Alfalfa to get back into planetary boundaries

2025 world alfalfa congress
FRANCE REIMS-CHÂLONS

New alfalfa-based cropping systems

Liu N. & Cree K.

Parallel session 3

FROM 03 › TO 06 nov. 2025

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New uses of alfalfa as a service plant for the resilience of cereal production

Mathieu Marguerie, Régis Hélias, Alain Baranger, Amélie Carrière, Benoit De Solan, Jérome Labreuche, Nicolas Salas, Jacques David

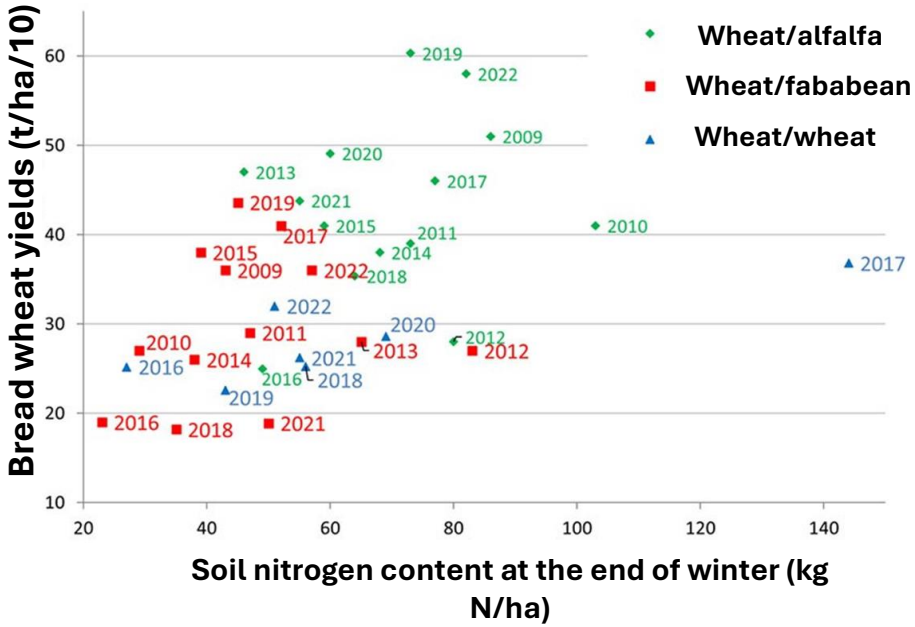
ARVALIS

INRAE
la science pour la vie, l'humain, la terre

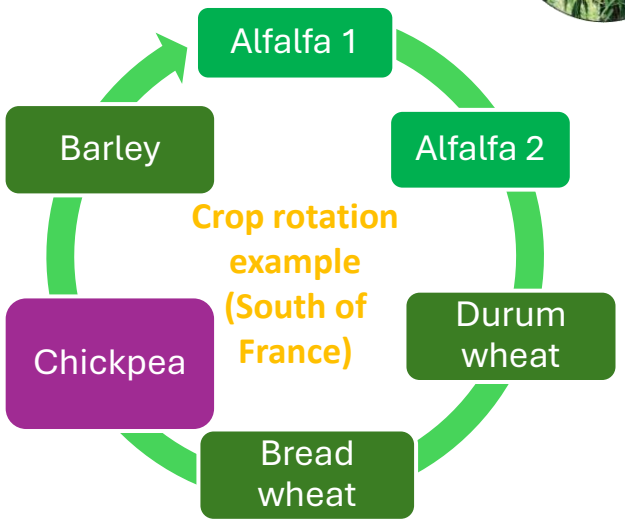
FROM 03 TO 06 nov. 2025

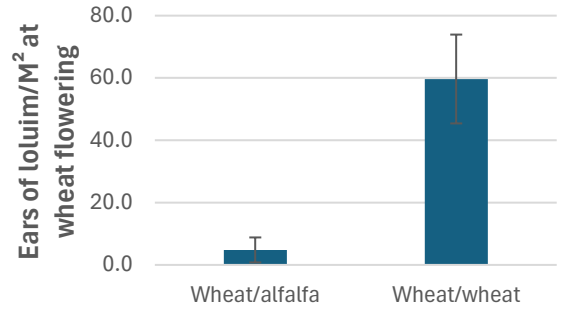
Alfalfa : many agronomic services in the crop rotation

- ✓ **Nitrogen nutrition for cereals crops** (especially in organic or low-input systems)
- ✓ **Yield security**
- ✓ **Complementary solution for weed management in a context of herbicide resistance/regulatory ban**



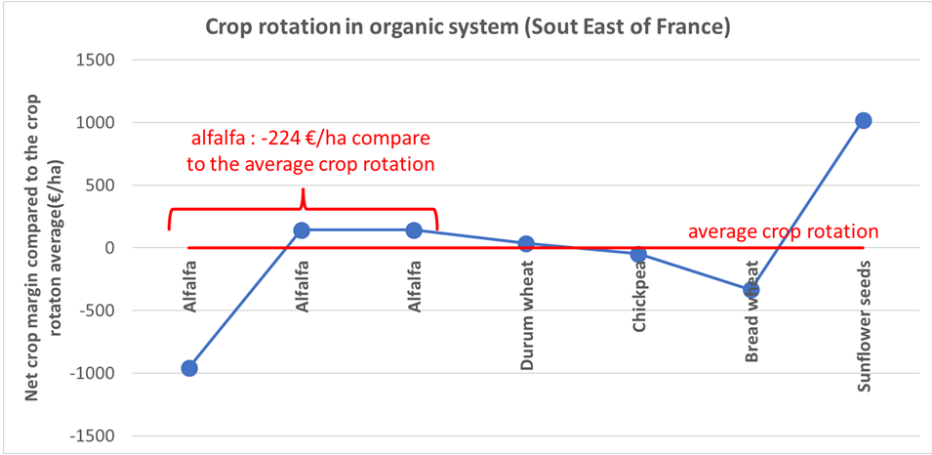
Yield and soil nitrogen content in organic production in long-term trail in Boigneville, France (Source: Arvalis)





Lolium infestation in durum wheat in South-East of France according to crop rotation in low herbicide system (Source : Arvalis in Bbsocoul project).

But uncertain economic benefits (Biodur, 2024)



Net crop margin of a crop rotation in organic cereal system in Sout-East of France (Source : Arvalis in BIODUR project).

Conservation agriculture : a way to increase soil fertility

Minimum soil perturbation (« conservation tillage »)

- Absence of inversion
- Elimination of tillage

Maintenance of permanent soil cover *

- Dead
- Alive
- Living mulch (alfalfa, clover… present for several years)

Crop rotation diversification

- Sufficiently varied rotations (sanitary reasons) including fabaceae (for fertility)
- Associated crop (over and under seeding)

Conservation Agriculture multi-performance

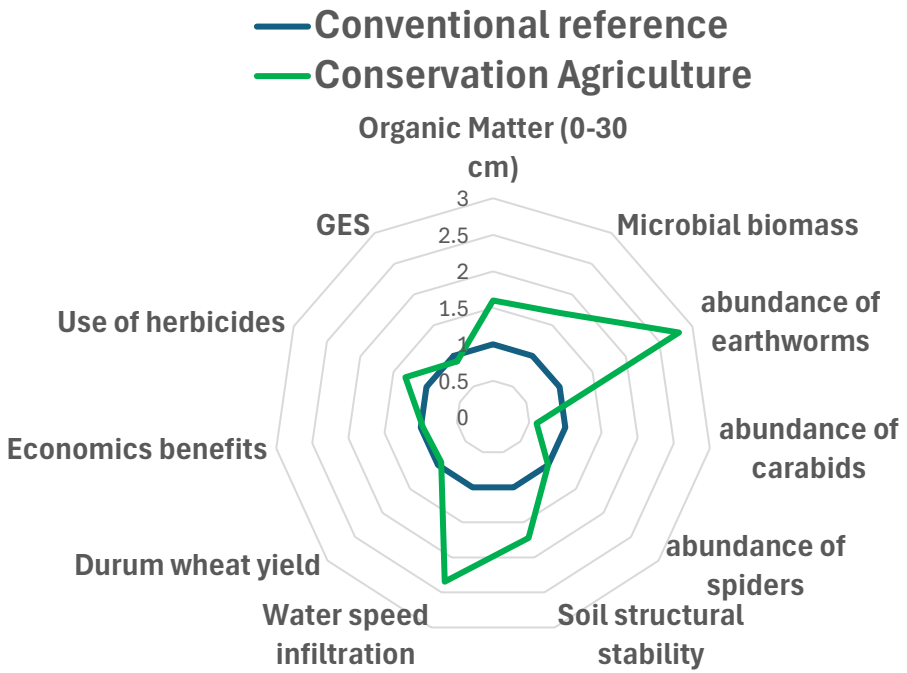
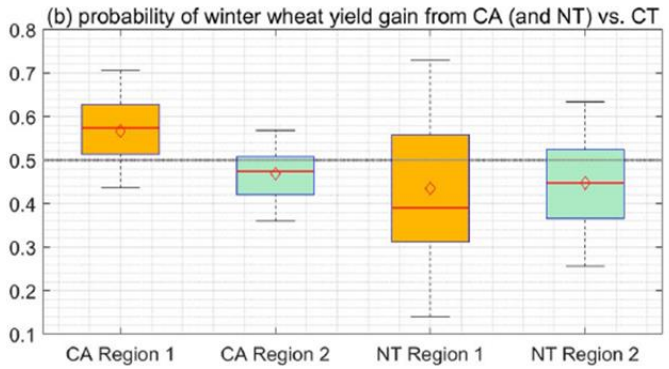


Figure 5 : multiperformance of Conservation Agriculture compared to conventional in South-East of France (Source : Arvalis)

Yields benefits in dry regions

Su et al., Nature, 2021



Region 1 = dry region
Region 2 = wet region
CA = conservation Agriculture
NT = No Tillage

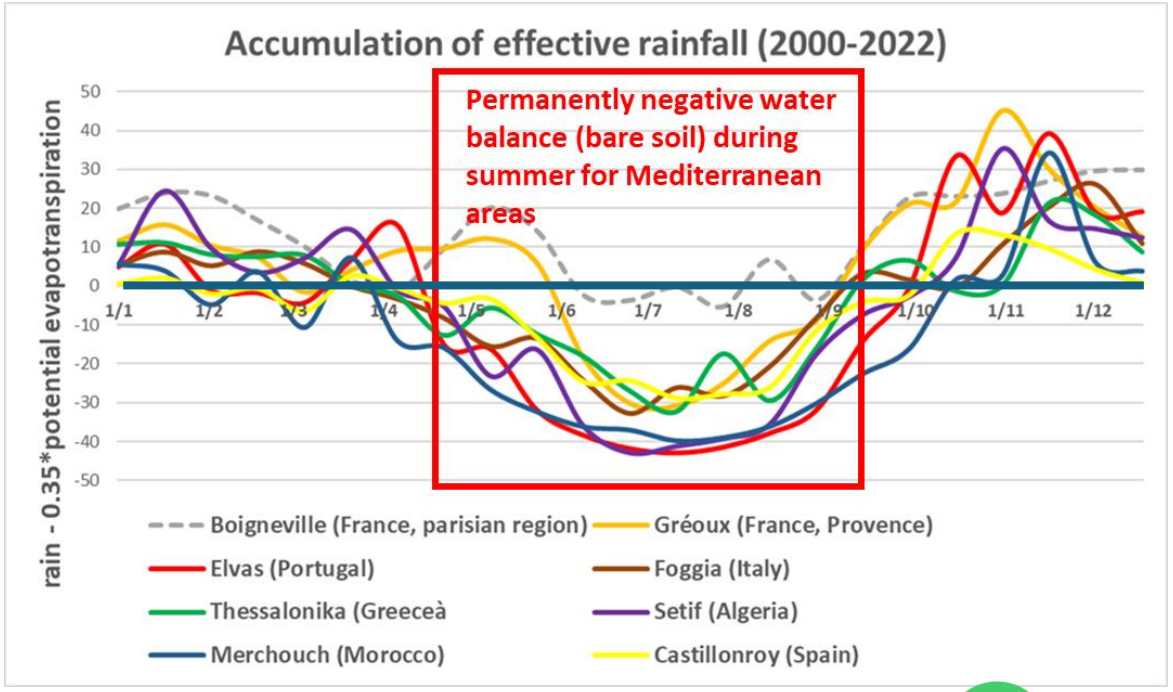
A system that can maintain maintain profitability and increased agronomic services

Sowing under cover of alfalfa

Alfalfa as living mulch : can be present for several years, associated to several winter cereal successive crops.

Economic interest : soil cover without reducing cash crops

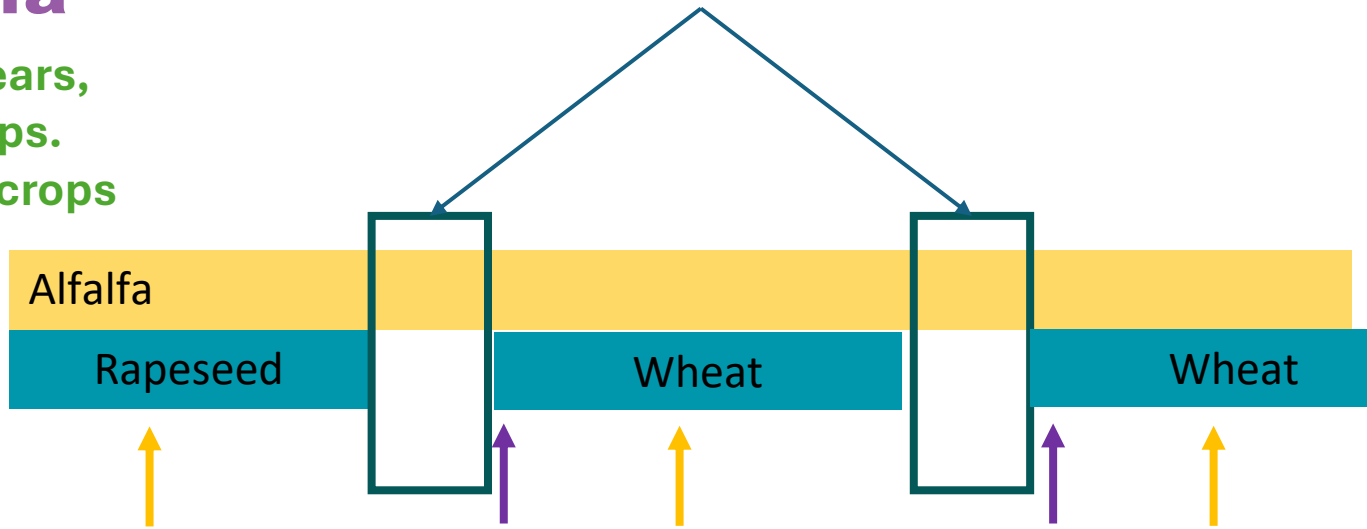
A way to cover the ground during the summer in dry regions



Alfalfa : permanent cover well adapted with winter cereals : persistent + dormancy.

Clover : low dormancy

Soil covered during summer (not possible with annual plant covers in dry regions) without reducing sales crops frequency



Necessary to control alfalfa growing in crops to avoid competition

➔ Before sowing crop : mechanical or chemical (Glyphosate) regulation

➔ After sowing crop : selective herbicides authorized on the crop

In wheat, the goal is to have **less than 1 tonne /ha of Dry Matter of alfalfa at wheat flowering to avoid yield penalties** (Labreuche, 2015)

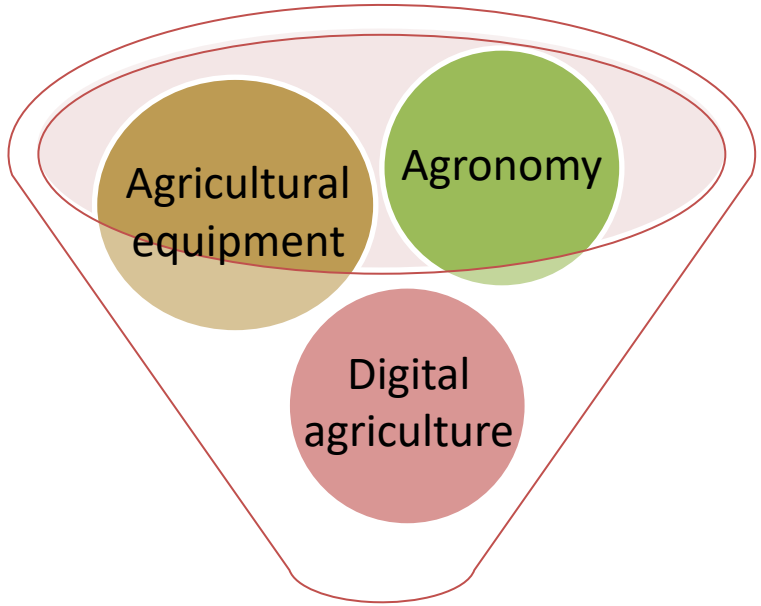

Oraison, Arvalis, 2022

Innovations to control alfalfa without herbicides

To separate a cash crop and a service plant in space in order to be able to manage them separately

RTK autoguidance
to sow and manage the 2 species

Inter-row mower
to manage the cover



agronomic graal

GRAAL project – Agronomic practises

Wheat sowing

Alfalfa crushing

Spacing between wheat rows: 30 cm

Two or three mowings of alfalfa rows

Wheat harvest

November

January

March - April

July to November

Spacing between alfalfa rows: 30 cm

- Reversal of dominance between species

- The small leaf area of alfalfa preserves the resources available for wheat (water, light)

- Soil cover in intercropping
- Nitrogen capture for the next crop
- Carbon storage
- Erosion control
- Refuge for biodiversity

GRAAL project : main results & perspectives

Yield components and protein contents ratios of cereal crops associated with mowed alfalfa and cereal sole crops

	Barley (Year 1)	Wheat (Year 2)	Wheat (Year 3)
Plants/m²	104% ab/a	63% b/a	86% NS
Ears/m²	55% b/a	94% b/a	41% ab/a
Grains/ear	92% NS	105% NS	77% NS
TKW (g)	108% NS	111% ab/ b	94% a/a
Yield (t/ha)	50% b/a	111% NS	29% ab/a
Protein	112% bc/c	115% a/b	112% a/b

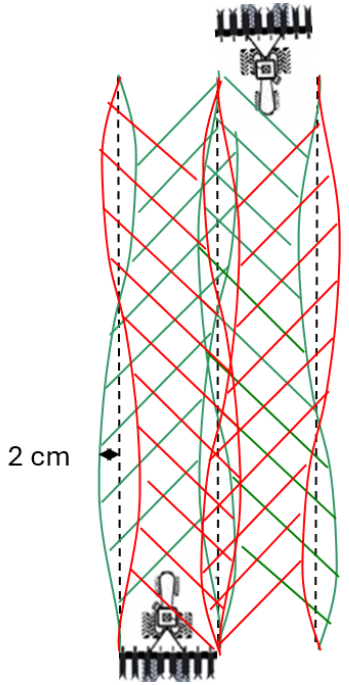
Alfalfa / uncovered

Deviations from the uncovered control of GEA alfalfa:

- Losses at the time of emergence
- A close number of grains/ear
- A close or higher TKW
- A lower yield except in Year 2
- Superior technological quality

Innovation needed

Precise RTK autoguidance



Sowing and mowing device

into planetary boundaries

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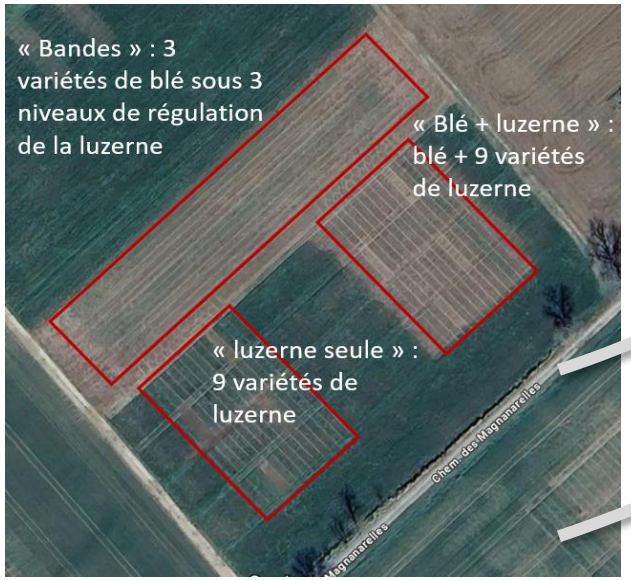
What to expect from genetics ?



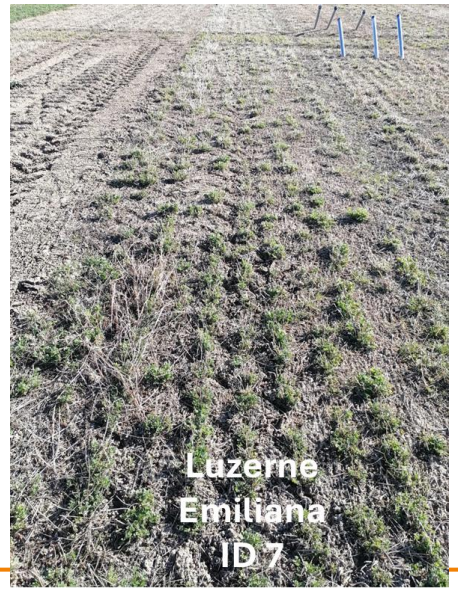
<u>9 contrasting fall dormancy racing</u>: a higher alfalfa dormancy allows less competition on durum wheat at the end of winter?

Micro-parcelle n° :	101	102	103	104	105	106	107	108	109	110	111
Bloc 1 Modalité :	1	5	3	4	8	7	6	9	10	2	SAINFOIN
Micro-parcelle n° :	201	202	203	204	205	206	207	208	209	210	211
Bloc 2 Modalité :	10	3	8	6	2	9	4	5	7	1	SAINFOIN
Micro-parcelle n° :	301	302	303	304	305	306	307	308	309	310	311
Bloc 3 Modalité :	7	6	9	5	1	2	8	10	4	3	SAINFOIN
Micro-parcelle n° :	401	402	403	404	405	406	407	408	409	410	411
Bloc 4 Modalité :	2	4	10	7	3	1	9	5	8	6	SAINFOIN

Numéro de modalité :	1	2	3	4	5	6	7	8	9	10
Variété de luzerne :	Milky Max	Occitane	Avia	Limory	Azura	Magali	Fado	Catera	Emiliana	Blé seul

Alfalfa genotype	Dormancy index
Limory	3
Fado Luz	3,4
Occitane	4,5
Milky Max	4,6
Catera	6
Azura	6
Magali	6,5
Emiliana	7
Avia	8

Comparison of the 9 varieties of alfalfa associated with the same wheat, over 2 seasons: moderate regulation of alfalfa (chemical)



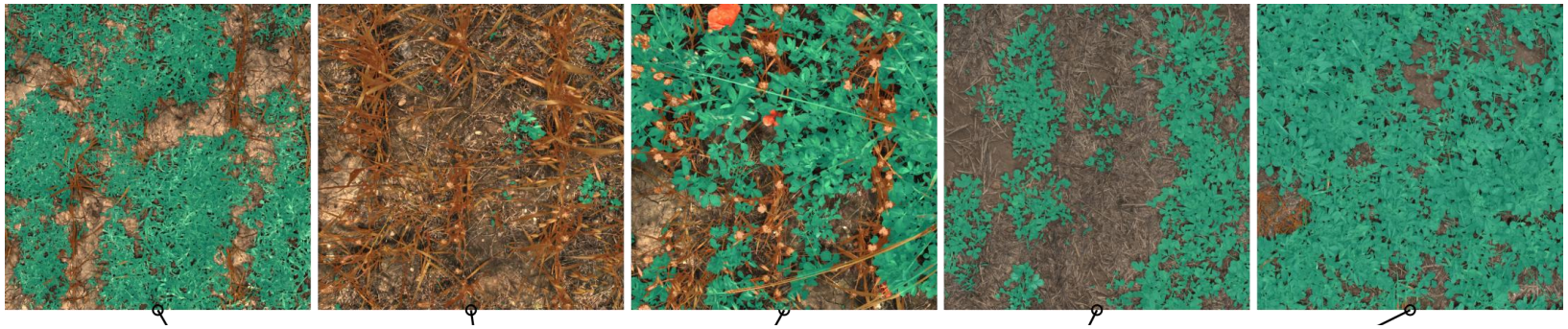
High-throughput phenotyping of associated crops: recent progress to better assess soil coverage and between species competition dynamics

Figure 7: Passage of the phenomobile on the Arvalis trials at Gréoux les Bains. Personal photo.

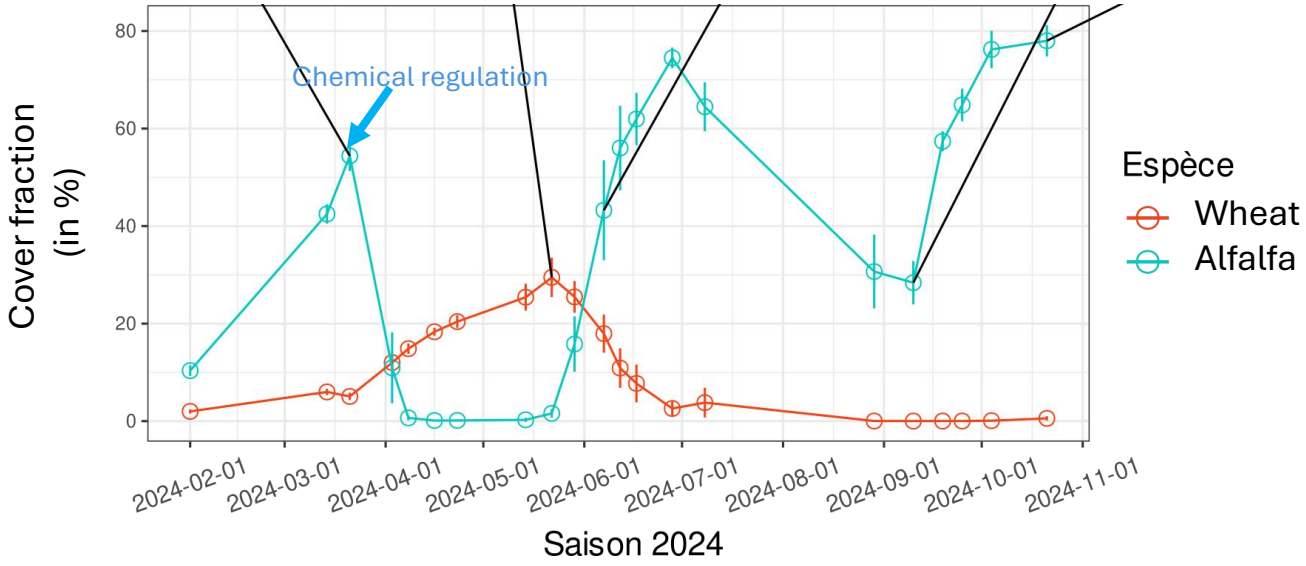
Sensors embedded by the phenomobile: RGB cameras, lidar, spectroradiometer

Very regular acquisitions to follow:

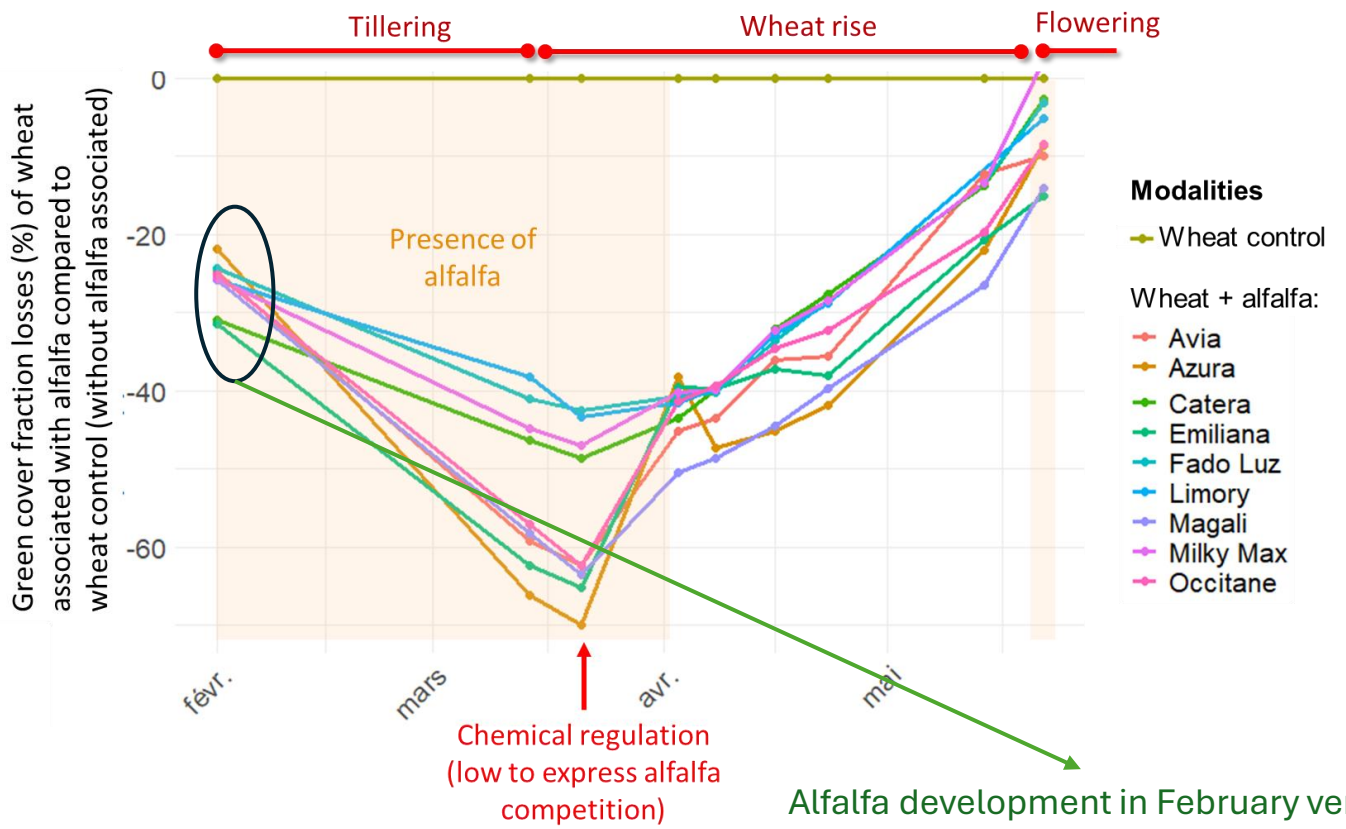
- The green fraction by species
- The height of pure alfalfa
- An estimate of biomass for pure alfalfa (3DPI)



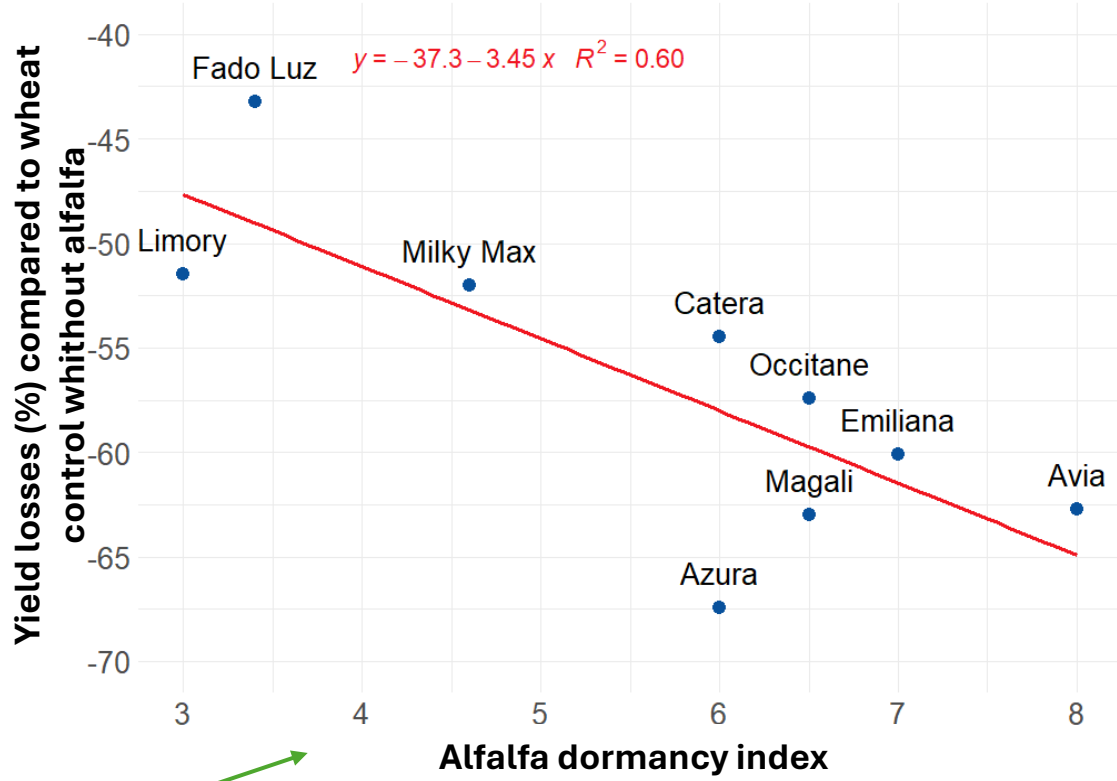
Competition between wheat and alfalfa
Evolution of the kinetics of green cover fraction at the scale of a microplot over 21 dates.
Images acquired by the phenomobile system



The most dormant alfalfa variety reduces between species competition, but not sufficiently to maintain durum wheat yield



relative loss of green fraction of associated wheat compared to wheat alone for each associated alfalfa variety in the 2024 season.



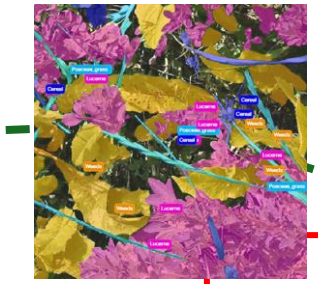
Alfalfa development in February very related to Dormancy Index (R^2 = 0.61)

- 40 % of yield losses with alfalfa (volontary under regulated).
- But from 40 to 67 % according to alfalfa genotypes.

From the idea to its development : a multidisciplinary approach and a continuous progress

How it started : from gardening...

2015



CAPTE

Phenotyping and AI
Understand and diagnosis of agronomic perfomances

2025

... to a multidisciplinary approachto combine the levers of success and progress

Equipment innovation :
RTK precision for inter-row mowing
Mowing quality

ECO-MULCH
MECAMAT
BIONALAN

X

Genetics:
Competitive wheat and low competitive alfalfa

INRAE
agri obtentions
RAGT

Farmers
Test and develop practices

Alfalfa to get back into planetary boundaries

Thanks for your attention

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