Origins of the performance gaps in innovative cropping systems under experimental assessment.
Caroline Colnenne-David, Gilles Grandeau, Véronique Tanneau, Marie-Helene Jeuffroy, Thierry Doré

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To meet new agricultural issues and make agriculture more sustainable, innovative cropping systems (ICSs) targeting a multiplicity of purposes need to be designed. Four ICSs were designed by prototyping (Reau and Doré, 2008) and assessed in a long-term field system experiment.

Our objective was to analyze the results after the first complete rotation, particularly the bad performances compared to the targeted aims.

**Materials and Methods**

### Multiple goals of the four designed ICSs (Colnenne-David and Doré, 2014)

**The PHEP ICS goals:**

1. **To satisfy multiple environmental criteria:**
   - low pesticide use → high crop diversity, highly resistant varieties
   - low direct energy consumption → only 1 ploughing within the rotation
   - low indirect energy consumption → legumes in the rotation
   - low nitrogen leaching → catch crop (CC) before spring crops and no N fertilization during autumn and winter
   - stabilization and/or to enrich soil organic matter → burying residues of all crops

2. **To reach yield targets**
   - matching the Ile-de-France yields

**Crop sequence:** winter faba bean, winter wheat, winter oilseed rape, winter wheat, mustard as CC and spring barley

**The L-GHG ICS goals:**

1. **50% GHG emissions compared to the PHEP ICS**
   - (i) increase soil C sequestration → many cereals, continuous soil cover, high yield targets, no ploughing
   - (ii) decrease N₂O emissions → high number of legume crops in the rotation, improvement of N fertilization management, crops with taproots in order to reduce soil compaction

2. **To satisfy multiple environmental criteria:**
   - Idem PHEP ICS

3. **To reach yield targets:**
   - matching the Ile-de-France yields

**Crop sequence:** catch crop (CC), maize, triticale, CC, spring faba bean, winter oilseed rape, winter wheat, CC, winter barley

**The L-EN ICS goals:**

1. **50% fossil energy consumption compared to the PHEP ICS**
   - (i) Low direct energy consumption → no ploughing and using direct sowing machine
   - (ii) Low indirect energy consumption → high number of legume species in the rotation, species with high N efficiency use, decrease N fertilization by reducing yield objectives

2. **To satisfy multiple environmental criteria:**
   - Idem PHEP ICS

3. **To reach yield targets:**
   - 20% lower than the Ile-de-France yields

**Crop sequence:** winter faba bean, winter wheat, winter flax, winter wheat–trifolium mixture, *Trifolium* as CC, spring oat

**The No-Pest ICS goals:**

1. **No pesticide is allowed**
   - long rotation including a wide diversity of species (e.g. hemp), alternate sowing dates, different dates and densities of sowing, highly resistant varieties or mixtures, ploughing and mechanical weeding

2. **To satisfy multiple environmental criteria:**
   - Idem PHEP ICS

3. **To reach yield targets:**
   - higher than organic systems in the Ile-de-France

**Crop sequence:** triticale, CC, maize, winter wheat, CC, spring faba bean, winter wheat, CC, hemp

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**Results: Classification of the major disparities**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Examples collected in the ICSs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some agronomic strategies were no suitable to reach the goals</td>
<td>In the L-GHG ICS: No ploughing → No increase of C sequestration as expected. C sequestration evolution = -149kgCO₂ ha⁻¹ year⁻¹ (+87kgCO₂ ha⁻¹ year⁻¹ expected)</td>
</tr>
<tr>
<td>Some practices were not adapted to satisfy a multiplicity of objectives</td>
<td>In the No-Pest ICS: No possible to satisfy both the pesticide constraint and the S.O.M. criteria. Restitution of small organic matter amounts + regular ploughings → Few weeds but adverse effect on C sequestration (C sequestration evolution = -560kgCO₂ ha⁻¹ year⁻¹)</td>
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<tr>
<td>Some practices were not appropriate in the context of the field-trial conditions</td>
<td>In the L-GHG ICS: Very dry conditions in summer 3 years / 6 → Low amount of aerial biomass of cover crops</td>
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<td>An unpredicted evolution of the agrosystem occurred</td>
<td>In both the L-EN and the L-GHG ICSs: High weed development → to mow oilseed rape plots in 2014</td>
</tr>
</tbody>
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**Discussions – Conclusion**

- After the first complete rotation the major sources of disparities were classified
- Nevertheless, a more complete agronomic diagnosis is necessary to identify and to rank all the causes of bad performances
- This knowledge allowed us to improve the innovative cropping systems through a new design step
- This experiment contributes to the learning design processes and cropping system management

**REFERENCES**