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Abstract

Direct seeding under permanent cover is an ambitious farming system. In the political context of glyphosate potential removal, the CASDAR ENGAGED project (2018-2022) brought together a number of agricultural stakeholders working with farmers in the Normandy Region on a project that aimed to 1/ conduct a technical survey on alternatives to glyphosate use, 2/ conduct field trials of technical practices on a network of farmers' plots, and 3/ redesign cropping systems in workshops with farmers and crop advisors. While technical monitoring enabled innovative practices implemented during the crop phase and fallow period to be identified, field trials tested crop management techniques such as shredding the cover crop, increasing the sowing density of the cereal crop and reducing the use of appropriate herbicides. Through the work of students and workshops with extension agents, the workshop-based redesign enabled farmers to face situations involving greater change than those they had undertaken on their own farms. The ENGAGED project showed that the framework of restrictions, based on a drastic reduction in herbicide use, does not make it possible to achieve yields equivalent to conventional management. The cover crop then becomes the main weed responsible for major yield losses and few viable technical solutions have been identified for a single crop year.

Keywords: glyphosate, no-tillage, permanent cover, weed control, co-conception, pedagogical method

1. Introduction

Permanent cover crop-based no-till system is a farming system designed to respect soil health, based on the application of three agronomic practices: drastically reducing soil disturbance, establishing as much plant cover as possible and maximising the diversity of crop species. These three pillars of conservation agriculture involve major changes in the agronomic and ecological functioning of cultivated plots. Despite practices designed to limit the development of weed flora, weed management is currently largely based on chemical weeding, with the use of active substances that penetrate the leaves, including glyphosate. Without this chemical control, weed species and perennial cover can lead to competition with the crop and yield losses, due in particular to competition for light energy (Carof, 2006; Carof *et al.*, 2007; Cordeau *et al.*, 2015) and water and nutrient resources. Given the current state of knowledge, the permanent cover crop-based no-till system is in a technical bind if the use of glyphosate is banned (Reboud *et al.*, 2017).

With the prospect of an announced ban on the use of glyphosate, Cerfrance Normandie Maine's ARAD², in partnership with the UMR Agroécologie (INRAE), the Normandie Ouest Cuma federation and the UniLaSalle Campus engineering school in Rouen, carried out the CASDAR ENGAGED project from 2018 to 2022, at the request of farmers using permanent cover crop-based no-till systems. The aim of this project was to build prototypes of direct seeding cropping systems under living or permanent plant cover, without the use of glyphosate and low in herbicides (Herbicide Treatment Frequency Index less than 1). To achieve this, three approaches were combined:

- A technical watch on alternatives to glyphosate for managing perennial cover crops
- Field trials in a network of farmers' plots
- Re-design in workshops with farmers and advisers via work by engineering students and re-design days with local players.

In consultation with the project's farmers, two ground cover management strategies were studied, including an analysis of the effects of these strategies on weed dynamics. In addition, in order to go beyond the experimental situations, co-design workshops were held. These enabled prototypes of glyphosate-free permanent cover crop-based no-till systems to be sketched out. This redesign also involved engineering students at the end of their initial agronomy training course, as part of a teaching module specifically designed for the project. Finally, an economic and working time evaluation of two prototype systems was simulated, in comparison with the permanent cover crop-based no-till system with glyphosate.

2. Weed dynamics under alternative crop management baning glyphosate use in permanent cover crop-based no-till system

2.2. Experimental set-up

Two ground cover management strategies were tested on winter wheat:

- Substitute glyphosate with a chemical strategy involving other herbicidal active substances during the intercropping period
- Increase the competitive effect of the crop on the canopy and weed flora by doubling the sowing density of the wheat (conventional density at 300 seeds/m²; high density at 600 seeds/m²).

For the first strategy, the 'control' management consisted of an application of adjuvated glyphosate (HRAC group[1] 9; 1.5 L/ha). During the cultivated phase, two herbicide applications were made: thifensulfuron-methyl/etsulfuron-methyl (HRAC group 2; 0.005 kg/ha), tribenuron-methyl (HRAC group 2; 0.016 kg/ha) and pinoxaden + cloquintocet-méxyl (HRAC group 1; 1.2 L/ha). Chemical substitution of glyphosate was achieved by the use of dicamba (HRAC group 4; 0.25 L/ha) applied in mid-October with or without prior shredding of the canopy, followed in certain conditions by an application of florasulam (HRAC group 2; 0.064 L/ha) in the wheat crop.

For the second strategy, which studied the competitive pressure of wheat, three conditions were set up: a control treated with glyphosate in the autumn and wheat sown at 300 grains/m², a condition without glyphosate also sown at 300 grains/m² and a condition without glyphosate sown at 600 grains/m².

The measurements are similar for the different years of experimentation and have made it possible to evaluate :

- The proportion of soil covered by weeds, dead plant debris (mulch), live cover, wheat and bare soil
- Weed species richness and density

[1] Herbicide Resistance Action Committee, a committee that classifies herbicides according to their active substance and mode of action.

- Wheat, canopy and weed development using above-ground biomass assessment
- The impact of modalities on wheat yield components (number of plants, tillers and ears)

Two flora survey campaigns were carried out at the end of November and mid-February. For each campaign, ten surveys were carried out per modality using quadrats (0.36 m²) laid randomly along the length of the modality (50 m long). The percentage of occupation in the delimited zone was estimated visually for weeds, mulch, live cover, wheat and bare soil.
The assessment of the species richness and density for each of the quadrats is completed by a drive carried out on each modality with the aim of capturing as many species as possible.

For the aerial biomass measurements, four survey campaigns were carried out: November, February, April and June. For each campaign, four surveys were carried out per modality. Quadrats were used to delimit an area from which all the plant biomass was taken. This biomass was then separated into three categories: wheat, canopy and weeds. For each of these categories, the fresh biomass is weighed in the field. A portion is then taken and oven-dried for at least 48 hours at 80°C to quantify the dry biomass.

2.3. Results

2.3.1. Chemical substitution of glyphosate

In the case of the chemical substitution strategy, although the weed flora was properly controlled in all the systems, the problem observed concerned the regulation of the white clover cover (Figure 1), with two critical phases: the establishment of the wheat and the re-vegetation of the clover.

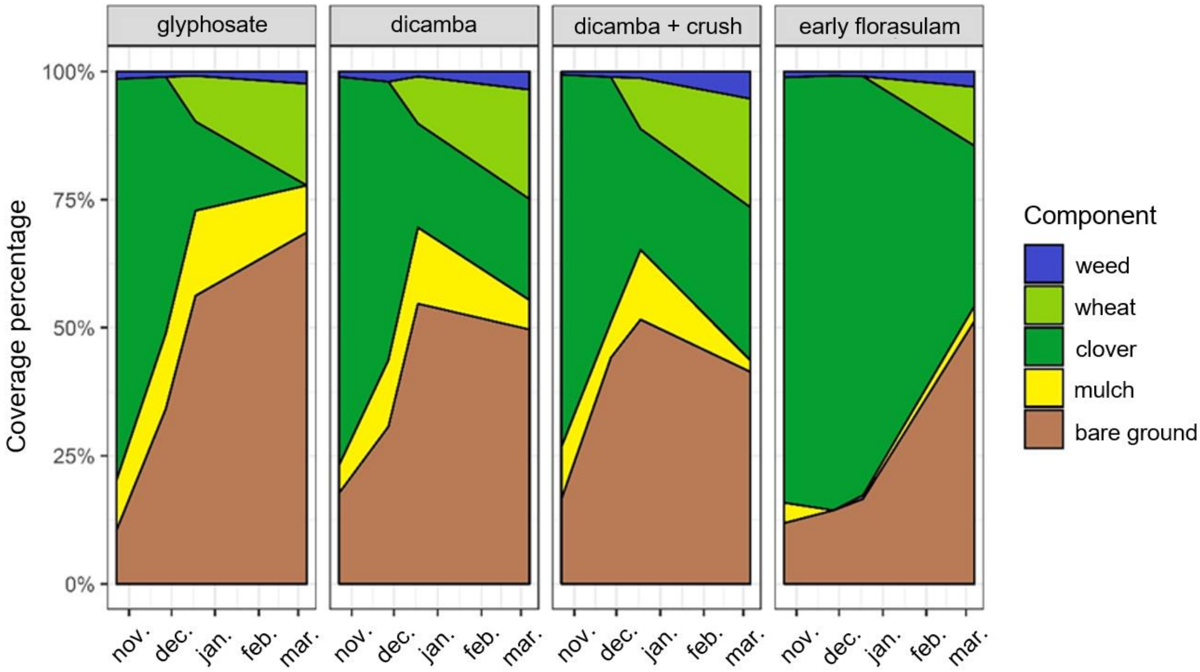

Figure 1: Changes in the proportion of soil cover (on four measurement dates between November and March), as a function of management method. Five soil cover components were observed: bare soil, mulch (dead plant material), clover (plant cover), wheat (crop) and weeds.

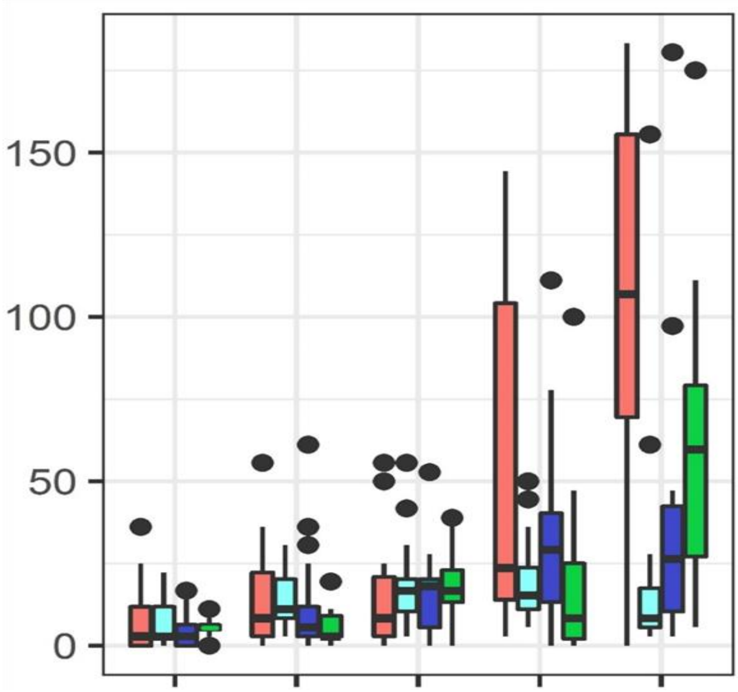

Figure 2: Weed density (plants/m²) according to weed control practices on the five dates of flora surveys (red: glyphosate, light blue: dicamba; dark blue: shredding + dicamba, green: early florasulam).

Overall, the "glyphosate" system provided satisfactory control of the canopy right up to harvest, favouring crop development at the start of the cycle. Chemical substitution with dicamba (action limited to broadleaf weeds) or the absence of chemical management during the intercropping period did not provide sufficient regulation of the flora (Figure 2) and the canopy, which ultimately resulted in a reduction in yields of more than 20 q/ha (Table 1).

Table 1: TFI and yield values as a function of management method, here as a function of the herbicide used.

EARLY WEEDING	GLYPHOSATE	DICAMBA	SHREDDING + DICAMBA	POST-EARLY FLORASULAM
Herbicide TFI	2,47	2,38	2,38	1,87
Yield (q/ha)	88,8	66,4	54,5	54,6

However, herbicide TFIs remained high throughout the crop year. The "glyphosate" control had the highest value (2.47). The alternatives tested used herbicide levels (from 1.87 to 2.38) that were too high in relation to the target set at the outset.

Under the conditions of this experiment, it appeared that too little control of the canopy when the crop was sown was highly detrimental to the development of the cereal crop, which was unable to establish itself properly.

2.3.2. Increasing the seeding rate for wheat

Weed flora was controlled satisfactorily, with maximum effectiveness in the glyphosate control. In the absence of the active ingredient, the increase in wheat density (600 grains/m²) resulted in better weed control (Figure 3).

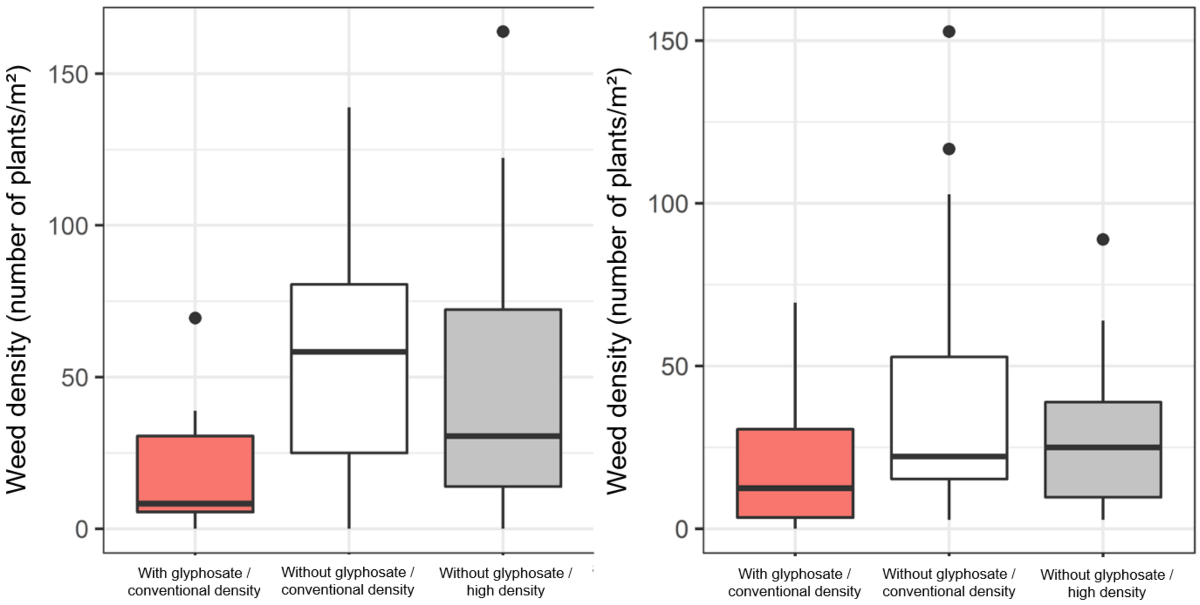

Figure 3: Weed density (plants/m²) according to management practices (red: with glyphosate; white: without glyphosate, conventional density sowing 300 gr/m²; grey: without glyphosate, high density sowing 600 gr/m²).

The best control of the clover cover between October (Figure 4a) and February (Figure 4b) was observed in the glyphosate control.

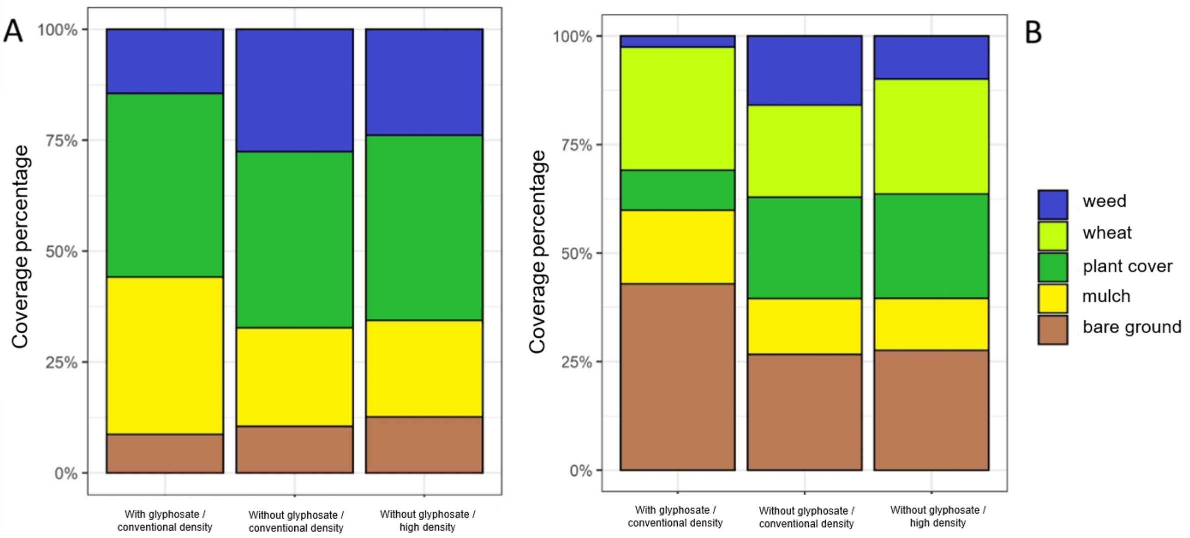

Figure 4: Changes in the percentage of soil cover (A: in October before sowing; B: after winter) as a function of 3 cover management methods. "With glyphosate / normal sowing density", control method with application of glyphosate and sowing of 300 seeds/m²; "Without glyphosate / normal sowing density", without glyphosate treatment and sowing of 300 seeds/m²; "Without glyphosate / high sowing density", without glyphosate treatment and sowing of 600 seeds/m² .

The percentage of clover cover (Figure 4) was only slightly affected by the increase in wheat cover.

The three methods produced similar yields with herbicide TFIs of less than 1.2 in the glyphosate-free situation, which was closer to the initial objectives (Table 2). Although not entirely satisfactory, the idea of increased competition from the crop was developed.

Table 2: Herbicide use (Herbicide treatment frequency index, HTFI) and yield values as a function of management method, here as a function of whether or not glyphosate was applied prior to sowing and the density at which the wheat was sown.

EARLY WEEDING	WITH GLYPHOSATE NORMAL SOWING	GLYPHOSATE-FREE NORMAL SOWING	GLYPHOSATE-FREE STRONG SOWING
Herbicide TFI	1.44	1.11	1.11
Yield (q/ha)	51.2	39.3	48.5

Increasing the density of the cash crop, in this case wheat, could therefore be a potential way of maximising competition with weeds and, under the conditions of the study, also appeared to be able to limit the development of white clover.

3. Development of a co-design teaching module for engineering students

3.1. Course of the teaching module

Over the three years of the project, the students spent a week designing a reference cropping system for farmers in Normandy who practise conservation agriculture and are interested in the issues raised by the ENGAGED project.

The teaching approach was based on three successive stages:

- Presentation of the CASDAR project and the resources available, as well as the production system and the reference cropping system on the basis of a tour of the plain with the farmer.
- Conducting co-design workshops with small groups of around five students over five half-days (i.e. 20 hours of work), with an intermediate review with a facilitator (ARAD2 engineer) and the support of an agronomy teacher (UniLaSalle Rouen).
- Oral presentation in the presence of the farmer and all the students, followed by the production of a summary document.

Co-design mobilises the students' scientific and technical knowledge as well as the various resources needed to assess the agronomic, economic and environmental performance of the redesigned cropping system. The redesign work involves taking into account the framework of constraints set by the ENGAGED project.

3.2. Results

As an example, we present here a cropping system redesigned by a group of students in December 2021. The farm was located in the south of the Eure department, with a focus on arable farming and poultry production. The reference cropping system was based on three main crops: oilseed rape, soft winter wheat and winter barley. The farmer practised direct seeding under a permanent cover of alfalfa. The soils were predominantly medium-deep loam and yield potential was considered good, with Olympic averages of 79 q/ha and 36 q/ha for wheat and oilseed rape respectively. The farmer's expectations were to tolerate a drop in yield of less than 10% and to pay particular attention to controlling weeds, especially ryegrass (*Lolium* spp.).

The students proposed a new cropping system based on a five-year crop rotation with oilseed rape at the head of the rotation, two wheats and including two new spring crops, spring barley and sunflower, and a succession of three different cover crops (boxes in red) (Figure 5).

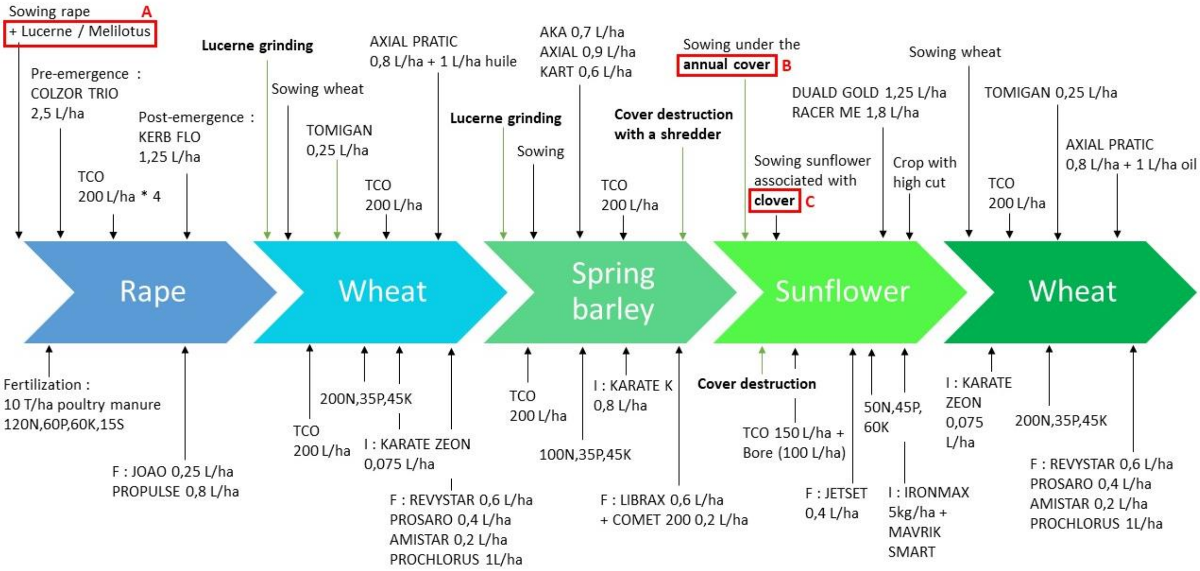

Figure 5: Example of a simplified decision scheme designed by a group of students (based on the reference cropping system of a farmer in the Eure region); F: fungicide treatment; I: insecticide treatment; TCO: oxygenated compost tea (Debreu *et al.*, 2022).

An initial multi-annual cover of alfalfa and sweet clover is sown when the oilseed rape is sown. The alfalfa is controlled by mowing and shredding, then mechanically destroyed after three years. An annual cover crop of white mustard, phacelia, daikon radish and rye is sown in August. This relay cover is mechanically destroyed a fortnight before sowing the sunflower in association with a multi-annual red clover cover. After two years, the clover will be destroyed after the second wheat.

The inclusion of two spring crops and the alternation of cover crops aimed to limit the development of weeds as much as possible and reduce the use of chemical control, with herbicide TFIs of between 0.7 and 1.5 depending on the crop, close to the objectives set for the redesign. The fungicide TFIs have also been lowered to take account of the farmer's desire to develop alternative practices (use of oxygenated compost tea).

Other indicators were calculated to assess *a priori* the performance of the cropping system, particularly from an economic point of view, with the calculation of gross margins for the various crops. These were compared with the results of a reference group provided by Cerfrance.

4. Economic and working time evaluation of prototype cropping systems

4.1. Materials and methods

The three prototype systems studied are direct seeding systems under permanent cover in cereal systems:

- System 1: Three-year rapeseed/wheat/winter barley rotation using glyphosate
- System 2: Three-year rapeseed/wheat/winter barley rotation without the use of glyphosate and implementation of alternatives: double seeding rate for wheat, two shredding operations, modulation of chemical regulation of the crop canopy, etc.
- System 3: Five-year rotation (with an annual herbicide TFI tending towards 1) Oilseed rape/Wheat/Spring barley/Sunflower/Wheat with double sowing density for wheat, two or three shreds depending on the crop, use of windrow mowing on wheat (to reduce the number of viable weed seeds at harvest time).

For each system, on a rotational basis, the gross margin with mechanisation and the working time were evaluated, taking into account :

- Three scenarios for selling prices and input costs (excluding plant protection products)
    - S1: low seed and fertiliser prices; low sales prices
    - S2: high seed and fertiliser prices; high sales prices
    - S3: high seed and fertiliser prices; low sales prices
- The impact of a collective solution (full CUMA-efficient equipment) on mechanisation costs

The fertiliser and crop protection product cost and selling price assumptions used for the simulations are shown in Tables 3 and 4.

The costs of the various work sites, including equipment and labour, are taken from the CUMA cost price guide for the west of 2021 and the ARPIDA work carried out in 2020. Most of the costs in this study are based on 2019 and 2020 accounts. Work rates can also vary significantly. These are machine times in operation in the field. In calculating working time, 20% of labour has been added. This overall working time does not take into account all the downtime on the road or on the farm, except in the case of sites specifically geared towards transport.

Table 3: Prices of crop protection products

Product	Type	Herbicidal active substance	Dose	Unit
GLYPHOSATE	H	glyphosate	10	€/L
ALLIE	H	metsulfuron methyl	380	€/kg
BOFIX	H	MCPA * fluroxypyr * clopyralid	12,5	€/L
CHALLENGE	H	aclonifen	23,5	€/L
DEFI	H	prosulfocarb	15	€/kg
FOSBURI	H	diflufenican * flufenacet	70	€/L
KERB	H	propyzamide	25	€/kg
NOVAL	H	metazachlor * quinmerac	24	€/kg
STARANE	H	fluoroxypyr	27	€/kg
PROPULSE	F	prothioconazole * fluopyram	35	€/L
REVYSTAR	F	Fluxapyroxide * mefentrifluconazole	30	€/L
PROSARO	F	trifloxystrobin* prothioconazole	42,8	€/L
LAMBDASTAR	I	lambda-cyhalothrin	60	€/L

Table 4: Fertiliser, seed and sales prices applied for the three scenarios

	€/un	€/un	€/un	€/un	€/un	18-46	
	N 33	P - super 45	K - KCl60	Soufre 50% (kiésérite)	Octoborate Bore 21%	18	46
S1 Low prices for inputs and crops	0,75	0,55	0,33	0,5	40,00	1,0	0,65
S2 High prices for inputs and crops	2,5	1,80	0,75	1,1	70,00	5,00	2,00
S3 High price for inputs and low price for crops	2,5	1,80	0,75	1,1	70,00	5,00	2,00

	Seeds €/kg							
	Wheat	Barley w	Barley s	Rapeseed	Sunflower	White clover	Red clover	Lucerne
S1 Low prices for inputs and crops	0,7	0,4	0,35	22	0,5	5	4	5
S2 High prices for inputs and crops	0,8	0,75	0,7	25	0,7	6	5	6
S3 High price for inputs and low price for crops	0,8	0,8	0,7	25	0,7	6	5	6

	€/T	€/T	€/T	€/T	€/T
	Blé	Px Oh	Px Op	Px Co	Px To
S1 Low prices for inputs and crops	170	170	250	340	280
S2 High prices for inputs and crops	300	300	400	600	650
S3 High price for inputs and low price for crops	170	170	250	340	280

4.2. Results

4.2.1. Presentation of the three prototypes

The control cropping system with glyphosate is an oilseed rape/soft winter wheat/winter barley rotation, and the crop managements are presented in Table 6. Permanent clover cover is sown with oilseed rape and continues throughout the rotation. Glyphosate is used to regulate the cover and manage weeds in intercropping. For this system, the herbicide TFI is 5.6 for the whole rotation. Yields are 40 quintals/ha for oilseed rape, 80 quintals/ha for wheat and 75 quintals/ha for winter barley.

Table 6: Crop management of the "3-year rotation with glyphosate" control system

	WINTER OILSEED RAPE	WINTER WHEAT	WINTER BARLEY
Sowing	3 kg/ha	300 gsm	300 gsm
Fertilisation	180 nitrogen units 170 units of sulphur 2 to 3 kg of boron	180 nitrogen units 40 units of potassium 50 units of phosphorus 50 units of sulphur	160 nitrogen units 40 units of potassium 50 units of phosphorus
Pesticide use	Before sowing: 1 litre of glyphosate Noval 1.2 L/ha Kerb 1.875 Lambdastar 0.075 L/ha Propulse 1 L/ha	Before sowing: 1 litre of glyphosate Fosburi 0.6 L/ha + Défi 2L/ha Ally 5 g/ha Lambdastar 0.075 L/ha Revystar 1.5 L/ha + Prosaro 0.6 L/ha	Before sowing: 1 litre of glyphosate Fosburi 0.6 L/ha + Défi 2L/ha Ally 5 g/ha Cover destruction: Bofix 1 L/ha Lambdastar 0.075 L/ha Revystar 1.5 L/ha + Prosaro 0.6 L/ha
Passage of equipment	1 disc drill pass for cover crops 1 direct tine drill pass 3 passes with a fertiliser spreader 5 sprayer passes Harvester + delivery	1 covered shredding 1 disc drill pass 3 passes with a fertiliser spreader 6 sprayer passes Harvester + delivery	1 covered shredding 1 disc drill pass 3 passes with a fertiliser spreader 5 sprayer passes Harvester + delivery

For cropping system 2, the rotation is unchanged and the itineraries are partly adapted to the absence of glyphosate. Glyphosate is replaced by an additional shredding pass and an additional dose of herbicide in spring to regulate the cover (0.2 L of starane). To compensate for the risk of competition between the canopy and the crop, the density of wheat has been doubled (600 g/m²) and that of winter barley is 500 g/m². The herbicide TFI is 5.3 over the rotation, an average of 1.8 per year.

For cropping system 3, the main difference with the previous system is the extension of the rotation to 5 crops: oilseed rape, wheat, spring barley, sunflower and wheat. A red clover cover is sown at 8 kg/ha with sunflower as a relay crop to the white clover cover. The Crop management for spring barley, sunflower and the second wheat are presented in Table 7. The herbicide TFI is 6.03 for the rotation, i.e. an average of 1.2 per year, which is close to the target of 1 set by the ENGAGED project.

Table 7: Crop management for system 3 "5-year rotation without glyphosate".

	SPRING BARLEY	**SUNFLOWER**	**WINTER WHEAT**
Sowing	500 gsm	80 kg/ha	600 gsm
Fertilisation	60 nitrogen units 40 units of potassium 50 units of phosphorus	50 nitrogen units 35 units of potassium 35 units of phosphorus 15 units of sulphur 2 to 3 kg of boron	160 nitrogen units 40 units of potassium 50 units of phosphorus
Pesticide use	Axial pratic 0.9L/ha Starane 0.2L/ha Cover destruction: Bofix 1 L/ha	Novall 1.2L/ha + Challenge 1L/ha	Fosburi 0.5 L/ha Ally 5 g/ha Starane 0.2 L/ha Revystar 1.5 L/ha + Prosaro 0.6 L/ha
Passage of equipment	1 direct disc drill pass 3 passes with a fertiliser spreader 5 sprayer passes 3 grindings Harvester + delivery	1 disc drill pass 3 passes with a fertiliser spreader 5 sprayer passes Harvester + delivery	1 covered shredding 1 disc drill pass 3 passes with a fertiliser spreader 5 sprayer passes 1 mowing swathing Harvester + delivery

4.2.2. Comparison of average gross margins for the three prototyped systems.

Under the assumption that yields were maintained, we observed a deterioration in the annual gross margin with the elimination of glyphosate between system 1 and 2, whatever the simulation scenario (Figure 6). This could be explained by a greater number of passes and higher seed costs (double density). The introduction of spring crops to extend the rotation (system 3) made it possible to maintain or even improve the margin, but only if the yield level was maintained.

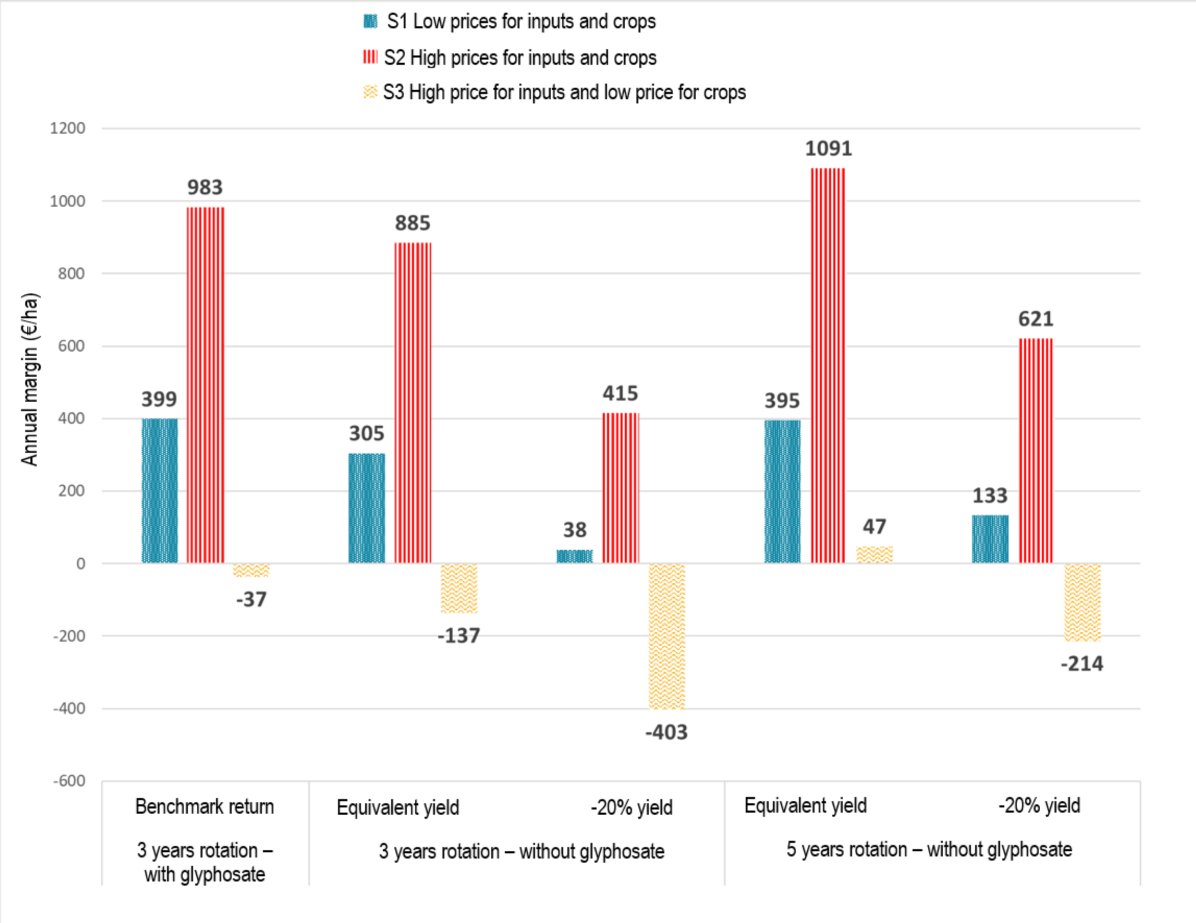

Figure 6: Comparison of the annual gross margins of the three prototyped systems (3-year rotation with glyphosate use, 3-year rotation without glyphosate use and 5-year rotation without glyphosate use) according to the 3 scenarios and under two yield assumptions (maintenance and 20% loss).

The simulations also showed that replacing glyphosate with the alternative techniques tested led to an increase in working time and in the weight of mechanisation in costs, which was explained in particular by an increase in the number of shredder passes. However, in the hypothesis of a reduction in yield, the use of a full CUMA only partially reduced the impact of mechanisation costs on margins. The challenge remained to control the permanent cover so as to limit competition and hence yield losses from the main crop.

5. Discussion and conclusions

The ENGAGED project has shown that the constraints set (no tillage, permanent cover, no use of glyphosate and limited use of herbicides during the cropping season) do not enable wheat yields to be obtained that are equivalent to those under conventional management. Under such conditions, the canopy becomes the primary weed responsible for yield losses, and few viable technical solutions have been identified for canopy management on an annual scale.

Furthermore, simulations of three prototypical cropping systems show that simply replacing glyphosate with alternative annual techniques leads to a reduction in gross margin across the whole rotation, whatever the price scenario studied. Extending the rotation with the introduction of spring crops, on the other hand, seems to enable the margin to be maintained or even improved, but on the assumption that the yield is maintained. However, trials show a yield loss of up to 20%. It is therefore essential to reduce competition between the cover crop and the crop of interest. A number of technical points still need to be clarified, such as the choice of cover species and varieties, with the aim of achieving sufficient soil cover to regulate weeds while limiting competition with the cash crop. The introduction of non-chemical cover management methods, such as the technical possibilities of inter-row shredding with wider crop spacing, are all solutions that farmers could select and improve according to their needs and the context of their plot.

It should be noted that the three simulation scenarios do not cover all the price situations that farmers may encounter. And for the analysis of mechanisation costs, the data dates from 2019 and 2020. However, the current context is causing the cost of equipment to rise rapidly (inflation and interest rates), with the result that there is now a very wide disparity in invoicing costs. It would therefore be interesting to redo these calculations with more up-to-date data. Other hypotheses could also be tested: new price scenarios, replacement of sunflower by maize, use of an agricultural works company, etc. This work could also assess the impact on other indicators such as disposable income or the distribution of work sites according to the days that are agronomically available.

Thus, in systems that have only recently been set up, where the cessation of glyphosate has only been tested for a year with non-degraded weed situations and in contexts of good yield potential such as those tested, an in-depth redesign of the system must be the solution envisaged. However, the ENGAGED project has confirmed that farmers are highly risk-averse, particularly with regard to the potential increase in weed seed stocks, which may act as a brake on the testing of breakthrough practices. Thanks to the work carried out with the students, the teaching module made it possible to provide farmers and project partners with new, *unprejudiced* ideas and to explore previously untried possibilities. This co-design workshop exercise was also highly beneficial to the students' learning process, as they gained a practical understanding of systems agronomy tools and approaches. The pooling of knowledge, the confrontation with the farmer's objectives and constraints, the justification of technical choices, the systemic reflection on the coherence and robustness of an innovative cropping system, as well as the evaluation, even partial, of the economic and environmental performances, represent a set of fundamental skills for future agronomists confronted with the necessities and difficulties of the agroecological transition of agricultural production systems. What's more, while the construction of a co-design activity in a workshop adapted for teaching purposes is nothing new, the fact that students are involved in a CASDAR project and that their productions are considered as sources of inspiration for professionals seems to represent an innovative and intellectually stimulating approach for everyone.

Ethics
The authors declare that the experiments were carried out in compliance with the applicable national regulations.

Declaration on the availability of data and models
The data supporting the results presented in this article are available on request from the author of the article.

Declaration on Generative Artificial Intelligence and Artificial Intelligence Assisted Technologies in the Drafting Process.
The authors used artificial intelligence in the translation process from French to English.

Authors' contributions
All the authors have read and approved the final manuscript.

Declaration of interest
The authors declare that they do not work for, advise, own shares in, or receive funds from any organisation that could benefit from this article, and declare no affiliation other than those listed at the beginning of the article.

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