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Environmental assessment of contrasting French organic vegetable farms

Antonin Pépin *, Hayo van der Werf, Kevin Morel, Dominique Grasselly, Marie Knudsen
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Context

• Diversity of organic vegetable farms (Pépin et al., 2021)

• What are the environmental performances of organic vegetable farms that are contrasted by their agroecological functioning?
Method: Life cycle assessment (LCA)

- **Inputs**: Farm
  - CO₂, N₂O, CH₄, NO₃, etc.
  - Energy, resources (metal, plastic, etc.)

- **Farming system approach of LCA**
  - All inputs and operations are estimated for the entire farm
  - The output is the total production of vegetables
  - Comparison of 3 contrasting farms

- **Outputs**:
  - Climate change
  - Land competition
  - Plastic pollution
  - Biodiversity

After Jolliet et al. (2015)
## MF: microfarm

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Microfarm (MF)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Outdoor</strong></td>
<td>0.16 ha</td>
</tr>
<tr>
<td><strong>Tunnel</strong></td>
<td>0.12 ha</td>
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<tr>
<td><strong>No. of veg.</strong></td>
<td>35</td>
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<tr>
<td><strong>Yield</strong></td>
<td>35 t/ha/yr</td>
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<tr>
<td><strong>Agroecology</strong></td>
<td><strong>Agroeco ++</strong></td>
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<td><strong>Inputs -</strong></td>
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<tr>
<td>Inputs</td>
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</table>

SP: specialised in sheltered production
OP: specialised in outdoor production

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<thead>
<tr>
<th></th>
<th>Microfarm (MF)</th>
<th>Sheltered production (SP)</th>
<th>Outdoor production (OP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor</td>
<td>0.16 ha</td>
<td>0 ha</td>
<td>17.5 ha</td>
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<tr>
<td>Tunnel</td>
<td>0.12 ha</td>
<td>2.0 ha</td>
<td>0 ha</td>
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<tr>
<td>No. of veg.</td>
<td>35</td>
<td>6</td>
<td>20</td>
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<tr>
<td>Yield</td>
<td>35 t/ha/yr</td>
<td>67 t/ha/yr</td>
<td>9 t/ha/yr</td>
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<tr>
<td>Agroecology</td>
<td>Agroeco ++</td>
<td>Agroeco -</td>
<td>Agroeco +</td>
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<tr>
<td>BY</td>
<td>Inputs -</td>
<td>Inputs ++</td>
<td>Inputs +</td>
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</tbody>
</table>
Climate change

Greenhouse gas emissions
Method: IPCC
Unit: kg CO₂ eq.

Contribution analysis
- Microfarm (MF):
  - Diesel 49% (irrigation + tractor)
  - Tunnel 27% (steel + plastic)
- Sheltered farm (SP):
  - Tunnel 34% (steel + plastic)
  - Fertiliser 16% (fabrication)
  - Seedling production 15% (gas heating of nursery)
- Open field farm (OP):
  - Diesel 54% (tractors)
  - Field emissions 34% (N₂O)
- Different environmental profiles → different hints for eco-design / redesign

Total values
- Ranking depends on functional unit
- Per ha, OP << MF << SP
- Per kg, OP < MF & SP, but smaller differences
- Higher productivity per ha does not fully compensate the higher impact of SP
Land competition

Land occupied by the system
Method: CML-IA non-baseline
Unit: m²a

- Per ha, same impact: little indirect land
- Per kg, OP has the largest impact
  - 1 cycle/year
  - Lower yields
- Trade-off: land competition vs. climate change
Growing concern in horticulture

- SP >> MF >> OP
  - Tunnel (SP & MF)
  - Single-use plastic (mulch, pipes) (SP)
  - Reusable plastic (MF)
  - Scale issue?

- Indicator combining all types of plastic and uses (single-use, hardware, in/out of soil, etc.)
  - Probably not the same impact
  - Indicator to be improved

- Not an LCA indicator: use, not impact
  - Microplastics in soil and water

Plastic pollution in LCA: emerging topic

- Recognising the long-term impacts of plastic particles (Gontard et al., 2022).
- Create LCA indicators for plastic pollution (Lavoie et al., 2021; Saling et al., 2020; Woods et al., 2021).

Method: the sum of plastic used on the farm or contained in its inputs
Unit: kg of plastic
Biodiversity

SALCA-BD (Jeanneret et al., 2014)
An expert system based on scientific literature
Based on a detailed inventory of farming practices

- On cultivated areas, small differences: MF & OP > SP
  - Sensitivity of SALCA-BD?
- On whole farms, including semi-natural areas: SP > MF > OP
  - Large fields → low field perimeter:area ratio (OP)
  - Large area of ruderal areas between tunnels (SP)
- Importance of semi-natural areas (hedges, extensive grassland, etc.) for biodiversity
- Question of spatial farm boundaries (MF)
Conclusion

- No clear ranking of the farms, depends on the indicator and the FU
  - Climate change & plastic: inputs
  - Land occupation: yield
  - Biodiversity: semi-natural areas, field size

- Complementarity of the systems
  - Vegetables / Markets
  - Responses to different environmental issues
  - Matter of choice: vision of farming

- Farm-specific effects / case study
  - MF: diesel vs. electric pump
  - SP: plastic tunnel vs. glasshouse
  - OP: use of plastic mulch

Find the best trade-off
Design of farming systems
Thank you!