Input and distribution of rice root-derived carbon in plant-soil-micro-ecological system following $^{14}$C continuous labeling

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Outline

- Background
- Objective
- Materials and methods
- Results
- Conclusion
Background (1)

- Photosynthetic C is an important component in the C cycling of atmosphere-plant-soil system, and the main source of soil organic C

Giardina et al. (2002)
The estimated total contribution of photosynthates to MBC amounted to 91 mg C plant\(^{-1}\), corresponding to 28% of total MBC at the end of the season or a 100% increase in MBC over the growing season (Lu 2002).

Only about 2%–5% of net plant C assimilation is retained in the soil (Hüsch et al., 2002).

Currently, little known about the new C input to soil C pools and its potential contribution to more stable soil C storage
Objective

- To understand the root-derived C dynamics in the soil-plant-microbial ecosystem
- To investigate the influence of rice-photosynthesized C inputs on changes in mineralization (i.e. priming effects) of the native SOC pool after rice harvest
Materials and methods

- **Crop**: Rice (Two-line hybrid rice *Peiyliangyou* 288)
- **Soils**: Four typical paddy soils (P1, P2, P3, P4)
- **$^{14}$C tracing technique**: Generated through the reaction between $^{14}$C-$\text{Na}_2\text{CO}_3$ and HCl
- **Two principal treatments were set up:**
  - rice-planted paddy soil
  - unplanted paddy soil
- **Harvest time**: 80 d after $^{14}$C labeling
- **Indices analysis**
  - $^{14}$C-SOC, $^{14}$C-DOC, $^{14}$C-MBC
Experimental system

- $^{14}$C-CO$_2$ concentration: 270-350 ppm;
- relative humidity: 80%–90%
- day/night temperatures: 31 ± 1°C / 24 ± 1°C
- light intensity: 12 h, 500 mmol photons m$^{-2}$ s$^{-1}$ PAR
Amounts of rice biomass in four different paddy soils after continuous labelling for 80 days.

<table>
<thead>
<tr>
<th>Soil</th>
<th>Shoot biomass</th>
<th>Root biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>5.42 a</td>
<td>c</td>
</tr>
<tr>
<td>P2</td>
<td>5.62 ab</td>
<td>b</td>
</tr>
<tr>
<td>P3</td>
<td>5.55ab</td>
<td>a</td>
</tr>
<tr>
<td>P4</td>
<td>4.09b</td>
<td>c</td>
</tr>
</tbody>
</table>

$^{14}$C-SOC / rice biomass C (%)
Contribution of photosynthesized C to SOC in different soils

SOC¹⁴ (mg kg⁻¹)

- **Rice-planted soil**
- **Non-planted soil**

Soils:
- P1
- P2
- P3
- P4
Contribution of photosynthesized C to MBC in different soils

- **Rice-planted soil**
- **Non-planted soil**

<table>
<thead>
<tr>
<th>Soils</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>c</td>
<td>a</td>
<td>ab</td>
<td>b</td>
</tr>
<tr>
<td>MBC$^{14}$ (mg kg$^{-1}$)</td>
<td>10</td>
<td>40</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

The letter codes (a, b, c) indicate significant differences among treatments.
Contribution of photosynthesized C to DOC in different soils

**Rice-planted soil**

**Non-planted soil**

**Soils**

<table>
<thead>
<tr>
<th>Soil</th>
<th>DOC\textsuperscript{14} (mg kg\textsuperscript{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>d</td>
</tr>
<tr>
<td>P2</td>
<td>c</td>
</tr>
<tr>
<td>P3</td>
<td>a</td>
</tr>
<tr>
<td>P4</td>
<td>b</td>
</tr>
</tbody>
</table>

**Legend**

- Rice-planted soil
- Non-planted soil
SOC$^{14}$ VS rice root biomass, MBC$^{14}$

- SOC$^{14}$ (mg kg$^{-1}$) vs. Root biomass (g plot$^{-1}$): $y=0.005x+0.004$ ($r=0.975^{**}$)

- MBC$^{14}$ (mg kg$^{-1}$) vs. Root biomass (g plot$^{-1}$): $y=0.107x+0.767$ ($r=0.935^{**}$)

- MBC$^{14}$ vs. SOC$^{14}$ (mg kg$^{-1}$)
A simple model of the contribution of rice photosynthesized carbon to DOC and MBC in a flooded rice system.

14C-CO2 → 4-6% → 14C-SOC → 2-4% → 14C-DOC → 9-18% → 14C-MBC → 78-80% → Other component
new and native SOC mineralization: 25°C, 100% air humidity soil incubation

5, 10, 20, 30, 40, 60, 80 and 100 d of incubation analyze $^{14}$C-CO$_2$ and CO$_2$
Cumulative CO$_2$ efflux derived from new C in rice-planted, non-planted soils

**Graphs:**
- **Rice-planted soil**
- **Non-planted soils**
  - P1
  - P2
  - P3
  - P4

**Axes:**
- **Incubation time (d)**
- **14CO$_2$ Evolution (mg kg$^{-1}$)**
The amount of CO$_2$ derived from native and new SOC in rice-planted and non-planted paddy soils
Conclusion

- At 80-d uniform labeling, organic $^{14}$C in rice-planted soils 4× more than in non-planted soils.

- At 80-d of labeling, SOC$^{14}$ concentration was positively correlated with biomass C$^{14}$.

- The distribution and transformation of the photosynthesized C had greater influence on the dynamics of DOC and MBC than that of SOC.

- Less native SOC mineralization (i.e. a negative priming effect) found in some soils.

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