Syppre

ARVALIS ITB Terres Inovia

Avec la contribution financière du compte d'affectation spéciale développement agricole et rural CASDAR

MINISTÈRE DE L'AGRICULTURE ET DE LA SOUVERAINETÉ ALIMENTAIRE
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DiverIMPACTS

Strategies of crop diversification, cover crop implementation and flexible tillage to improve soil fertility and the multi-performance of cropping systems

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Terres Inovia
l'agronomie en mouvement

Building tomorrow's cropping systems together

Soil fertility in the agroecological transition

- **Improving soil fertility** is key for the **agroecological transition of cropping systems** (Wezel *et al*. 2014)

- It requires to adopt systemic approaches and strategies adapted to the local context

→ the French technical institutes for arable crops Arvalis, Terres Inovia and ITB launched the collaborative **Syppre project** to design cropping systems reaching multiperformance, and to contribute to support the agroecological transition (Toqué et al., 2015)

The Syppre experimental network

Aim : design and assess cropping systems achieving multiperformance (productivity, profitability and respect of the environment) and robustness

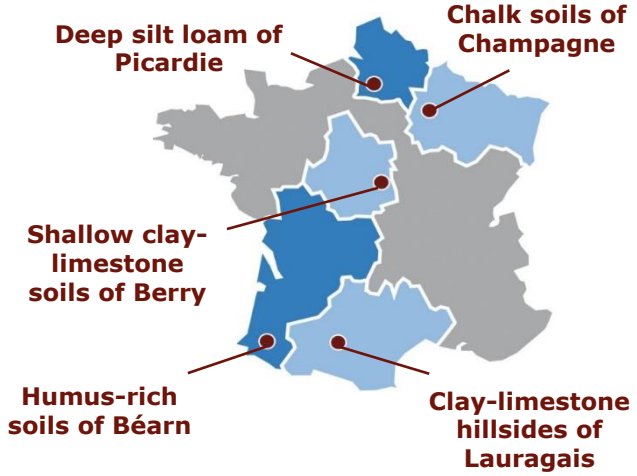
5 experimental sites in contrasted production situations of France

Experimental design:

- **Innovative system** designed to meet both multiperformance objectives and address site-specific issues **vs reference system** representative of local practices
- Designed and regularly fine-tuned with local experts
- ≈ 10 ha
- 2 or 3 replicates

Data collection and computation:

- Cultural practices from 2017 to 2023
- Performance indicators based on cultural practices calculated with Systerre tool
- Crop and soil observations



Questions addressed in the presentation

Focus on 2 of the 5 sites : Berry and Picardie

- What are the cropping systems and strategies, designed to meet multiperformance objectives and local issues including soil fertility, after 7 years of adjustments?
- What are the impacts of these strategies on soil fertility and crops performances?
- Do the cropping systems reach the multiperformance objectives?

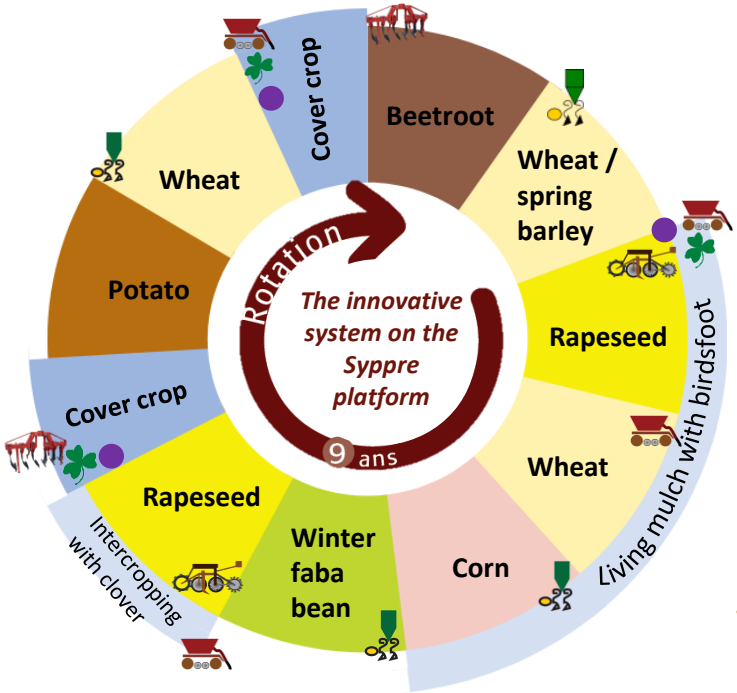
Innovative cropping system in Picardie

Context:

- Deep loamy soils
- Industrial high N-demanding crops
- Low OM content (risk of crusting, erosion)
- Heavy machinery : risk of soil compaction

Main local aims:

- Increase soil fertility (decrease risks of compaction and crusting)
- Decrease mineral fertilizers dependency



Innovative system

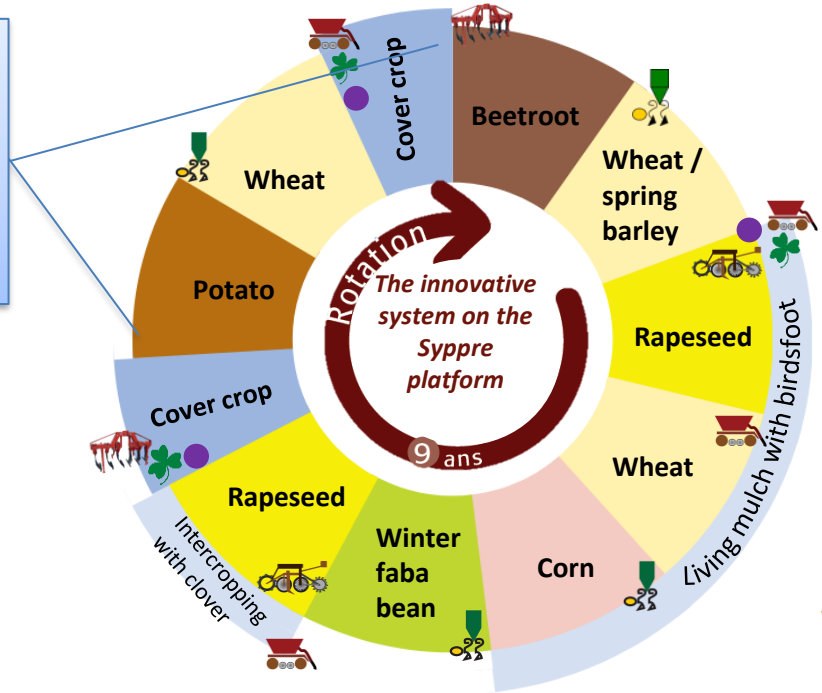
- Beetroot
- Wheat
- Potato
- Wheat
- Rapeseed
- Wheat

Reference system

Direct seeding
Superficial tillage
Non-inverting deep tillage
Conventional ploughing
Compost
Legumes

Innovative cropping system in Picardie

Flexible tillage : no ploughing, occasional tillage if required, innovative crop establishment strategies (autumn ridging of potatoes, superficial tillage for beetroot, strip-till for rapeseed)



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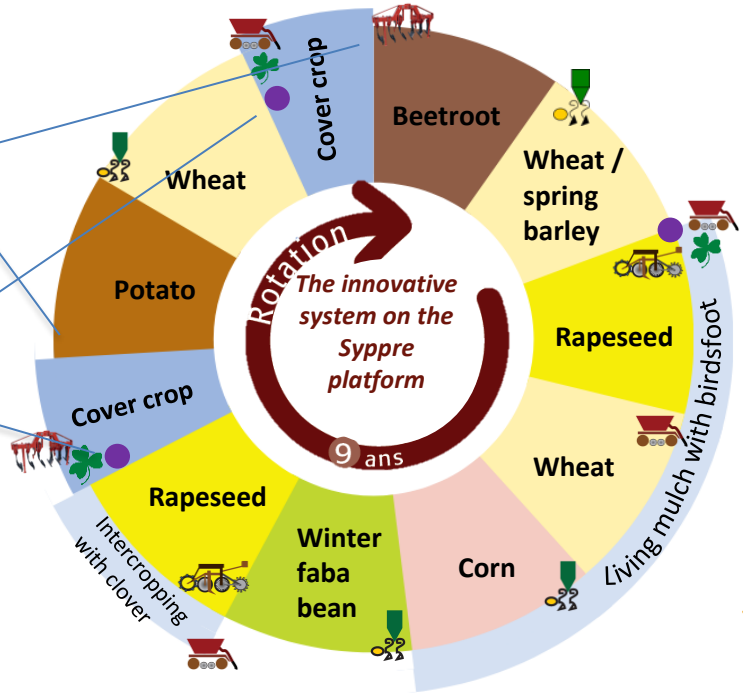
Compost supply



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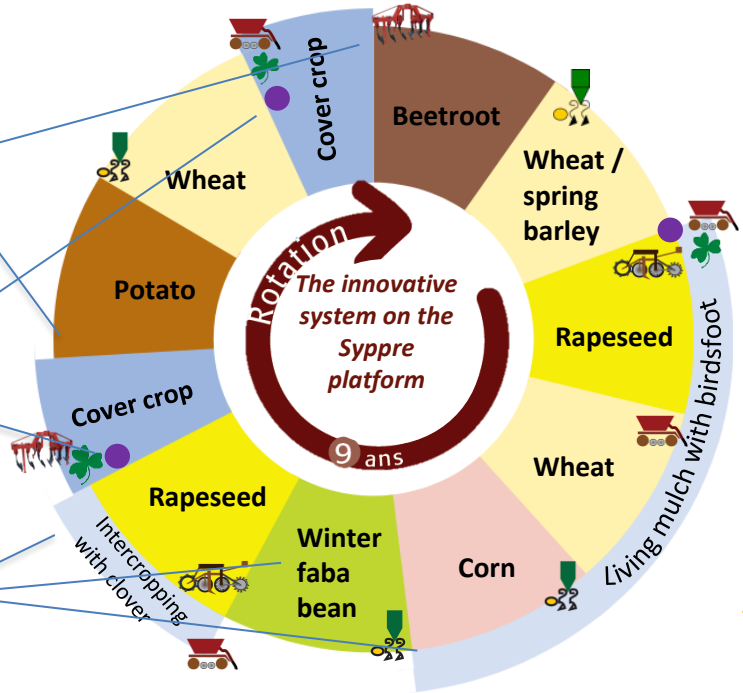
Compost supply

Diversification of the cropping system :
- Legume crops
- Crops with high OM restitution : corn, rapeseed



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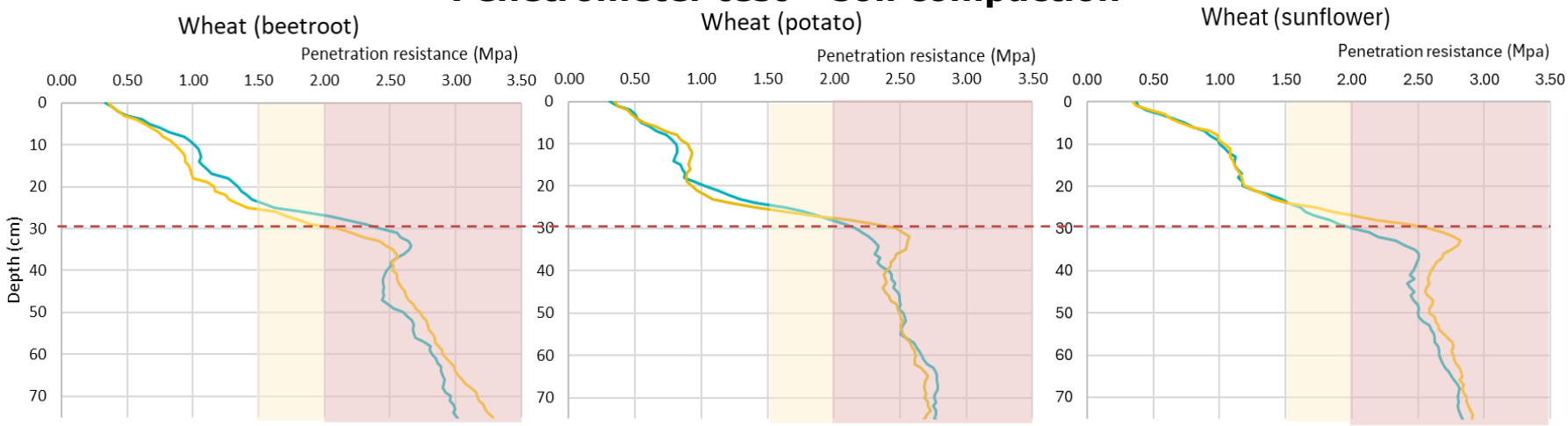
Soil fertility and crop performances - Picardie

Assessment of soil physical properties

Penetrometer test – soil compaction



Soil measures realised on 18 plots (9 innovative – 9 reference, wheat (beetroot), wheat (sunflower), wheat (potato) in 2024

- **Similar compaction profile on 0-30cm** : penetration resistance < 2 MPa (no risk for crops roots development)
- **Rupture zone** at 30 cm, more with a higher penetration resistance in the reference system (compaction)

Soil fertility and crop performances - Picardie

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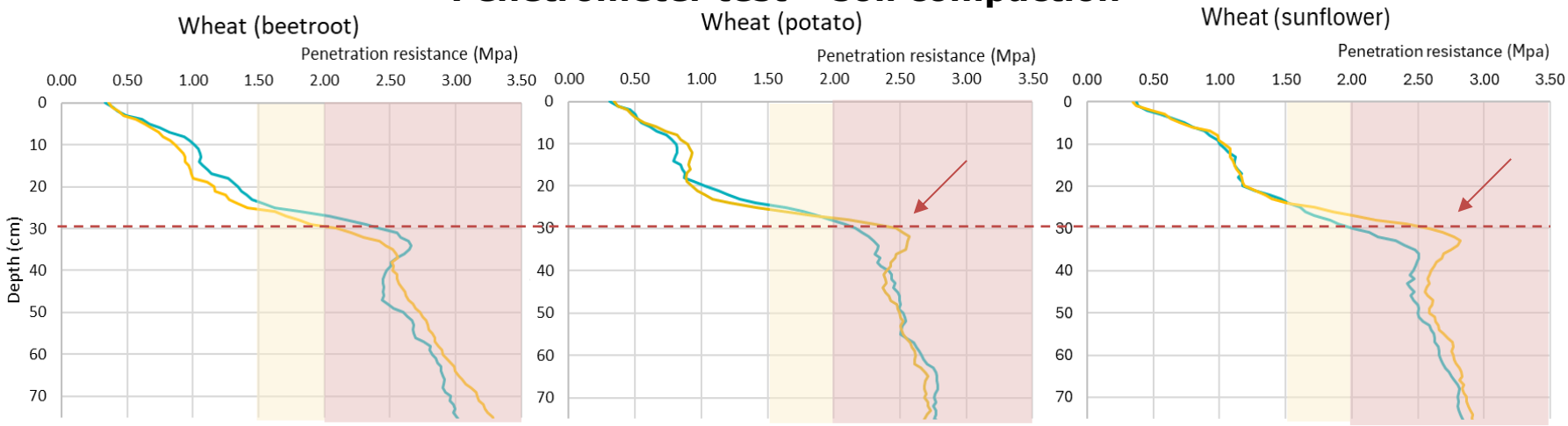

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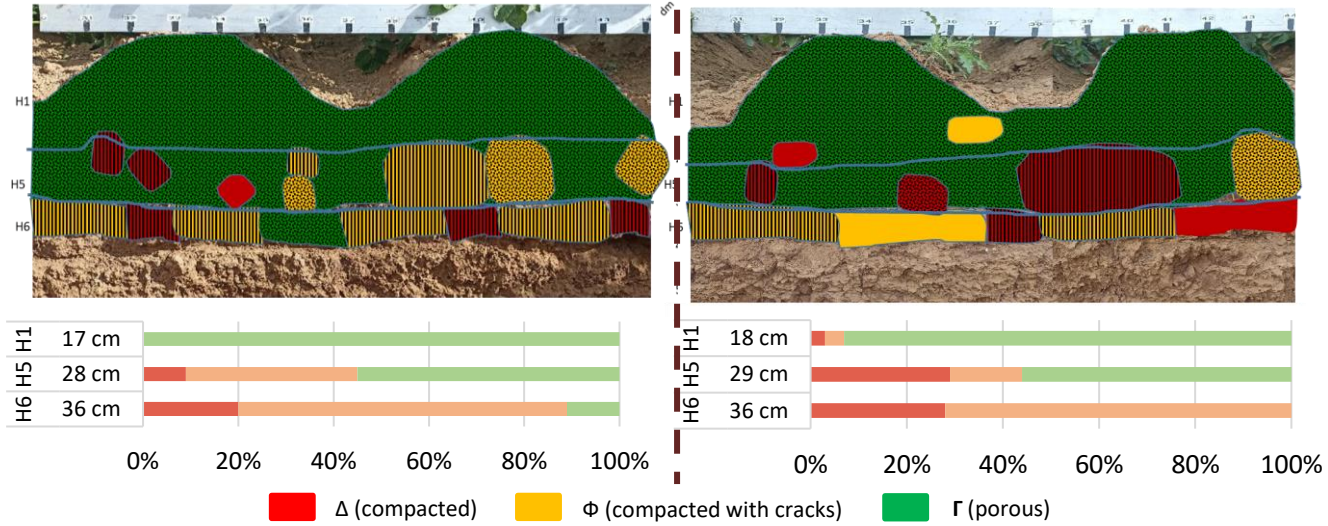
Soil fertility and crop performances - Picardie

Illustration with potatoes' performances

Innovative system:
Crop establishment = autumn ridging /Preceding crop = rapeseed

Cover crop on the ridges during winter

Reference system:
Crop establishment = ploughing / preceding crop = cereal



- Soil observation : less compaction in the innovative system (potatoes 2022)

Soil fertility and crop performances - Picardie

Illustration with potatoes' performances

Year	Tuber yield - %17 starch (t/ha)		Gap between innovative and reference
	Potato - innovative system	Potato – reference system	
2021	73.2 ± 8.5	67.1 ± 7.6	+ 9 %
2022	43 ± 5.2	38.2 ± 2.4	+ 12.7 %
2023	52.1 ± 1.7	51.9 ± 2.2	+ 0.4 %

Explanatory factors:

- Crop establishment strategy
- Soil physical properties
- Crop rotation effect: different preceding crops, lower frequency in the rotation …

- Potatoes' productivity is higher in the innovative system since 2021

Multiperformance assessment - Picardie

	Indicator	Objectives (Inno vs Reference)	Result : Average of 7 years (Inno vs Reference)
Technical performances	Treatment Frequency Index	≤ -20%	-21 ± 9% *
	Mineral nitrogen application (kg/ha)	≤ -20%	-30 ± 7% *
Environmental performances	Greenhouse Gases emissions (t eq. CO_2/ha)	≤ -20%	-14 ± 8% *
Productivity	Gross energy production (MJ/ha)	≥	-23 ± 7% *
	Energy efficiency	≥	-4 ± 10% *
Profitability	Direct margins with subsidies (€/ha)	≥	-40 ± 21% *

** : p-value of system effect < 0.05*

Multiperformance objective not achieved for the innovative system:

- ✓ technical and environmental performance's objectives achieved
- ✗ but productivity and profitability objectives not achieved

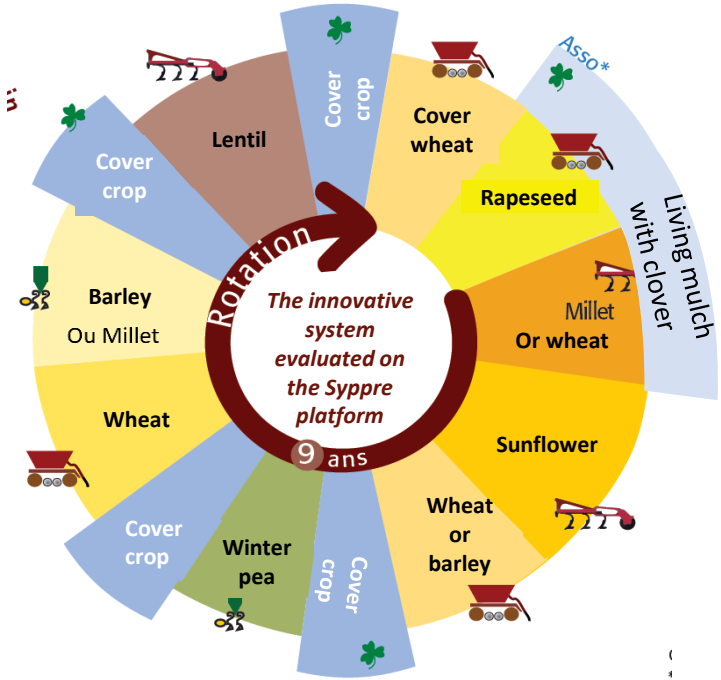
Innovative cropping system in Berry

Context :

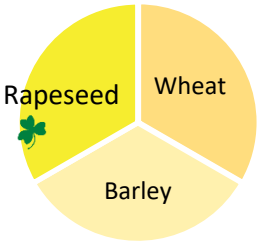
- Shallow clay-limestone soils (stony, low extractable soil water, low N mineralisation potential)
- Short crop rotation of winter crops (high risk of pest and weed pressure)

Main aims :

- Improve weed management
- Improve soil fertility (N mineralisation and soil structure)
- Improve crop robustness



Innovative system

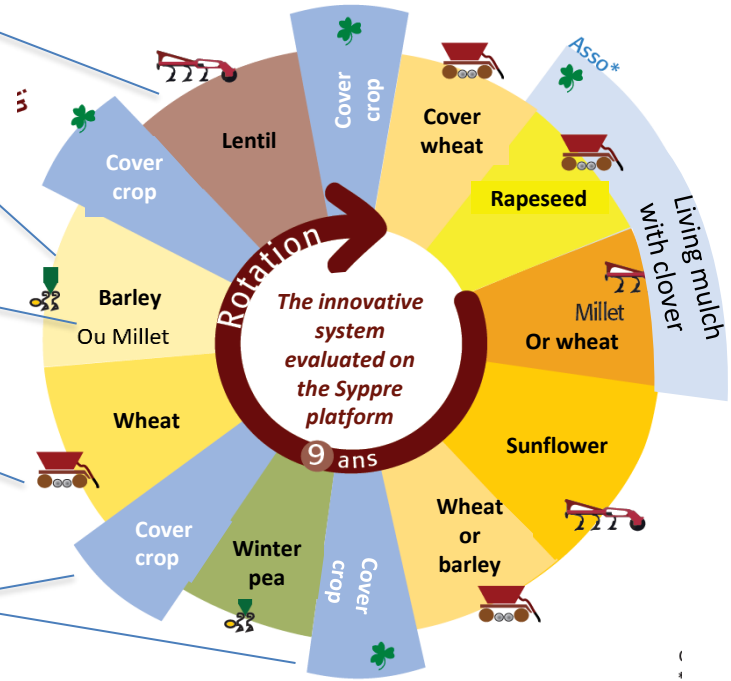


Reference system

Direct seeding
Superficial tillage
Deep tillage
Legumes

Innovative cropping system in Berry

- Legume crops
- Diversification, introduction of spring crops
- Flexibility of crop position in the rotation
- Reduction and flexibility of tillage (direct seeding of winter crops)
- Summer cover crop, living mulch



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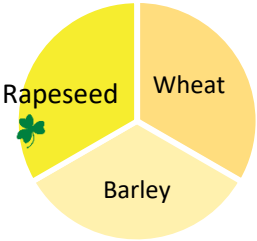

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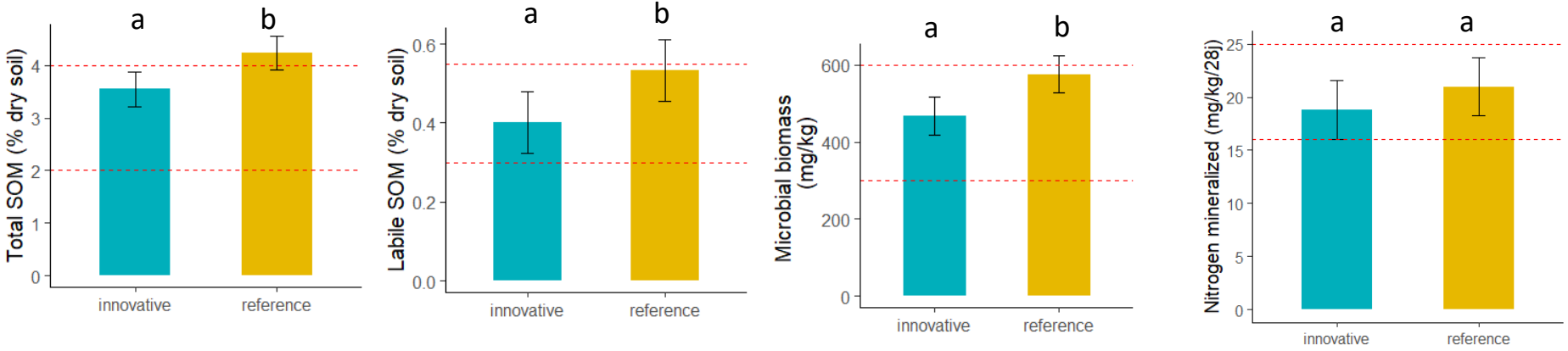
Soil fertility - Berry

Assessment of soil biological properties



------ Reference value for this soil type from Celesta Lab

Means of soil biological properties realised in 18 plots (9 innovative system – 9 reference system with the same crops, 3 replicates) in 2024, on soil depth of 0-20cm. Means comparison with Tukey test at α = 0.05. SOM = Soil Organic Matter Maximum tillage depth = 20cm (innovative & reference)

- After 8 years, OM content and more broadly soil biological properties are better in the reference than in the innovative system

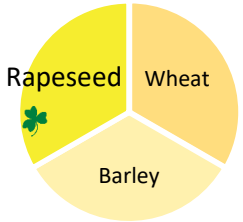
Soil fertility - Berry

Assessment of soil biological properties

Explanation :

- lower OM restitutions from crops of the innovative system than from the reference system
- variability of cover crops performances in this soil and climate conditions

Reference system



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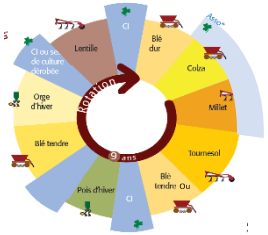

It shows:

- the **antagonism** between **diversification** of rapeseed-wheat-barley cropping system and **soil OM increase**

- the **difficulty to combine** improvements in **soil fertility** and **weed management**, as they involve antagonistic levers (diversification, soil tillage vs cover crops during intercrop period…)

Difficult to increase soil fertility while targeting multiperformance in this context!

Multiperformance assessment Berry

	Indicator	Objectives (Inno vs Reference)	Result : Average 2017 - 2023 (Inno vs Ref)	Result : Average 2021 - 2023 (Inno vs Ref)
Technical performances	TFI	≤ -20%	-21 ± 19% *	-32%
	Mineral nitrogen application (kg/ha)	≤ -20%	-30 ± 14% *	-16%
Environmental performances	GHGs emissions (t eq. CO_2/ha)	≤ -20%	-25 ± 11% *	-28%
Productivity	Gross energy production (MJ/ha)	≥	-20 ± 6% *	-16%
	Energy efficiency	≥	1 ± 13% NS	9%
Profitability	Direct margins with subsidies (€/ha)	≥	-9 ± 24% *	12%

** : p-value of system effect < 0.05*

- Multiperformance objective not achieved for the innovative system in average (less profitable)
- But improvements of profitability of the innovative system the last 3 years, mainly due to weed management improvement, the main issue of the system (at the expense of soil fertility improvement)

multiperformance achieved since 2021 for the Berry innovative system

Conclusion and perspectives

- Crop diversification, cover crop implementation and flexible tillage are a way **to improve soil fertility and cropping system performances**. However :
  - It is **not always sufficient to reach multiperformance** on the short-term
  - It **depends on the local context** : improving soil fertility is harder in cropping system with weed management issues (as weed management and soil fertility improvement often **require antagonistic practices**), in soil and climate conditions not favorable to grow cover crops, with no access to organic waste products…

- Perspectives :
  - **Further experimentation** required : As soil fertility improvement and cropping systems effect take time to materialize, the experimentations will go on (improvement and test of new practices…)
  - More **soil measures** required, in order to assess the long-term effect of innovative cropping systems on chemical, physical and biological properties of soil on the 5 platforms

Thank you for your attention