Goods for European farmers and consumers

Urs Niggli
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- What is the state-of-the-art in literature on the public goods delivered by organic farms?
- Are ecological advantages of organic farming neutralized by weak yields?
- Which direction should innovation in organic farming take?
- How to fill up the gap between organic certification and best organic practice?
References from field research sites
.meta-analyses

Gattinger et al., 2012 (FiBL)
www.pnas.org/cgi/doi/10.1073/pnas.1209429109
Established in 1981.
Three cropping systems are compared.
8 replications, 3 crops represented each year in each system.
Plot size: 20 x 300 ft (6 x 91.5 m)
Lysimeters installed in 4 reps in fall of 1990.
Long-term Agronomic Experiments since 1978

The DOK farming system comparison (CH)

- 8 treatments
- 3 crops
- 4 replicates
- 96 plots at 100m²

**D**: Bio-dynamic
**O**: Bio-organic
**K**: Integrated
1: low input (0.7 LSU/ha)
2: standard input (1.4 LSU/ha)

Control treatments:
**M**: Integrated no manure
**N**: unfertilized

- Maize
- Soybeans (catch crop)
- Winter wheat I (catch crop)
- Potatoes
- Winter wheat II
- Grass-clover
- Grass-clover

Mäder, Fliessbach, …., Niggli (2002), Science 296
Frick soil tillage field experiment (since 2002)

Plough vs. reduced tillage system.
Slurry vs. composted manure + slurry top.
+/- biodynamic preparations.

Stagnic Eutric Cambisol
2.2% organic carbon
45% clay
7.0 pH
1000 mm precipitation
Long-term farming systems comparisons (since 2007)

- Bolivia
  - Agro-forestry
    - humid
    - cocoa

- Kenya
  - Subsistence farming
    - semi-humid
    - maize
    - vegetables

- India
  - Cash crop
    - semi-arid
    - cotton
    - soya
    - wheat

How certification is supposed to work

Source: Roscher, 2007
[Retrieved: 15.10.2010]
Also a question of individual commitment

Organic farmers in Switzerland have higher proportions of semi-natural land, land for ecological compensation or set-aside land than conventional farms (dataset: 60‘000 farms = 100%)

## Biodiversity on organic farms* (global literature review of comparison studies)

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Positive</th>
<th>Negative</th>
<th>No difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds</td>
<td>7</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mammals</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butterflies</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Spiders</td>
<td>7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Earthworms</td>
<td>7</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Beetles</td>
<td>13</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Other arthropods</td>
<td>7</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Plants</td>
<td>13</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Soil microbes</td>
<td>9</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>66</strong></td>
<td><strong>8</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>

* Scales: Plots, fields, farms, landscape

Hole et al., 2005. Biological Conservation 122, 113-130
Meta-analyses of 74 field trials world-wide: sequestration rate (Mg ha\(^{-1}\) year\(^{-1}\)) and C stocks

Organic fields sequester 450 kg more atmospheric carbon per year than conventional ones.

Mean difference in carbon stocks: 3.5 tons C per hectare
### Less N$_2$O from organically managed soils

<table>
<thead>
<tr>
<th>Land-Use</th>
<th>MD *</th>
<th>CI</th>
<th>p</th>
<th>Studies</th>
<th>Comp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (annual)</td>
<td>-1.04</td>
<td>0.41</td>
<td>0.00</td>
<td>12</td>
<td>70</td>
</tr>
<tr>
<td>Arable</td>
<td>-1.01</td>
<td>0.42</td>
<td>0.00</td>
<td>11</td>
<td>67</td>
</tr>
<tr>
<td>Grassland</td>
<td>-2.42</td>
<td>5.16</td>
<td>0.36</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Rice-paddies</td>
<td>-1.39</td>
<td>2.22</td>
<td>0.22</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Overall</td>
<td>-1.03</td>
<td>0.32</td>
<td>0.00</td>
<td>18</td>
<td>98</td>
</tr>
</tbody>
</table>

| GWP d N$_2$O emissions per acreage (kg CO$_2$-eq. ha$^{-1}$ a$^{-1}$) |
|-------------------|-----------------|-----|-----|---------|-------|
| MD * | CI  | p   | Studies | Comp. |
| -486 | 191 | 0.00| 12      | 70    |
| -472 | 195 | 0.00| 11      | 67    |
| -1133| 2416| 0.36| 2       | 3     |
| -850 | 1038| 0.22| 1       | 3     |
| -482 | 150 | 0.00| 18      | 98    |

Mean difference for all studies 0.5 t ha$^{-1}$ yr$^{-1}$ less CO$_2$ eq. as nitrous oxide.

**Cut-off point: - 17 % yields**

Soil properties in the DOC experiment (year 24)
Organic = good adaptation to climate change due to higher soil carbon levels

- Increased **aggregate stability** (Gerhardt, 1997; Siegrist et al., 1998; Brown et al., 2000; Mäder *et al.*, 2002; Pulleman et al., 2003; Williams & Petticrew, 2009).

- Increased **water holding capacity**, higher **water content in soil** (Brown et al., 2000; Lotter et al., 2003; Pimentel et al., 2005)

- Improved **infiltration rate** of water (Lotter et al., 2003; Pimentel et al., 2005; Zeiger & Fohrer, 2009).
Yields: state-of-the-art of literature

- Temperate zones: The ratio between organic and conventional yields (intensive farms) is between 0.75 and 0.8.

- Proof of concept: The DOK trial running in permanence in Switzerland since 1977: Ratio of yields of several seven year crop rotations: 0.83 organic/conventional.
Yields: state-of-the-art of literature

- Sub-Saharan Africa: The ratio between organic and traditional yields is **2.16** in favor of organic.

- An older meta-analyses of global data: the average yield ratio “organic/conventional” was slightly <1.0 for studies in the developed world and >1.0 for studies in the developing world.
DOK trial in CH, since 1977: Organic yields 83 %, excellent input/output ratio

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Organic farming</th>
<th>Integrated farming (IP) with FYM</th>
<th>Organic in % of IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient input</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrient input</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg $N_{total}$ ha$^{-1}$ yr$^{-1}$</td>
<td>101</td>
<td>157</td>
<td>64 %</td>
<td></td>
</tr>
<tr>
<td>kg $N_{min}$ ha$^{-1}$ yr$^{-1}$</td>
<td>34</td>
<td>112</td>
<td>30 %</td>
<td></td>
</tr>
<tr>
<td>kg P ha$^{-1}$ yr$^{-1}$</td>
<td>25</td>
<td>40</td>
<td>62 %</td>
<td></td>
</tr>
<tr>
<td>kg K ha$^{-1}$ yr$^{-1}$</td>
<td>162</td>
<td>254</td>
<td>64 %</td>
<td></td>
</tr>
<tr>
<td>Pesticides applied</td>
<td>kg ha$^{-1}$ yr$^{-1}$</td>
<td>1.5</td>
<td>42</td>
<td>4 %</td>
</tr>
<tr>
<td>Fuel use</td>
<td>L ha$^{-1}$ yr$^{-1}$</td>
<td>808</td>
<td>924</td>
<td>87 %</td>
</tr>
<tr>
<td>Total yield output for 28 years</td>
<td>%</td>
<td>83</td>
<td>100</td>
<td>83 %</td>
</tr>
<tr>
<td>Soil microbial biomass as „output“</td>
<td>tons ha$^{-1}$</td>
<td>40</td>
<td>24</td>
<td>167 %</td>
</tr>
</tbody>
</table>
Long-term field trial Madhya Pradesh State (Nimar Valley), semi-arid, 800 mm rainfall

![Graph showing agronomic N efficiency kg yield/kg N for different crops and methods.]

- **Organic**
- **Conventional**
- **Conventional + Bt cotton**

**Crop Types:**
- Seed cotton
- Soybean grains
- Wheat grains
- Total crop rotation
Having a clear strategy for innovation

- We need more innovation, otherwise organic farming will become irrelevant.

- The approach taken by the organic movement towards innovation is controversial:
  - For some innovations like bio-control, ICT, precision farming, robots, food processing technology, food storage and packaging, food logistic, glasshouse production, a **technology-affine** approach is taken.
  - Whilst in many cases, technology is seen as a diametric opposite to traditional farmer knowledge.
Having a clear strategy for innovation

- Organic farming should better adopt the full pathway to innovation (and be leading at critically assessing technologies case by case).

- Hierarchy of innovation to be consequently adopted in organic agriculture: Traditional farmer knowledge → farmer driven innovation (on-farm and action research; social and product innovation) → eco-functional innovation → scientific, technical and technological innovation.
Habitat management in cabbage

Ecological compensation areas, field margins, hedge rows

Plants attractive for crop specific enemies and antagonists

Wild flower strips

Cabbage

Direction of attraction for natural enemies and antagonists.

Functional diversity

Companion plants increase life span, fecundity and mobility of parasitoids

*Iberis amara*  
*Centaurea cyanus*  
*Diadegma semiclausum*
Companion plants serve as food sources within the crop to enhance longevity and oviposition of parasitoids

Parasitoids: from 2 day survival in cabbage (mono) to 20 days in cabbage + cornflower

Céline Géneau, 2008
Abundance and biomass of earthworms (g/m²)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>All</th>
<th>Juvenile</th>
<th>Cocons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight</td>
<td>Number</td>
<td>Weight</td>
</tr>
<tr>
<td>Plough</td>
<td>56.1</td>
<td>156.5</td>
<td>11.2</td>
</tr>
<tr>
<td>Reduced</td>
<td>83.3</td>
<td>261.8</td>
<td>18.8</td>
</tr>
<tr>
<td>Red/Plough</td>
<td>+48%</td>
<td>+67%</td>
<td>+68%</td>
</tr>
</tbody>
</table>
IFOAM: Best practice (SOAAN)
Conclusions

› Overwhelming evidence for being good at delivering public goods at a reasonable level of productivity.
› How to upscale and mainstream organic farming?*
› Discussion about a clearer strategy towards innovation.
› Best organic practice will become important.

* Reasons for niche position:
  • Lack of information of consumers?
  • Big Business opposed?
  • Lack of research (less than 1 % of research spending)?
  • Too expensive?
  • True cost accounting not applied?