The climate relevance of organic farming systems – what do we know?

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The manifold role of agriculture regarding climate change

Climate polluter

Climate Change

Affected

Climate protector
Organic Farming and Climate Change at FiBL Focus: Emission reduction

Scientific Basis:
- Feldmessungen
- Reviews/Meta-Analysen
- Prozessmodellierungen
- Betriebserhebungen

Process and system knowledge, Climate balance

Information/Dissemination:
Bio-Sektor, Verbände, Betriebe

Implementation:
- Klima-Betriebsmodell
- SMART
- carbon-offset Methodologien
- politische Fördermassnahmen
Contents

➢ More soil carbon in soils under organic management?

➢ Less GHG emissions from soils under organic management?

➢ GHG mitigation of organic crop production at global scale?
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The concept of C sequestration in soil

$\text{CO}_2$ –fixation via photosynthesis

Transformation into soil organic matter (Humus formation)
GHG mitigation through carbon storage in soils: organic vs. non-organic

Geographic distribution of the system comparisons for meta-analysis

74 studies globally with up to 211 paired comparisons

Gattenger et al., PNAS, 2012
More carbon in organically managed soils?

Higher soil organic carbon concentrations (%) and stocks (t ha\(^{-1}\)) under organic farming management.
Is carbon sequestration possible within organic farming systems?

Yes, it is possible. Net sequestration of 450 kg C ha\(^{-1}\) y\(^{-1}\) (= 1.7 Mg CO\(_2\) eq ha\(^{-1}\) y\(^{-1}\)) for all organic systems; the potential is lower for zero net input systems (< 1.0 ELU ha\(^{-1}\)): 70 – 270 kg C ha\(^{-1}\) y\(^{-1}\).
Contents

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N2O emissions from agricultural soils

Bellarby et al. 2008
Meta study II: Soil-derived GHG fluxes (N$_2$O, CH$_4$) in soils under organic and non-organic management

18 studies globally with up to 98 paired comparisons

Skinner, Gattinger et al., STOTEN, 2014
### Less N\textsubscript{2}O from organically manaded soils?

<table>
<thead>
<tr>
<th>Land-use</th>
<th>Area-scaled N\textsubscript{2}O emissions \ (kg N\textsubscript{2}O–N ha\textsuperscript{-1} a\textsuperscript{-1})</th>
<th>Area-scaled GWP \textsuperscript{d} N\textsubscript{2}O emissions \ (kg CO\textsubscript{2}-eq. ha\textsuperscript{-1} a\textsuperscript{-1})</th>
<th>Yield-scaled GWP \textsuperscript{d} N\textsubscript{2}O emissions \ (kg CO\textsubscript{2}-eq. t\textsuperscript{-1} DM)</th>
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</thead>
<tbody>
<tr>
<td>All (annual)</td>
<td>\textmd{MD} \textsuperscript{a} 1.05, CI \textsuperscript{b} 0.34, \textit{p} 0.00, 12, comp. \textsuperscript{c} 70</td>
<td>\textmd{MD} \textsuperscript{a} 492, CI \textsuperscript{b} 160, \textit{p} 0.00, 12, comp. \textsuperscript{c} 70</td>
<td>\textmd{MD} \textsuperscript{a} 42.4, CI \textsuperscript{b} 33.1, \textit{p} 0.01, 7, comp. \textsuperscript{c} 25</td>
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<tr>
<td>Arable</td>
<td>\textmd{MD} \textsuperscript{a} 1.06, CI \textsuperscript{b} 0.35, \textit{p} 0.00, 11, 67</td>
<td>\textmd{MD} \textsuperscript{a} 497, CI \textsuperscript{b} 162, \textit{p} 0.00, 11, 67</td>
<td>\textmd{MD} \textsuperscript{a} 41.1, CI \textsuperscript{b} 34.2, \textit{p} 0.02, 6, 23</td>
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<td>Grassland</td>
<td>\textmd{MD} \textsuperscript{a} 2.33, CI \textsuperscript{b} 5.40, \textit{p} 0.40, 2, 3</td>
<td>\textmd{MD} \textsuperscript{a} 1091, CI \textsuperscript{b} 2531, \textit{p} 0.40, 2, 3</td>
<td>\textmd{MD} \textsuperscript{a} 45.6, CI \textsuperscript{b} 190.3, \textit{p} 0.64, 2, 2</td>
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<td>Rice-paddies</td>
<td>\textmd{MD} \textsuperscript{a} 1.38, CI \textsuperscript{b} 2.22, \textit{p} 0.22, 1, 3</td>
<td>\textmd{MD} \textsuperscript{a} 646, CI \textsuperscript{b} 1040, \textit{p} 0.22, 1, 3</td>
<td>\textmd{MD} \textsuperscript{a} 25.4, CI \textsuperscript{b} 49.2, \textit{p} 0.31, 1, 3</td>
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<tr>
<td>Overall</td>
<td>\textmd{MD} \textsuperscript{a} 0.93, CI \textsuperscript{b} 0.25, \textit{p} 0.00, 18, 98</td>
<td>\textmd{MD} \textsuperscript{a} 434, CI \textsuperscript{b} 118, \textit{p} 0.00, 18, 98</td>
<td>\textmd{MD} \textsuperscript{a} 30.7, CI \textsuperscript{b} 28.9, \textit{p} 0.08, 8, 30</td>
</tr>
</tbody>
</table>

\textsuperscript{a} MD, Mean Difference under organic treatments; negative values mean less emissions compared to non-organic treatment.
\textsuperscript{b} ± 95% confidence interval (CI).
\textsuperscript{c} Comparisons.
\textsuperscript{d} Greenhouse Warming Potential (GWP).
\textsuperscript{e} EF: Emission factor; total inputs: external inputs plus those from within the field e.g. N fixation and plant residues.
\textsuperscript{f} All annual measurements excl. rice (arable & grassland).
\textsuperscript{g} All landuse types excl. rice; annual and short time measurements.

Related to area: ca. 0.5 t ha\textsuperscript{-1} yr\textsuperscript{-1} less CO\textsubscript{2} eq. in form of N\textsubscript{2}O under organic management

Related to yield: ca. 0.05 t ha\textsuperscript{-1} yr\textsuperscript{-1} more CO\textsubscript{2} eq. in form of N\textsubscript{2}O under organic management

Skinner, Gattinger et al., STOTEN, 2014
Less CH$_4$ from organically manured soils?

Only a few studies: in arable soils increased CH$_4$ uptake under organic, but in riced paddies highest CH$_4$ emission under organic management

Skinner, Gattinger et al., STOTEN, 2014
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What is most effective in GHG mitigation in crop production?

A few thoughts….

- **Conversion from wetland to upland rice production** (saving of 4.0 Mg CO₂ eq ha⁻¹ y⁻¹; Skinner et al. 2014)
- **Restoration of farmed organic soils** (saving of 10.0 Mg CO₂ eq ha⁻¹ y⁻¹; Freibauer et al., 2004), *restricted agricultural utilisation*
- **C sequestration by conversion to OF** (saving of 1.7 Mg CO₂ eq ha⁻¹ y⁻¹; Gattinger et al., 2012), *not permanent, less yield*
- **C sequestration by adoption of reduced tillage** (saving of up to 1.0 Mg CO₂ eq ha⁻¹ y⁻¹) *not permanent*
- **N₂O mitigation by conversion to OF** (saving of 0.5 Mg CO₂ eq ha⁻¹ y⁻¹; Gattinger et al., 2012), *less yield*
- **N₂O mitigation by site-specific fertilisation** (saving of up to 30%; Sehy et al., 2003)
- **C seq. + N₂O + CH₄ mitigation by converting to OF**: no rice-paddies + reduced tillage + site-specific fertilisation + biochar…?
Thank you very much for your attention!

Further infos:
http://www.fibl.org/de/themen/klima.html
http://www.fibl.org/de/themen/nachhaltigkeit.html
http://www.organicandclimate.org