Effects of long term soil organic matter restitution mode on soil heterotrophic respiration and soil biological properties.

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Introduction

• Soil Heterotrophic Respiration (SHR): positive feedback to global change in the future?
• Agricultural soils = potentially important sources of CO$_2$.

⇒ Importance of crop management (e.g. Organic Matter Restitution Mode = « OM-RM »)
Scientific questions

1. Does long term (> 50 years) application of different OM-RM cause differences in SHR fluxes?

2. Do different OM-RM imply different responses of SHR to Temperature and Soil moisture content?

3. Is the experimental set-up suitable to answer these questions?
Material and Methods
Experimental design

– Situated in Liroux, near Gembloux
– 6 different OM-RM (RM1 → RM6)
– 6 plots (repetitions) in each treatment: 10 by 70 (or 60) m
– All plots ploughed over 0-25 cm depth
Manual SHR flux measurements

• Studied OM-RM (in 3 out of the 6 repetition plots):
  – RM 1: Control (exportation of all residues)
  – RM 4: Manure
  – RM 6: Restitution of residues

• Weeded areas (3 m by 3 m): 4 measurement points ➔ 12 points/treatment
Manual SHR flux measurements

– From 2 April to 30 July 2010 (14 measurement dates).
– Dynamic closed chamber system ([CO$_2$] vs Time).
– Measurements of Temperature and Soil moisture content.
Main results
Temporal evolutions of SHR fluxes and Soil temperature
Temporal evolutions of SHR fluxes and Soil moisture content

**Soil respiration flux [µmol CO₂.m⁻².s⁻¹]**

**Date**

**Soil water content [% Vol.]**

- **Control**
- **Manure**
- **Residues**
- **SM**

**IMPORTANT SPATIAL VARIABILITY**

⇒ Normalization of the fluxes: for each collar, division of the fluxes by the average over the season.
SHR fluxes vs Temperature

- **Control**
  - Q10 model - Control
- **Manure**
  - Q10 model - Manure
- **Residues**
  - Q10 model - Residues

**Average-normalized SHR fluxes [-]**

- **Temperature [°C]**

<table>
<thead>
<tr>
<th>OM-RM</th>
<th>R15</th>
<th>Q10</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8</td>
<td>1.31</td>
<td>0.32</td>
</tr>
<tr>
<td>2</td>
<td>0.63</td>
<td>1.46</td>
<td>0.15</td>
</tr>
<tr>
<td>3</td>
<td>0.73</td>
<td>1.31</td>
<td>0.24</td>
</tr>
</tbody>
</table>

↘ R15 and Q10 factors: No significant difference between treatments (ANOVA, p > 0.05)
- No clear direct relationship between SHR fluxes and SM content.
- Very few points at high SM content.
Increase of SHR fluxes after increase of SM content between two measurement dates.

Class of Soil moisture content difference [m$^3$·m$^{-3}$]

Control  Manure  Residues
Spatial variability issue

Does spatial variability preclude the assessment of potential differences between treatments?

<table>
<thead>
<tr>
<th>SOC content</th>
<th>Relative difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control vs Manure</td>
<td>25.6</td>
</tr>
<tr>
<td>Control vs Residues</td>
<td>15.8</td>
</tr>
<tr>
<td>Residues vs Manure</td>
<td>10</td>
</tr>
</tbody>
</table>

SHR Fluxes  Relative uncertainty (%)
Control       17.3  
Manure        14.1  
Residues      13.6  

SHR fluxes Relative difference (%)
Control vs Manure  22.4  
Control vs Residues 22.0  
Residues vs Manure 19.6  

Only differences between « Control » and « Manure » could potentially be assessed. The amount of measurement points should be min. 9, 24 and 45 to assess differences between Control/Manure, Control/Residues and Residues/Manure respectively.
Main findings and discussion

• **Question 1:** SHR flux differences between the treatments?
  ➔ No.
  ➔ Potential reasons:
    - Problem of spatial variability
    - Impact of drought ➔ low fluxes ➔ smaller differences

• **Question 2:** Different responses to T° and SM content?
  ➔ No.
  ➔ The study showed a strong SHR response to rewetting events.
  ➔ Birch effect? Solubilization of labile carbon?

• **Question 3:** Is the experimental set-up sufficient?
  ➔ Not totally. Because of the very important spatial variability more measurement points would be necessary.
Perspectives

• New flux measurement campaign in 2011
• Further investigation: « What are the effects of long term application of different OM-RM on soil biological properties (microbial biomass, metabolic activity, qCO$_2$, labile carbon)? »
Thank you!

This research is funded by the FNRS.
## Types of OM-RM

<table>
<thead>
<tr>
<th>RM</th>
<th>Description of treatment</th>
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</thead>
<tbody>
<tr>
<td>RM 1</td>
<td>Control (exportation of residues)</td>
</tr>
<tr>
<td>RM 2</td>
<td>Straw + liquid manure</td>
</tr>
<tr>
<td>RM 3</td>
<td>Straw + liquid manure</td>
</tr>
<tr>
<td>RM 4</td>
<td>Exportation of residues + Manure</td>
</tr>
<tr>
<td>RM 5</td>
<td>Restitution of residues</td>
</tr>
<tr>
<td>RM 6</td>
<td>Restitution of residues</td>
</tr>
</tbody>
</table>

- Today’s situation.
- RM 2, 3 and 5 changed before and after 1998.
- RM 1, 4 and 6 were left unchanged since 1959.
Mean differences of:
- 10 % between « Manure » and « Restitution of Residues »
- 15.8 % between « Control » and « Restitution of residues »
- 25.6 % between « Control » and « Manure »