Origins of the performance gaps in innovative cropping systems under experimental assessment.
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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: faba bean, winter wheat, winter oilseed rape, winter wheat, CC, winter 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

### Results: Classification of the major disparities

#### Classification

<table>
<thead>
<tr>
<th>Examples collected in the ICSs</th>
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<tbody>
<tr>
<td>Some agronomical strategies were no suitable to reach the goals</td>
</tr>
</tbody>
</table>

- 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)

<table>
<thead>
<tr>
<th>Some practices were not adapted to satisfy a multiplicity of objectives</th>
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<tbody>
<tr>
<td>In the No-Pest ICS:</td>
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<tr>
<td>- No possible to satisfy both the pesticide constraint and the S.O.M. criteria.</td>
</tr>
</tbody>
</table>
| - Restitution of small organic matter amounts + regular ploughings → Few weeds but adverse effect on C sequestration (C sequestration evolution = -560kgCO₂ ha⁻¹ year⁻¹)

<table>
<thead>
<tr>
<th>Some practices were not appropriate in the context of the field-trial conditions</th>
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<tr>
<td>In the L-GHG ICS:</td>
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</table>
| - Very dry conditions in summer 3 years / 6 → Low amount of aerial biomass of cover crops

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<tr>
<th>An unpredicted evolution of the agrosystem occurred</th>
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<tbody>
<tr>
<td>In both the L-EN and the L-GHG ICSs:</td>
</tr>
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</table>
| - High weed development → to mow oilseed rape plots in 2014

### 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
