (NT / IN), 15 mg/kg (NT / OUT)
  - September 2012: 13 mg/kg (T / IN), 15 mg/kg (T / OUT), 14 mg/kg (NT / IN), 16 mg/kg (NT / OUT)
  - October 2012: 14 mg/kg (T / IN), 16 mg/kg (T / OUT), 15 mg/kg (NT / IN), 17 mg/kg (NT / OUT)

- **Ca (mg/kg)**
  - October 2011: 2 mg/kg (T / IN), 4 mg/kg (T / OUT), 3 mg/kg (NT / IN), 5 mg/kg (NT / OUT)
  - November 2011: 3 mg/kg (T / IN), 5 mg/kg (T / OUT), 4 mg/kg (NT / IN), 6 mg/kg (NT / OUT)
  - December 2011: 4 mg/kg (T / IN), 6 mg/kg (T / OUT), 5 mg/kg (NT / IN), 7 mg/kg (NT / OUT)
  - January 2012: 5 mg/kg (T / IN), 7 mg/kg (T / OUT), 6 mg/kg (NT / IN), 8 mg/kg (NT / OUT)
  - February 2012: 6 mg/kg (T / IN), 8 mg/kg (T / OUT), 7 mg/kg (NT / IN), 9 mg/kg (NT / OUT)
  - March 2012: 7 mg/kg (T / IN), 9 mg/kg (T / OUT), 8 mg/kg (NT / IN), 10 mg/kg (NT / OUT)
  - April 2012: 8 mg/kg (T / IN), 10 mg/kg (T / OUT), 9 mg/kg (NT / IN), 11 mg/kg (NT / OUT)
  - May 2012: 9 mg/kg (T / IN), 11 mg/kg (T / OUT), 10 mg/kg (NT / IN), 12 mg/kg (NT / OUT)
  - June 2012: 10 mg/kg (T / IN), 12 mg/kg (T / OUT), 11 mg/kg (NT / IN), 13 mg/kg (NT / OUT)
  - July 2012: 11 mg/kg (T / IN), 13 mg/kg (T / OUT), 12 mg/kg (NT / IN), 14 mg/kg (NT / OUT)
  - August 2012: 12 mg/kg (T / IN), 14 mg/kg (T / OUT), 13 mg/kg (NT / IN), 15 mg/kg (NT / OUT)
  - September 2012: 13 mg/kg (T / IN), 15 mg/kg (T / OUT), 14 mg/kg (NT / IN), 16 mg/kg (NT / OUT)
  - October 2012: 14 mg/kg (T / IN), 16 mg/kg (T / OUT), 15 mg/kg (NT / IN), 17 mg/kg (NT / OUT)
The research study investigated the phosphorus levels (P mg/kg) over different time periods and depths. The graphs show the following:

- **Depth A (0 - 10 cm)**: There is a slight decrease in phosphorus levels from T / IN to NT / IN over the time period, with T / OUT and NT / OUT showing a more stable trend.
- **Depth B (10 - 20 cm)**: Similar to Depth A, T / IN shows a decrease, while T / OUT and NT / IN/OUT remain relatively stable.
- **Depth C (20 - 30 cm)**: The phosphorus levels are more stable across all treatments, with a slight fluctuation over the time periods.
Our findings don’t confirm the negative impacts of soil tillage on earthworm population.

The presence of crop residues can explain the difference between IN and OUT.

In cultivated plots, the agricultural practices don’t determine real impact on soil physical and chemical properties.

More years will be necessary in order to evaluate the long term impacts of cultivation practices on earthworm and soil dynamics.
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Thank you for your attention…