Innovative cropping systems under a GHG emissions constraint: assessment from a long-term field trial

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Context and Objectives

To mitigate global warming and make agriculture more sustainable, innovative cropping systems (ICSs) targeting low greenhouse gas emissions (GHG) need to be designed. Our objectives were (i) to design ICSs by prototyping (Reau and Doré, 2008[1]) and (ii) to assess them in a long-term field system experiment.

Here, we present the results of two out of the four ICSs collected over the first complete rotation (2009-2014).

Materials and Methods

Multiple goals of the designed ICSs (Colnenne-David C. *et al*., 2014[2]).

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

*stabilize or to enrich soil organic matter → burying residues of all crops

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

Crop sequence: winter faba bean, winter wheat, winter oilseed rape, winter wheat, mustard as catch crop (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 N_2O emissions → high number of legume species in the crop rotation, N fertilization improvement, crops with taproots to reduce soil compaction

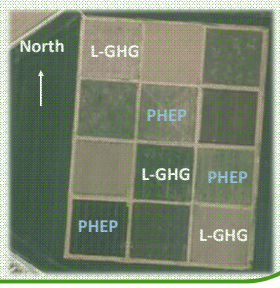
2. To satisfy multiple environmental criteria: idem **PHEP ICS**

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

Crop sequence: CC, maize, triticale, CC, spring faba bean, winter oilseed rape, winter wheat, CC, winter barley.

Main characteristics of field trial

- ✓located in Grignon (78, France)
- ✓6.2 ha (surface plot: ≈ 4000 m²)
- ✓3 blocks
- ✓deep loamy soil
- ✓Beginning of field assessment: 2008
- ✓Duration: 12 years, 2 rotations



Results

1. Carbone balance of the ICSs

Formula = CO_2 emissions - C sequestration (kg CO_2-eq.ha^{-1}year^{-1})

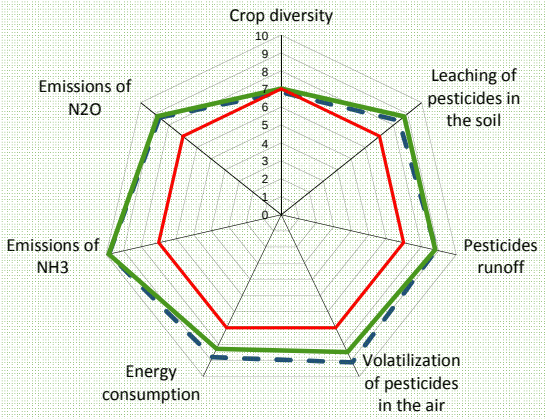
Assessment using Ges'tim[3] data and SIMEOS[4] tool over a 50-year period (S.O.M. = 1.6%)

	CO_2 emissions	C sequestration	C Balance
PHEP	1072	672	399
L-GHG	1052	613	439
L-GHG/PHEP			**110.2%**

Higher than expected

2. Agro-environmental indicators

calculated with the Indigo®tool **for the ICSs**



L-GHG ICS **- - PHEP ICS**

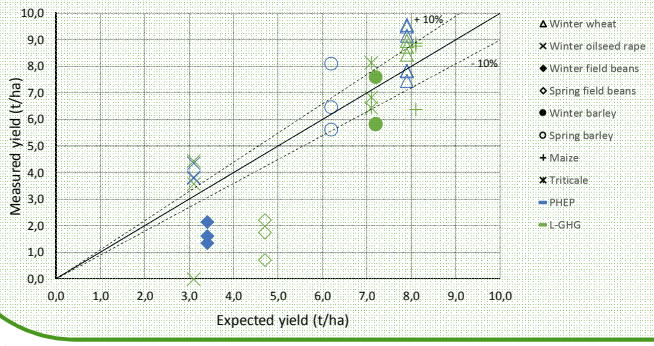
Min values (v ≥7) to satisfy environmental criteria

The two ICSs satisfy environmental criteria:
each indicator calculated achieved a value of 7

3. Yields

Results vary according to crop:

- cereal and oilseed rape yields were frequently as expected
- faba bean yields were systematically lower than expected



Discussion - Conclusion

➢ In the context of this long-term field trial, agronomic strategies implemented in the L-GHG ICS were not successful at reducing GHG emissions by 50% relative to the PHEP ICS. The main goal, *i.e.* increase C sequestration, was not reached because biomass productions were lower than expected: (i) cover crops did not grow three years out of six because of dry conditions in spring and (ii) faba bean growth was systematically lower than expected. Because the L-GHG ICS is expressed in reference to the PHEP ICS, the performance of this system plays an important role. In this ICS, crop residue quantities were regularly higher than expected (particularly for winter wheat) and cover crops sown in wet years produced high biomass quantities.

➢ As a result, we need to redesign the L-GHG ICS in order to satisfy the goal of GHG mitigation.

➢ However, the L-GHG ICS satisfied the environmental criteria and yields, except for faba bean, were close to expectations and match current regional levels, *i.e.* those required to ensure food security.

➢ More accurate data analyses need to be carried out to better understand why faba bean yields were low.

➢ These results need to be compared to the current regional system in order to put them in perspective and to judge their actual environmental performance.

➢ The two ICSs achieved a high score in terms of overall sustainability. The main difference occurred in the economic assessment: for some species, yields in the L-GHG ICS were regularly lower than those in the PHEP ICS. For both ICSs, the environmental assessment scored very high, with a high performance in terms of GHG emissions and C sequestration. The social assessment scored high as well. This economic disparities need to be assessed in different economic contexts in order to analyze the sensitivity of the two ICSs to a diversity of economic contexts.

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