



HAL
open science

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

Caroline C. Colnenne-David, Gilles Grandeau, Véronique Tanneau, Lucie Lefèvre, Marie-Hélène Jeuffroy, Thierry Doré

► **To cite this version:**

Caroline C. Colnenne-David, Gilles Grandeau, Véronique Tanneau, Lucie Lefèvre, Marie-Hélène Jeuffroy, et al.. Innovative cropping systems under a GHG emissions constraint: assessment from a long-term field trial. Climate smart agriculture confrence, Mar 2015, Montpellier, France. hal-01358616

HAL Id: hal-01358616

<https://agroparistech.hal.science/hal-01358616>

Submitted on 1 Sep 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

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, 2008¹) 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.*, 2014²).

The PHEP ICSS 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 ICSS goals:

1. **50% GHG emissions compared to the PHEP ICSS.**

- (i) **Increase soil C sequestration** → many cereals, continuous soil cover, high yield targets, no ploughing
- (ii) **decrease N₂O emissions** → high number of legume species in the crop rotation, N fertilization improvement, crops with taproots to reduce soil compaction

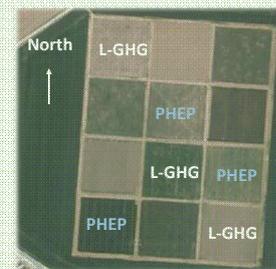
2. **To satisfy multiple environmental criteria:** idem PHEP ICSS

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



1. Carbone balance of the ICSS

Formula = CO₂ emissions - C sequestration (kg CO₂-eq.ha⁻¹.year⁻¹)

Assessment using Ges'tim³ data and SIMEOS⁴ tool over a 50-year period

(S.O.M. = 1.6%)

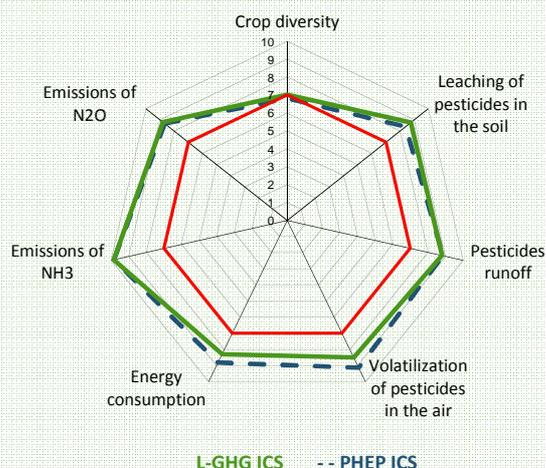
	CO ₂ emissions	C sequestration	C Balance
PHEP	1072	672	399
L-GHG	1052	613	439
L-GHG/PHEP			110.2%

Higher than expected

Results

2. Agro-environmental indicators

calculated with the Indigo[®] tool for the ICSS



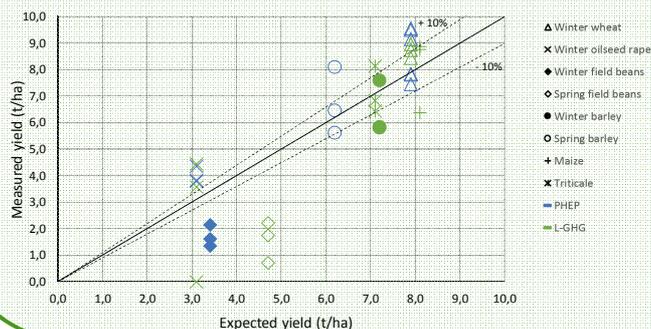
L-GHG ICSS **-- PHEP ICSS**

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 ICSS were not successful at reducing GHG emissions by 50% relative to the PHEP ICSS. 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 ICSS is expressed in reference to the PHEP ICSS, the performance of this system plays an important role. In this ICSS, 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 ICSS in order to satisfy the goal of GHG mitigation.
- However, the L-GHG ICSS 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 ICSS were regularly lower than those in the PHEP ICSS. 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.

REFERENCES

- ¹Reau R. & Doré T. (2008). "Systèmes de culture innovants et durables : quelles méthodes pour les mettre au point et les évaluer ?" *Educagri Editions, Dijon, France*, pp 175
- ²Andriulo A. *et al* (1999). "Modelling soil carbon dynamic with various cropping sequences on the rolling pampas." *Agronomie*, 19: 365-379
- ³GES'TIM 2010. Ministère de l'agriculture, de l'alimentation, de la pêche, de la ruralité et de l'aménagement du territoire. Réf. 0933103.
- ⁴Colnenne-David C., Doré T., 2014. Designing innovative productive cropping systems with quantified and ambitious environmental goals. "Renewable Agriculture and Food Systems". doi:10.1017/S1742170514000313.